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Document Version
Final published version

Citation (APA)
Qi, Y., Qian, Q. K., Meijer, F. M., Visscher, H. J., & Lu, H. (2026). Explaining policy implementation gap by policy network analysis: Evidence from China's energy renovation project quality failures. *Journal of Cleaner Production*, *540*, Article 147399. https://doi.org/10.1016/j.jclepro.2025.147399

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Journal of Cleaner Production 540 (2026) 147399

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Explaining policy implementation gap by policy network analysis: Evidence from China's energy renovation project quality failures

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HIGHLIGHTS

- Top-down renovation targets prioritize scale over quality in local government actions.
- The administrative cost of market-based policy instruments results in delays and inefficiencies in project execution.
- Engaging residents as investors in renovation projects has proven effective in enhancing oversight of quality.
- Funding from residents may impose financial burdens on economically disadvantaged groups.

ARTICLE INFO

Keywords:
Policy network theory
Policy instruments
Quality failures
Energy renovation projects

ABSTRACT

As climate change becomes a global concern, policymakers and practitioners are paying increasing attention to low carbon development in urban building zones. Among various measures, energy-saving renovations of existing residential buildings have become among the most vital developments for reducing carbon emissions in China. However, Quality failures—such as improper installation of steel nails or missing rivetsdefined as completed work that does not comply with prescribed technical standards—occur frequently during construction processes. These quality failures, representing a gap in policy implementation for residential building energy renovations, have received relatively little academic attention. This research seeks to address this gap by applying policy-network analysis to two case studies of renovation projects in Inner Mongolia in China, examining how actor interdependencies and adoption of policy instruments contribute to quality failures. The findings indicate that market-based policy instruments incur significant administrative costs, thereby impeding the maintenance of project quality. Additionally, mandatory policy instruments frequently lead to goal displacement at various governmental levels, further compromising the quality of energy renovation projects. Conversely, involving residents as a voluntary policy instrument can alleviate financial pressures on local governments while enhancing oversight of renovation quality. Nonetheless, this approach may impose financial burdens on economically disadvantaged groups. Based on these results, it is recommended that the government adopt a nuanced combination of policy instruments to minimize quality failures and realise the energy-efficiency potential of residential renovation initiatives.

1. Introduction

Ever-increasing carbon emissions **have exerted profound impacts on** global climate change (Huo et al., 2022). China is **currently** the largest contributor to carbon emissions in the world, and its emissions **are expected to continue rising** due to its rapid economic expansion (Zhou et al., 2018). The existing residential building sector contributes the **largest share** of building carbon emissions, exceeding 40 % (Huo et al., 2020), which has a significant effect on total carbon emissions (Gan et al., 2019). China's northern regions have been prioritized for **large-scale** energy-efficiency renovations primarily because of their extreme heating energy demands, coal dependence and pollution

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https://doi.org/10.1016/j.jclepro.2025.147399
Received 26 January 2025; Received in revised form 13 November 2025; Accepted 22 December 2025
Available online 6 January 2026
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challenges. Therefore, Chinese central government has set ambitious targets to complete energy-saving renovation in 1.2 billion m^2 of existing residential buildings in Northern China by 2020 (Chen et al., 2013).

As the **core** policy objective, the energy-efficiency target **aims to reduce heating energy consumption by 40–65 %** relative to levels in the early 1980s (Zhou et al., 2018). However, **quality failures frequently occur in energy renovation projects of residential buildings**. Quality is defined in this paper as completed construction work meeting the technical requirements in the building regulations (Meijer and Visscher, 2017). Quality failures are not only unintended results at the project level, but also at the regional and national levels, as central and provincial governments expect these projects to save energy and help in a low carbon transition. This can cause inefficient energy performance, safety hazards, overall cost increases, and other unexpected losses (Qi et al., 2019). Improving quality in energy renovation projects is also aligned with Sustainable Development Goal 11, which emphasizes **making cities and human settlements inclusive, safe, resilient, and sustainable**.

Some previous studies have identified the technical mechanisms underlying quality failures—such as material defects, installation errors, and design inconsistencies (Chong and Low, 2005; Forcada et al., 2012), while, others have elaborated on the relative significance of these causes through Interpretive Structure Modelling method, Structural Equation Model, Bayesian network model and Fault tree analysis (Aljassmi and Han, 2014; Forcada et al., 2014; Hughes and Thorpe, 2014; Qi et al., 2021). However, **these studies tend to concentrate narrowly on technical and individual factors, overlooking how interactions among different actors within the regulatory environment influence quality outcomes.** In building energy renovation projects, the main actors include governments, construction companies, supervision companies, design companies and residents (Liu and Yang, 2010). Yet, **how the interdependencies among these actors shape policy implementation and contribute to quality failures remains insufficiently explored.**

The central research question addressed in this research is how the actor interdependency and policy instrument adoption affect quality failures during the renovation implementation process in Northern China. Policy network theory elucidates why policy intentions often fail to materialize on the ground, or more mildly, why they **tend to become** diluted or distorted during implementation (Hudson et al., 2007; Klijn and Koppenjan, 2000; Lehmbruch, 1991; Falcone and Tutore, 2025). Despite its broad application, the theory has been criticized for being overly descriptive and lacking in explanatory power regarding policy outcomes (Klijn and Koppenjan, 2000). To address this gap, this study leverages actor interdependency and policy instruments as key explanatory factors for understanding policy networks, as suggested by Bueren et al. (2003). The underlying reason is that actors in these networks aim to achieve their objectives by leveraging resources controlled by others, with policy instruments being one of these critical resources (Falcone et al., 2019). *Therefore, the main objectives of this research are to: 1)investigate the actors, actors' interactions and their conflicts in renovation projects; 2) elucidate why quality failures happen through the lens of policy network analysis; 3) recommend targeted network-governance strategies and instrument designs to close the efficiency gap in practice. .*

The key findings of this research indicate that market-based policy instruments entail high administrative costs, which hinder the ability to sustain project quality. Similarly, mandatory policy instruments often result in goal displacement across different government levels, therefore further diminishing the quality of energy renovation initiatives. In contrast, engaging residents as a voluntary policy measure can reduce financial strain on local governments while improving quality oversight. However, this approach risks placing undue financial pressure on lower-income households.

The remainder of this paper is organised as follows. Section 2 outlines key definitions and applications based on policy network theory, explaining how this helps to explore the causes of quality failures in building energy renovations. Section 3 summarises the policy instrument adoption, main actors and their interdependency in different arenas during energy renovation processes. Section 4 introduces the methods for this study. Section 5 then presents and analyzes two cases of building energy renovation projects. There is a discussion about the actor interdependencies and policy instrument adoption in Section 6. In the final section, the conclusions are presented, and some suggestions are offered for future high-quality renovation construction and successful policy implementation.

2. Literature review

2.1. Policy network theory

The concept of **the policy network** emerged in political science and public policy literature as a **theoretical** framework for understanding how complex decision-making processes involve multiple actors beyond formal government institutions. The early foundations of policy network come from pluralist and corporatist lenses, and it has been further developed by more systematic theory building, such as Rhodes (1996), Marsh and Smith (2000) and Kickert et al. (1997). Policy network theory is a cluster of concepts, rather than one single theory, in which the making and implementation of the policy are considered as a process (de Jong et al., 2016; Lu et al., 2018). These approaches share a common emphasis on the interdependent relationships among multiple actors, whose behaviours mutually influence and depend upon one another (van Bortel, 2009). One way to understand the policy networks is through the distinction between the Anglo-Saxon school and the German–Dutch school. The Anglo-Saxon tradition adopts a micro- and meso-level perspective, emphasizing the interactions among organizations and, in some cases, individual actors. This orientation aligns more closely with the analytical aims of this research and is therefore adopted in this study.

Policy network theory builds on the result of an interaction between multiple actors (see Fig. 1). So, it focuses on the interaction processes between interdependent actors and their conflicting interests (Fawcett and Daugbjerg, 2012). In this paper, several key conceptual terms are explained, such as *goals*, *perceptions*, *arenas*, *interactions* and *conflicts*.

First, policy actors are assumed to have goals they aim to see realised as if in a game-like network setting, and this includes a perception of the problem situation at hand (Bueren et al., 2003). These perceptions have generally evolved based on earlier learning experiences. Both the goals and strategies are derived from these perceptions. Goals are concrete (partial) translations of perceptions (Koppenjan et al., 2004). The actors' strategy refers to the tacit knowledge or routines of actors, which can affect decision-making and implementation processes (Koffijberg et al., 2012). For instance, in energy renovation projects, government agencies may aim to ensure the timely promotion and completion of renovation programmes, and their strategies are reflected in the selection and

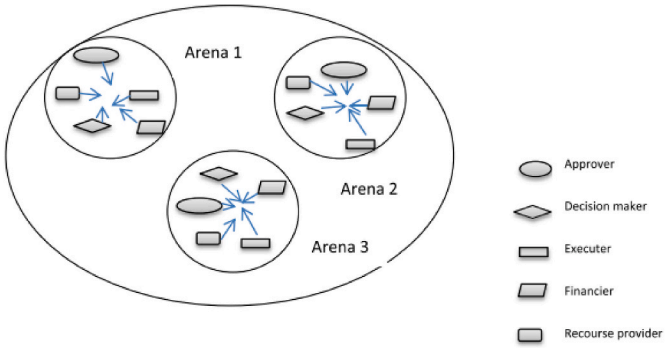


Fig. 1. The actors and their interactions according to policy network theory (Lu et al., 2018).

deployment of specific policy instruments.

Besides these attributes of actors (goals, perception, strategies, and resources), it is possible to understand further the interactions and conflicts among actors in the policy process. Interactions are played out in one or more arenas, where specific groups of actors interact on issues and make choices (Zheng et al., 2010). Arenas are places in which specific groups of actors interact on issues and make choices on specific aspects of the issues (Bueren et al., 2003; Søndergaard and Ricardo, 2020). For instance, in energy renovation projects, arenas can be divided by the different project process, such as target setting, project preparation and project construction. Networks have complex interactions because each of the actors is autonomous and has its own perception of problems, solutions and strategies. This leads to substantial differences in perceptions, value conflicts and disagreements about implementing policies (Klijn & Koppenjan, 2015).

Conflicts in the arenas make the policy process and outcome dynamic and unpredictable. Conflicts in problem perception, goals and adopted strategies are important explanations for the failure of concerted policy. Differences and disagreements in perception between actors may cause conflicts and block interactions, which demands trust and shared motivation from actors to solve problems (Raynor and Whitzman, 2020). The divergence in perceptions and goals of involved actors can often be found in energy-saving studies, as the pursuit of economic development is still the priority of governments in many countries (Mu et al., 2019). These problems are related to actors' values or ideology on certain issues, such as energy use, environmental protection, and economic development.

Changes in policy network variables—such as goals, perceptions, arenas, and interactions— can directly or indirectly reshape patterns of resource exchange, thereby driving the evolution of policy processes. These shifts in policy network variables are triggered by exogenous factors, including environmental pressures, economic conditions, and technological advancements (Compston, 2009). In this study, the specific exogenous factors influencing the cases will be further elaborated in the case introductions.

2.2. Policy instrument adoption in networks

Actor interdependency is the core element in the policy networks. Actors are dependent on resources owned by other actors, and this dependence determines their positions in the arena. This resource-dependence also forms power dependence among actors, which is different from the rational choice approach to form a network via actors' bargaining and evaluation (Milhorance et al., 2020). Furthermore, the actors strategically deploy their resources to generate and manage interdependencies in order to achieve their policy goals (Howlett, 2019; Klijn and Koppenjan, 2000). These resources include a range of political, legal, financial, organizational, physical, and informational instruments or tools that jointly flesh out policy concepts into visible concrete action (Milhorance et al., 2020). Through swapping objectives/needs and resources/instruments, involved actors develop interactions through which they aim at impacting the behaviours of other actors, hoping to solve their own problems as well as those of society at large. Thus, policy instruments are the key concept to understand the actor interdependency.

The interactions between actors within policy networks significantly influence the adoption of policy instruments, which in turn affects how conflicts are resolved within these networks (Klijn & Koppenjan, 2015). Majone (1976) suggested that the distribution of power among social actors is closely linked to the selection of policy instruments. Extending this idea, Bressers and O'Toole (1998) elaborated on how policy instrument selection is informed by different types of policy networks, which are distinguished by their interconnectivity and cohesion. Their central argument posits that the selection of policy instruments within a network is shaped by the configuration of actor relationships and their interactions in pursuit of shared policy goals.

In the energy-saving field in the Chinese context, the main feature of actor relationship and interaction is the government is the key actor in policy process. Policy instruments in the energy sector are categorized into mandatory, market-based, and voluntary types (Lo, 2014; Ma et al., 2021). A notable trend in China's energy-saving landscape is the government's continued reliance on mandatory policy instruments, such as setting energy-saving targets for targeted groups. Conversely, private greater use of market-based and voluntary instruments (Li et al., 2018).

The adoption of market-based policy instruments always involves public and private actors. Market-based policy instruments are regulations that encourage behavior through market signals (Lu et al., 2025). Broadly defined, market-based policy instruments can include charge systems; tradable permits, interest-subsidized loans or subsidies (Blazquez et al., 2018; Chang et al., 2023). In the case of energy renovation project, government financial support can enhance profit expectations for private actors, thereby encouraging greater private-sector investment. In some cases, government and private actors also established public–private partnerships. However, the effectiveness of public–private partnerships may be undermined by divergent behavioural norms, differing objectives, and communication gaps among participating actors (Gregorio et al., 2019; Tang et al., 2010).

Additionally, voluntary policy instrument needs the participation of other actors, such as residents. In the public-private partnerships, private actors tend to focus on enterprises, and the role of residents are less discussed (Pinilla-De La Cruz et al., 2022). However, residents are crucial in shaping local needs, community interests, and shared value creation (Xue et al., 2022). Scholars have thus emphasized the need to reinvent public participation mechanisms in energy-saving projects to mediate resident–government conflicts (van Aalderen and Horlings, 2020). However, other studies show that bringing additional actors into the arena can increase conflicting relationships and detract from agreed solutions (Scott and Thomas, 2017). Thus, it is necessary to explore the actors and their interactions when governments adopt certain intensive policy instruments.

3. Policy background

The building renovation programme is based on recent energy policies in China. Its performance needs to be researched to improve construction quality. Energy-saving renovations of existing residential buildings occur through diversified instruments covering administrative regulations issued by governments to improve the energy performance of residential existing buildings (Liu et al., 2020). The following section reviews the policy instruments adopted, the main actors involved, and the arenas of interaction in renovation projects in existing buildings in Northern China.

3.1. Policy instruments adopted

3.1.1. Mandatory instrument

The national government has adopted a mandatory instrument by setting specific goals for each five-year plan period. The Chinese national government aims to reduce heating energy consumption by 40 %–65 % relative to levels recorded in the early 1980s. In addition to this energy-efficiency target, specific Chinese energy conservation plans stipulated the floor areas for renovation in the 12th, and 13th five-year plan periods.

In January 2011, the Chinese central government issued guidelines to emphasise the targets of the renovation area in heating zones. During the 12th five-year plan (2011–2015), the area target was that 400 million m^2 of building floor area in existing residential buildings must be renovated. Additionally, the 13 provinces must complete the implementation of building energy renovation of at least 35 % of existing residential buildings. Consequently, by the end of the 12th five-year plan, the energy renovation for existing buildings had achieved all renovation targets, and 1.17 billion m^2 of building floor area was

renovated (Zhang et al., 2019). According to the 13th five-year plan period (2016–2020), the central government expanded this target to 2.5 billion m^2 of building floor area (Zhang et al., 2024).

3.1.2. Market-based and voluntary policy instruments

One huge challenge to the renovation projects lies in securing sufficient financing (Zhang and Wang, 2013). To address this issue, the governments adopted efficient market-based instruments. Two primary sources of financial incentives are considered in building energy renovations. For most building energy renovation projects, financial support from the Chinese central government is combined with funding from local governments, which can be understood as market based policy instruments. In some cases, the residents also need to provide small financial shares (about 5 %–10 % of the total investment per household) for renovating old windows. The financial participation of residents can be regarded as the voluntary policy instrument.

3.2. Main actors

The actors involved in the implementation of energy renovation projects in Northern China are the central and local levels of governments, construction companies, supervision companies, design companies, and residents.

In the Chinese context, most building energy renovation projects are led and funded by central and local governments. However, the central government is often not directly involved in managing building energy renovation projects. Generally, the central government develops top-down mandatory requirements for intensity targets for renovation areas of energy renovation projects. To complete the intensity targets for renovation areas, provincial governments coordinate with municipal and district governments to prepare and organise the project from start to finish (from preparation to completion).

The private companies involved include design companies, construction companies, and supervision companies to maximise income and minimize costs because of their profit-oriented nature. During building energy renovation processes, design companies provide design services. Construction companies are responsible for construction activities, including making the construction plan, arranging construction resources, and managing the construction processes. Supervision companies are required to co-supervise the construction quality, cost and time with local governments. Residents are the end-users of the renovation housing, and they provide a portion of the funding in some cases.

3.3. Actor interdependency in different arenas

The paper focuses not only on the responsibilities and roles of individual actors, but also on how actors are affected by the other actors by matching their respective goals and resources. Actors require specific resources to attain their own goals, so they often need to cooperate with other actors. Therefore, interdependencies in a network originate from the fragmentation of resources among these actors (van Bortel, 2009).

Unlike general construction projects, renovating existing residential buildings is a complex and multi-layered process. The different levels of government and private companies are both involved. The projects start with energy-saving renovation area targets, which are set from the top. The complexity and uncertainty of the context for building energy renovation projects requires local governments to organise and prepare. Subsequently, private companies are involved in the renovation construction processes. This paper focuses on the interactions among actors in three arenas: (a) target setting, (b) project preparation and (c) project construction (see Fig. 2). The resources held by the actors are connected with their positions within the different arenas.

In the *target setting arena*, local governments receive renovation area targets from national governments and make renovation plans. Governments fund the building energy renovation projects in Northern China. Thus, the financial support mechanism is planned by national and local governments in this arena. In the *project preparation arena*, to determine which existing buildings should be renovated, information such as building age, total floor area, and structural condition must be collected (Zhou et al., 2017). Municipal governments select construction companies, supervision companies, and design companies by a tendering and bidding process, according to the renovation area and distribution, which, in turn, are responsible for the tasks in building energy renovation projects. The major activities in the *project construction arena* are to do a site survey and make construction plans to arrange construction resources, such as staff, materials and machines (Ye et al., 2014).). This arena involves the most complex construction activities, which exert a significant influence on project quality.

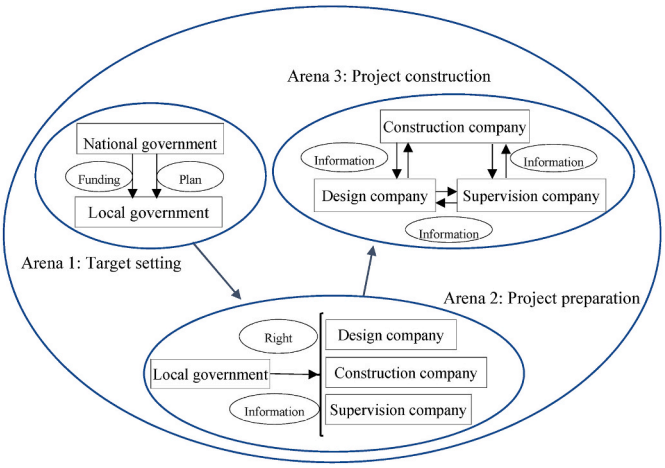


Fig. 2. The arenas of building energy renovation projects.

4. Research design

The research utilizes policy network theory to analyze the interactions and interdependencies among actors involved in different arenas (target setting, project preparation, and project construction). Based on the two cases, this research aims to explore the causes of quality failures in energy renovation projects through the lens of policy instruments implementation (Fig. 3). Case studies of building energy renovation projects were carried out to find actors and their roles. The interview gathered detailed information about the actors' interactions during the renovation processes and their conflicts during the implementation of the building energy-saving renovation programme. To ensure the validity and reliability of the interview responses, this study employed a triangulation strategy by combining archival research with interviews. Additionally, the responses from different experts interviewed in this study were cross-validated, enhancing the reliability of the interview data.

4.1. Case study

The cases in this research are located in the Inner Mongolia Autonomous Region (see Fig. 4). The energy renovation projects in Inner Mongolia Autonomous Region can represent those in Northern China due to following reasons. First, similar to other regions in North China, Inner Mongolia experiences long, harsh winters with extremely low temperatures, its energy renovation challenges with those of the broader northern region. Second, the governance model in Inner Mongolia involves coordination among various levels of government, private enterprises, and community organizations. This multi-tiered administrative structure is reflective of broader practices across China's northern regions, making Inner Mongolia an appropriate case for analyzing policy implementation and actor interdependencies in energy renovation projects. Third, public funding and subsidy mechanisms in

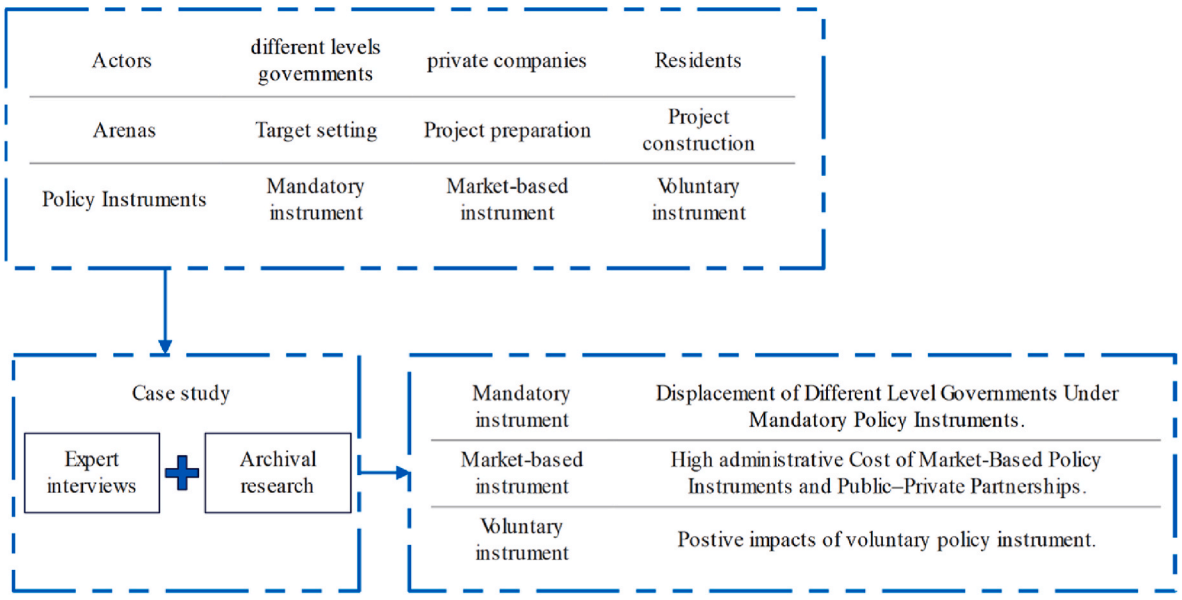


Fig. 3. Research design.

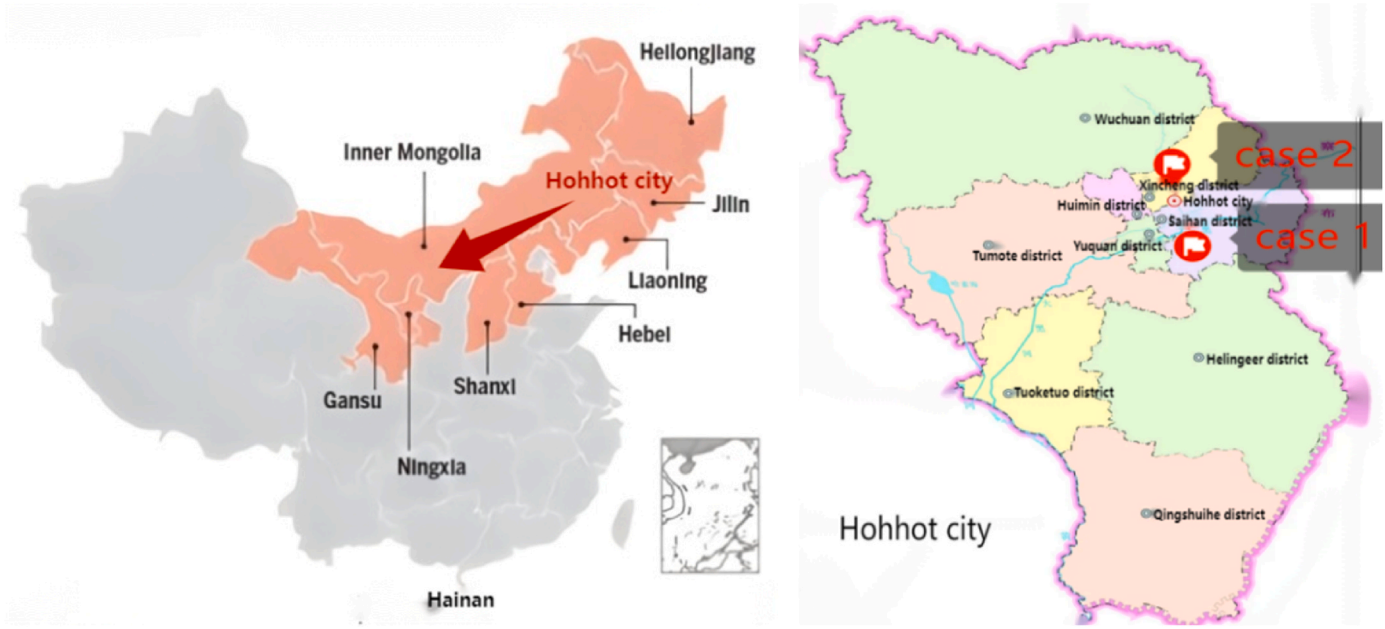


Fig. 4. The location of the two cases in Northern China.

Inner Mongolia are managed through multi-level government agencies, which are emblematic of broader practices in northern China. Therefore, the region serves as a representative case for examining the dynamics of energy renovation projects and the implementation of related policy instruments.

Building energy renovation is a relatively new policy issue in China. Meanwhile, the actors' interactions, the renovation plans and the financial support mechanisms in energy renovation projects in existing residential buildings are different from those in other construction projects. For instance, **in these projects, governments act as the primary investors rather than private entities.** As such, it would not be suitable to use population-wide questionnaire surveys. Instead, a case-study-based approach is the preferred choice. Case-based data collection and case study analysis are preferred methods when how and why questions are considered (Yang et al., 2016).

The two cases were deliberately chosen in this research to exemplify different case selection, because they share the same policy goal to achieve energy renovation of residential buildings but differ sharply in their dominant policy-instrument mix, administrative capacity, and actor configurations. First, these cases are representative renovation projects in the Inner Mongolia Autonomous Region, as **jointly** supported **by national and local governments** and **embody the region's typical practices and challenges** in implementing energy renovation. Second, these two cases were selected to illustrate the implementation of residential building renovations under different policy instrument features: 1) Case 1 was completed in November 2015, the end of the 12th five-year plan (2011–2015). This case operated under the policy framework of that period, which emphasized energy conservation and emission reductions, with specific targets for building renovations. 2) Case 2 took place in 2016, during the 13th five-year plan period (2016–2020).

The 13th Five-Year Plan set higher renovation area targets and reinforced energy conservation in the building sector. This case was influenced by stronger mandatory policy instrument aimed at accelerating energy renovation efforts of central and local governments. The higher renovation area targets are also an exogenous factor to influence actor perception and strategies.

Additionally, market-based instruments were adopted in both cases, and voluntary policy instruments also appeared in Case 2. In Case 1, the financing source included central government, provincial government and municipal governments funds.[1] The financial sources in Case 2 were residents and local governments (including the provincial government and municipal government).[2] The diminishing financial support from central government is an exogenous factor to influence actors to adopt specific policy instrument. Namely, voluntary policy instrument was also adopted in Case 2. In Case 2, residents contributed 5 %–10 % of the total investment per household. From the perspective of renovation types, in addition to window replacement and external wall thermal insulation, Case 1 involves energy-saving upgrades to the floor, while Case 2 focuses on roof insulation improvement. Both measures target the building envelope and are classified as medium-level renovations in terms of intervention intensity. Table 1 presents the basic information on the two cases. Thus, **the comparative analysis of Cases 1 and 2 provides valuable insights into the dynamic nature of actor interactions as policy instruments and interdependencies evolve (see Table 2).**

4.2. Data collection

The fieldwork was carried out in Hohhot. Geographically, Hohhot is the provincial capital of Inner Mongolia, which is located in the northwest of the territory, where winters are long and cold. Consequently, building heating is a significant energy demand of this city, and Hohhot has been designated as one of the pilot cities for energy-saving renovations of existing residential buildings. The urban area of Hohhot is divided into five districts. The two cases selected for this study are in Saihan District and Xincheng District, respectively, which are the pilot districts for energy-saving renovation projects in Hohhot. They can be seen as examples of energy-saving renovation of existing residential buildings. A series of semi-structured interviews with representatives of involved actors in each of the two cases was undertaken to formulate actor interdependence in different arenas. The following criteria formed the basis for the interviewee selection. First, the actors were from different key backgrounds/roles to provide a comprehensive understanding of the causes of quality failures in energy renovation projects. Second, except for the residents, all other actors have sufficient working experience with engaging in the renovation field for over eight years. All of the actors have a bachelor's degree. Therefore, the actors are with sufficient knowledge regarding building energy renovations. Separate interviews were conducted in two cases with 15 actors, six of whom were interviewed more than once (the details are illustrated in Appendix I). Interviewees were requested to take into consideration the characteristics of energy renovation projects in the Chinese context. Additionally, the interviews included a mix of open-ended questions designed to elicit detailed responses about actors' experiences and perspectives. In order to make the data on actor interdependence more complete, they were asked to explain the actors' relationship in different arenas of energy renovation projects. For instance, questions might have included: "Can you describe your role in recent energy renovation projects?", "What challenges have you encountered during the implementation of these projects?"

As for interview data analysis, an open coding approach was applied in identifying the concepts related to actor interdependencies in renovation projects. In this study, initial codes were systematically generated to label significant features of the interview data. Similar codes were then grouped and comparatively analyzed to identify patterns and relationships (Section 5.3). Each interview lasted approximately 30–60 min, providing ample time to delve into complex topics and allow actors to share comprehensive narratives.

5. Case analysis and results

5.1. Actors and their roles

5.1.1. Case 1

Case 1 is a building energy renovation project located in Hohhot, which is a typical northern city in China. It concerns a five-storey residential building renovation project located in Saihan District, on the south-east coast of Hohhot. The total building floor area of energy renovation is 9925 m^2. It was built in the 1990s before the first Chinese thermal regulations came into effect. Typically, the building has a brick and concrete structure. The building envelope is not insulated, as was common practice at that time. The different energy-saving technology measures were to windows, floors, roofs, and external walls. The windows were double glazed with steel frames, and the floors were lightweight slabs. The floor and external walls have a significant impact on the energy performance of a building. In detail, as shown in Table 1, the insulation thicknesses were considered about 50 mm expanded polystyrene insulation (EPS) in floor renovation and external wall renovation (MHURD, 2008).The renovation project was carried out between September and December 2015 in the 12th five-year plan (2011–2015).

Local governments (including the Inner Mongolia provincial government, Hohhot municipal government and Saihan district government) played the leading role in Case 1. Encouraged by the goals set by the national government, the provincial government announced the goal of about 50 million m^2 of building floor area renovation during the 12th five-year plan. In reality, the renovation target was to complete about 71.4 million m^2 of the building floor area by 2015, which was significantly more ambitious than the central government's area targets.

5.1.2. Case 2

The total building floor area of Case 2 covered 12,756 m^2. This building energy renovation project included four existing buildings built in the 1990s in Xincheng District. For the window frames, polyvinylchloride (PVC) was chosen as material due to its cost-effectiveness, always with double-glazing (MHURD, 2008). For the roof, the renovation measure consisted of placing 50 mm EPS boards on the roof slab. For the external wall, the renovation measures consisted of the application of 50 mm EPS (Table 1). The renovation period of Case 2 was 180 days from May 2016 to December 2016 in the 13th five-year plan (2016–2020). Table 3 gives a sketch of the actors involved and their roles.

5.2. Conflicts in arenas

In this paper, examples of *arenas* are target setting, project preparation, and project construction, in which the main actors interact with each other regarding specific policies. In the target setting arena, the central government, Inner Mongolia provincial government, Hohhot municipal government and district government were the primary implementers of energy renovation policies. To meet the central government's energy-saving renovation area targets, local governments intensified the implementation of national directives. Moreover, provincial and municipal governments devised more concrete energy-saving policies for adaptation to the characteristics of the specific

[1] In 2015, the financial contributions of the central, provincial and municipal governments were 21.60 million RMB (2.75 million Euros), 21.60 million RMB (2.75 million Euros) and 102.72 million RMB (13.10 million Euros), respectively.

[2] In 2016, the Inner Mongolia government invested 68.13 million RMB (8.69 million Euros) to renovate existing buildings in Hohhot city.

Table 1
Basic information on the two cases.

No.	Renovation Area Targets of Mandatory Instrument	Main Financial Supporters	Renovation Period	Renovation types	Renovation level
Case 1	400 million m^2	National and local governments	12th five-year plan period	*Windows replacement, Floor thermal insulation, External wall thermal insulation*	Medium
Case 2	2.5 billion m^2	Local government and residents	13th five-year plan period	*Windows replacement, Roof thermal insulation, External wall thermal insulation*	Medium

Table 2
Actors and their roles in Case 1.

Actor	Role	Key Resources	Arenas
National government	Administrator	Funding, renovation area target, information provision	Target setting
Inner Mongolia provincial government	Administrator	Funding, renovation area target, information provision	Target setting
Hohhot municipal government	Administrator	Funding, renovation area target, approval right, contracting with private companies, information provision, supervision right	Target setting, project preparation
Saihan district government	Administrator	Information provision, supervision right	Project preparation, project construction
Design company	Designer	Information provision, design service	Project preparation, project construction
Construction company	Constructor	Information provision, construction service	Project preparation, project construction

Table 3
Actors and their roles in Case 2.

Actor	Role	Key Resources	Arenas
National government	Administrator	Funding, renovation area target, information provision	Target setting
Inner Mongolia provincial government	Administrator	Funding, renovation area target, information provision	Target setting
Hohhot municipal government	Administrator	Funding, renovation area target, approval right, contracting with private companies, information provision, supervision right	Target setting, project preparation
Xincheng district government	Administrator	Information provision, supervision right, selecting buildings to undergo renovation	Project preparation, project construction
Design company	Designer	Information provision, design service	Project preparation, project construction
Construction company	Constructor	Information provision, construction service	Project preparation, project construction
Supervision company	Supervisor	Information provision, supervision right	Project preparation, project construction
Residents	Co-funder	Funding, supervision right	Target setting, project construction
Residential Committee Members	Administrator	Information provision, explanation right	Target setting, project construction

provinces. To support the ambitious renovation area targets from the local governments, the funding system was crucial for the implementation of the building energy renovations. Conflicts affect the construction quality indirectly from the actors' interaction perspectives.

5.2.1. Case 1

According to on-site investigations, some quality failures were found in Case 1. The final energy-saving rate fell below 51 % as a result of quality failures during construction, leading to inadequate energy performance throughout the buildings' usage phase. The examples included detachment between the different EPS boards, misalignment of the waterproof roof layer and missing rivets. These quality failures may cause serious safety issues and poor energy performance. Missing rivets in practice leads to the potential hazards of thermal insulation materials falling off. Likewise, water leakage is possible due to defective waterproof layers. Despite having been repaired before quality acceptance, these quality failures still had a detrimental impact on the energy performance of the buildings. In three arenas of building energy renovation projects, the conflicts were identified (see Table 4).

1) Target setting

In the 12th five-year plan (2011–2015), the Ministry of Finance arranged funds to support building energy renovation projects in Northern China at a national level. The capital subsidy was granted according to climate zones: 55 RMB/m^2 (7.0 Euros/m^2) went to the severe cold zone (where Case 1 is located). In Case 1, the Inner Mongolia provincial government and the Hohhot municipal government were also financiers of the building energy renovation projects in the 12th five-year plan. The energy efficiency target was to achieve above 47 % energy reduction in this case.

Table 4
Conflicts in area target setting, project preparation, and project construction in Case 1.

Arena	Conflicts	Sources
Area target setting	High cost pressures and limited funding from governments	Interviewee 1
Project preparation	Due to the climatological conditions, the construction period had to be shortened	Interviewees 4 and 6
	The funding application and provision procedure made it difficult for construction companies to maintain their cashflow	Interviewees 4 and 6
Project construction	Improper supervision role distribution	Interviewees 2 and 3
	Inexperienced supervision engineers in renovation projects	Interviewee 5

Based on the interviews, the conflict in the target setting arena was that limited financial support from all investors caused local governments and private companies to work under high cost pressures in building energy renovation projects (Interviewee 1, officer in the provincial government). Meanwhile, more attention has been paid to renovation costs than to renovation quality. The following quote from Interviewee 1 depicts the conflicts in the target setting: "*The renovation*

tasks need to be completed with limited funding *from the central levels of governments, so we demand that municipal level governments also allocate* funds *for energy-saving renovations*." In the target-setting stage, provincial governments have allocated financial provision responsibilities to municipal governments. Consequently, **construction companies faced challenges in using high-quality materials**, creating potential risks to **overall building quality**.

2) Project preparation

There are two conflicts in this arena: shortened renovation periods and slow funding provision process. The first conflict in project preparation is shortened renovation periods. Due to the climatological conditions in Case 1, the time of project preparation and construction in building energy renovation projects was shortened. In addition, the application and approval process took up too much time. The following quote from Interviewee 4 (project manager) explained this situation:

Due to the temperature characteristics of the severe cold zone (where Case 1 was located), the low temperature had a negative effect on the construction quality after the end of October. Therefore, the construction activities of renovation projects needed to be finished before November. The project approval took a long time, and we started the renovation works at the end of September 2015. That led to substantial pressure on the construction time.

Due to the special time requirements of the energy-saving renovation project, construction companies needed to increase labour and working time to complete the renovation project on schedule. However, some construction companies may not have had the capacity to hire the necessary labour and cover the cost. It is possible that these construction companies met their renovation project targets by compromising the renovation quality.

The second conflict is the slow funding provision process for energy renovation projects. During the project preparation phase, construction companies were required to provide funds by themselves first, and the local governments would reimburse the funding later (Interviewee 4). As Interviewee 4 stated: "*The government requires us to pay first for energy saving renovation projects, and the government will settle the payment with us afterwards, which takes about a year. This poses a challenge to our cash-flow*." Due to the lengthy appropriation process in the financial system, construction companies are required to advance funds. However, the payments to private companies are often not made promptly, which also highlights the conflict in the project preparation arena.

The conflict was more serious when local governments promised to refund the construction companies after the completion of the renovation work, but had not actually done so by 2016 (Interviewee 6, staff member in a design company[3]). Interviewee 6 stated:

The central and local financial supports were decisive factors that affected the implementation of building energy renovation projects seriously. Furthermore, cost pressure in building energy renovation projects was higher than other construction projects. However, an efficient financial support system has not been established yet. Hence, the speed of refunding to private companies from the governments is too slow.

The governments' behavior related to the refunding delay has caused dissatisfaction among private companies. However, a few private companies still decided to participate in the renovation projects. These companies choose to participate in renovation projects as a way to demonstrate their capabilities and commitment, which could lead to more extensive collaboration with governments on future initiatives.

[3] Among private companies, a design company is the earliest actor to be involved. The design company can provide information on conflicts throughout the preparation and construction processes, from the perspective of a private company.

3) Project construction

The conflict in project construction is due to the distribution of the supervision role. For general government-funded construction projects, the government needs to establish a dedicated task force to supervise the project quality with the supervision company, conducting on-site inspections throughout project implementation. However, due to the large workload associated with energy-saving renovation projects, it is challenging for local government to implement processing oversight. Municipal and district governments asked supervision companies to act on their behalf. Interviewees 2 (officer in the municipal government) and 3 (officer in the district government) pointed to the conflicts in the project construction arena. The following quote is from Interviewees 2 and 3:

> In the energy renovation projects, as investors, the local governments have transferred too many management rights to the supervision company, and they do not even participate in process management during project construction.… The workload of the renovation project is very large, and the district government is unable to provide a large number of professional supervisory personnel; therefore, effective supervision relies more on supervisory companies.

As a result, the supervision process lacks the involvement of municipal and district governments.

Moreover, lack of experience among supervising engineers in renovation projects also deepens the conflict in supervision. Renovation items and techniques for energy-saving renovation projects are different from those of general construction projects (Department of Housing and Urban-rural Development in Inner Mongolia, 2015). Most supervising engineers do not have relevant experience. Additionally, the government does not require the provision of a mandated checklist. As a result, there is no quality inspection checklist for energy-saving renovation engineering in the supervision companies. "*The government did not require us to provide a process inspection checklist. Due to the short construction period, many concealed works were not subjected to an inspection checklist*" (Interviewee 5, chief supervisor). Thus, the **limited supervision capacity** of **supervision companies**, combined with **weak government oversight**, created significant **vulnerabilities in project quality control**, which may have **contributed to quality failures** in the renovation works.

5.2.2. Case 2

The overall quality failures in Case 2 were reduced. The energy-saving rate was not achieved in the first on-site evaluation, but it improved to 43 % after these quality failures were addressed. Based on the interviewees, several conflicts and solutions were found in Case 2. As a complementary case to Case 1, Case 2 highlights distinct conflicts not observed in the former case (see Table 5). As the conflicts in project preparation arena in Case 2 is similar to that of Case 1, the analysis focuses exclusively on the distinct conflicts identified in the target setting and project construction arenas.

1) Target setting

Table 5
Conflicts in target setting, project preparation, and project construction in Case 2.

Arena	Conflicts	Sources
Target setting	Larger number of buildings to be renovated in targets	Interviewee 7
	Limited financial support from the central government and residents' unwillingness to contribute to the financing	Interviewees 10, 13 and 14
Project construction	Construction companies use unapproved building materials due to limited supervision and to increase profit	Interviewees 9, 11 and 15

There are two main conflicts in this arena: higher energy renovation project targets and residents' unwillingness to fund the projects. First, compared with Case 1, Case 2 covered the 13th five-year plan period, when the renovation area targets in terms of floor area were higher, which placed higher pressure on provincial and municipal governments. To achieve the renovation area targets during the 13th five-year plan, the provincial government renovated about 8.49 million m^2 of building floor area in existing residential buildings within Inner Mongolia in 2016. Meanwhile, in 2016, the Hohhot municipal government (renovated 1.45 million m^2 of building floor area in Hohhot) and Xincheng district government (renovated 0.33 million m^2 of building floor area in Xincheng district) over-fulfilled the energy renovation area targets.

During this process, the provincial government felt high pressure, and it transferred this pressure down to other actors. "*The central government has established very ambitious targets for energy-saving renovations. To compete with other provinces, we will set even more ambitious renovation targets in our plan*" (Interviewee 7, officer in the provincial government). The same competition behaviours of local government by setting higher goals than central government can be found in economic development or environmental protection areas (Jiang et al., 2022; Yang et al., 2020). Therefore, the high demand for renovation speed and performance was still the main conflict between local government and private companies in the target setting arena (Inner Mongolia Autonomous Region Government, 2024).

Second, residents were required to provide a small proportion of the renovation cost. Some residents chose not to cooperate with local government and construction companies initially as they thought it was too costly. Although they also benefited from energy renovation buildings, residents were not willing to pay for the renovation cost as the renovation did not influence the basic living function of the buildings (Interviewees 10, 13 and 14). The following quote from Interviewee 10 (officer in the district government) depicts the conflicts:

Residents were not active in energy saving renovations, because most of those living in the existing buildings had low levels of consumption. Although the government subsidies covered the majority of the renovation costs, residents were still unwilling to pay the remaining expenses.

Some residents in interviews also expressed their unwillingness to pay (Interviewee 14). "*I do not want to pay for the new windows, because this payment is too high for me. Moreover, the old windows can still be used. I, therefore, refuse to replace them.*" There is a lack of residents' participation in energy-saving renovation projects, and residents are generally dissatisfied with the outcomes of such initiatives.

The committee's responsibilities include organizing informational sessions, gathering feedback, and addressing concerns related to the renovation process. In this process, Residential Committee serves as a grassroots organization for self-management, playing a crucial mediation role in persuading residents to participate in energy-saving renovation projects. In the context of this case, as an entity closely associated with the Subdistrict government, the Residential Committee is well-positioned to inform residents about the benefits of energy-saving renovations. Its members, maintain close relationships with the community, enabling them to effectively communicate the benefits and logistics of energy renovation projects. This familiarity fosters trust, making residents more receptive to information and more willing to participate in renovation initiatives. Furthermore, the Residential Committee collaborates with local authorities and construction companies to ensure that residents' needs and preferences are considered in the renovation plans. This collaborative approach not only enhances the effectiveness of the projects but also strengthens community cohesion and trust in the renovation process. Through their efforts, many residents are convinced to invest in the renovation projects. Following this initial acceptance, other residents tend to follow suit, influenced by the majority's decisions.

2) Project construction

In project construction, the different conflict in Case 2 is the more obvious intention of construction companies to maximise their profits by taking advantage of the limited supervision from local government and supervision companies. In the 13th five-year plan period, some construction companies decided to profit from the limited supervision of renovation projects in the 12th five-year plan period. Due to the financial pressure and the desire to earn more profits, some construction companies used unapproved building materials. Interviewee 9 (officer in the municipal government) stated "*We found out that the construction company procured and used non-specified fire-resistant EPS boards. They thought this could maximise theirs profit without being noticed in these energy renovation projects.*" As the cost pressures in building energy renovation projects were higher than in other construction projects, the incentive to use unapproved materials was further strengthened by the relatively low revenue in these projects in these energy renovation projects.

In the supervision process of energy-saving renovation projects, residents have become active participants alongside professional supervision companies to monitor construction quality. As both users and investors of the housing, residents are motivated to demand higher standards from construction companies. For instance, one interviewee highlighted "*During the project construction process, residents actively supervise the quality of construction materials (e.g., windows). They even provide suggestions through the Residential Committee*" (Interviewee 15). Although this involvement may decelerate the project's progress, it is instrumental in bolstering the quality of supervision, thereby significantly enhancing the overall quality of the renovation. This collaborative approach underscores the critical role of resident engagement in maintaining high construction standards and accountability.

5.3. Comparative analysis of actor interdependency and policy instrument adoption

The differences between the two cases are shown in the actor interdependence maps during the target setting (Fig. 5). In the target setting arena, the main actors are the national government and local governments (provincial government, municipal government, and district government). The relationships between the main actors in this arena are shown by arrows. In Case 1, the central government, along with provincial and municipal governments, is one of the main investors for the renovation projects. The funding is transferred from the central government to the municipal government, which is different from Case 2. Fig. 5shows the actor interdependency map of Case 1 in the target setting arena. Unlike Case 1, residents also needed to pay for the new windows, accounting for 5 %–10 % of the total investment per household, in Case 2. Residential Committee also plays the mediation role to

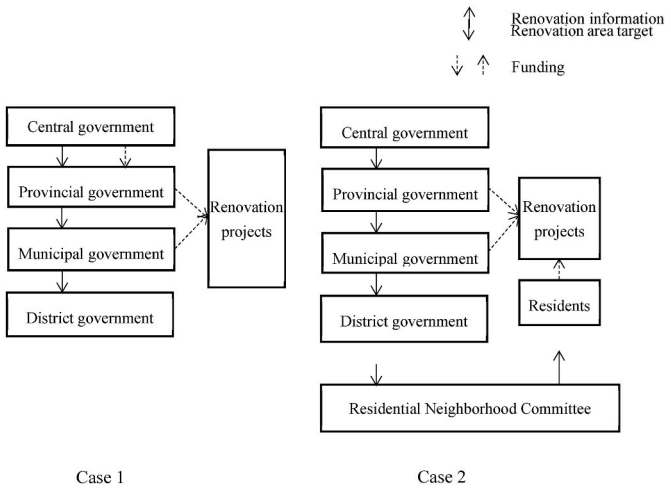


Fig. 5. Actor interdependency map in target setting arena.

persuade resident to invest in energy renovation projects.

Fig. 5 illustrates that both central and provincial governments primarily use mandatory policy instruments to establish targets within the framework of energy renovation projects. Additionally, the diagram highlights how the financial involvement of residents in these projects represents the adoption of a voluntary policy instrument. This strategy not only alleviates financial pressures on local governments but also enables residents to actively monitor and influence the quality of the renovations. This dual role of residents underscores the significant contribution of voluntary policy instruments in enhancing both project financing and oversight.

In the project preparation arena, the actor interdependency maps are similar between Case 1 and Case 2. For the project preparation period (Fig. 6), the main actors include local governments (provincial, municipal and district governments) and private companies (design companies, supervision companies and construction companies). In this arena, market based policy instruments are adopted as both governments provide funding for the renovation projects.

In the project construction arena (Fig. 7), the main actors include municipal governments, district governments, supervision companies, design companies and construction companies. A key distinction from Case 1 is the inclusion of residents as a supervisor in Case 2 (see Fig. 7).

Fig. 7, pertaining to Case 2, illustrates a distinctive aspect of the renovation project: the proactive involvement of residents in monitoring construction quality alongside the supervision company. In this scenario, residents not only provide additional oversight but also contribute their knowledge and suggestions. This collaboration introduces an extra layer of scrutiny and input to the construction activities, significantly enhancing the project's adherence to quality standards and expectations.

Comparing the two cases, Case 1 represents a typical government-led model, while Case 2 illustrates a resident-participation model. In Case 1, after determining which buildings will be renovated, the municipal government finds the private companies to construct and supervise the renovations. Construction and supervision rights are transferred from the government to the construction companies and supervision companies through the bidding and tendering process. Conversely, municipal and district governments only play the role of manager based on the contract to ensure the realisation of project performance and public interest. Thus, process quality management receives less attention from local governments, which may undermine the construction quality in the end. In Case 2, residents are both house users and investors, and they have the motivation to monitor renovation quality. This active resident engagement contributes to improvements in overall renovation quality to a certain extent.

6. Discussion

Based on the interviews in two renovation cases, the research examines how actor interdependencies and the adoption of policy instruments influence conflicts and their resolutions. *Specifically, while mandatory instruments ensure implementation efficiency, they can also induce goal displacement. The local government's focus on project scale instead of quality can undermine energy renovation project quality. Market-based instruments, conversely, help alleviate financial constraints but impose administrative costs that dampen private sector participation and innovation. Finally, voluntary instruments, exemplified by resident involvement, demonstrate a positive correlation with project quality; however, their long-term viability is uncertain due to the limited financing capacity of residents relative to other stakeholders.*

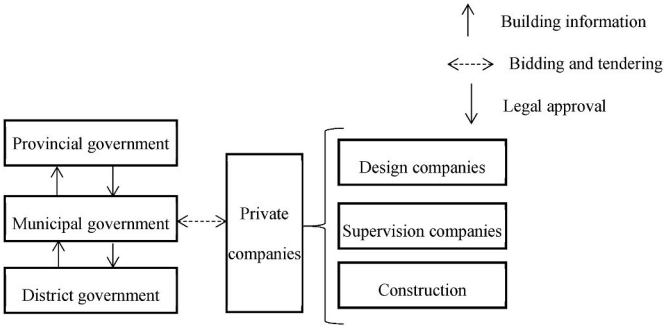


Fig. 6. Actor interdependency map in the project preparation arena.

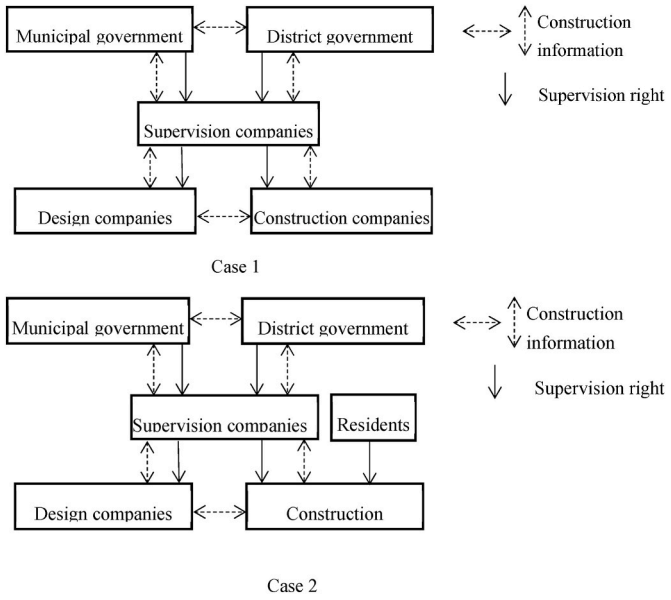


Fig. 7. Actor interdependency map in the project construction arena.

6.1. Goal displacement of different level governments under mandatory policy instruments

Under mandatory policy instrument adopted by the central government, goal displacement has been demonstrated in the policy implementation of local government. Local governments have to realise the renovation area targets under intense pressure, rather than focusing on renovation project overall performance, particularly project quality. Fig. 5 shows that renovation area targets are transferred from higher level governments to lower level governments. Namely, the goals of renovating building areas are announced in the five-year plans by provincial governments. Accordingly, to meet the central government's energy-saving renovation targets, municipal governments not only set specific renovation area goals and implementation plans but often exceed national benchmarks to demonstrate strong performance and outpace peer jurisdictions. This phenomenon is consistent to official promotion competition in China (Chen et al., 2024). Role of municipal governments is to fulfill targets set by higher-level authorities. Consequently, municipal governments not only establish specific renovation targets and implementation plans but frequently exceed national benchmarks to demonstrate efficacy and gain a competitive advantage over peer jurisdictions. Thus, municipal governments are forced to execute renovation projects under severely constrained timelines and intense cost pressures (Li and Yu, 2025).

Consequently, municipal governments lack interest in achieving energy saving. In turn, they pay more attention to construction schedules. In building energy renovation, local governments need to realise renovation area targets rather than high-quality performance (Shilei and Yong, 2009). This phenomenon is also found in other studies, such as local governments changing energy-saving objectives and diverting attention from environmental performance (Lo, 2014). It is recommended that central governments develop reasonable renovation targets

and avoid using target completion as the sole evaluation criterion for lower-level governments.

6.2. Administrative cost of market-based policy instruments

In China, the building renovation programme is conducted through market-based instruments, primarily government subsidies and direct public investments. As illustrated in Case 1, the central government served as the primary financial contributor, supplemented by additional subsidies from local governments. The initial intent of the government financing was to alleviate financial burdens on private companies to promote the implementation of building energy renovation projects. However, administration costs associated with central and local fiscal allocation were subtantial. The complexity of intergovernmental fund disbursement led to delays in reimbursement and inefficiencies in public-private collaborations, according to Case 1.

The protracted approval process for renovations, evident in both cases, poses significant challenges to public–private partnerships. As Fig. 5 shows, the multi-tiered approval structure requires district governments to submit proposed renovation projects to municipal government, which then forward the list to provincial governments for final authorization. This bureaucratic reporting mechanism prolongs the building renovation phase due to the complicated administrative workflows (Interviewee 8). Subsequently, municipal government needs to contract tasks with private companies, further extending the time line. To adhere to project deadlines, the bidding and tendering phases were often expedited, compromising the thoroughness of quality oversight. This type of administrative delay, common across multiple policy domains, generates increased red tape and client complaints, thereby eroding organizational performance(Kaufmann et al., 2019; Pandey and Bretschneider, 1997).

While market-based policy instruments remain pivotal in advancing energy renovation projects, their complex procedure can also demotivate private actors to some extent. In many countries, efforts to simplify the cooperative procedures have had a prominent place on national political agendas (Meijer and Visscher, 2017).

6.3. Benefits and challenges of voluntary policy instrument

In Case 2, the involvement of residents as investors in energy renovation projects is notable for its impact on reducing the financial burden on local governments. As both users and investors of the properties, these residents are highly motivated to ensure the quality of the renovations. This finding aligns with previous research by Liu et al. (2015), which suggests that resident participation can significantly aid the successful implementation of energy renovation projects.

This research, further discussed residents also invest in a small proportion of energy renovation projects, which can also be regarded as a private actor in the public private partnerships. However, it is not easy to involve resident participation in public-private partnerships due to trust and financial capacity. A key facilitator in this process is the Residential Committee. As a self-organized entity, the Residential Committee commands substantial trust from the residents, which empowers it to effectively mediate among the residents, local government, and construction companies. This trust enhances its ability to encourage investment and ensure rigorous quality monitoring of the renovation projects, demonstrating the critical role of community-led organizations in the governance of local development initiatives. This result is consistent with previous research that Residential Committee plays an important role in informal governance in China (Fu, 2025).

However, in the Chinese context, the residents' financial involvement also become a burden for the economically disadvantaged group. Most residents who live in the apartments are predominately from low socioeconomic status backgrounds. Even if residents pay a small share of building renovation, such as new windows, it is still a significant sum for the poor. The limited financial capacity of citizens compared with enterprises or organizations required the further consideration of way of citizen participation in public private partnership projects (Xue et al., 2022).

7. Conclusion

This research has elucidated the dynamics of quality failures in energy renovation projects **by analyzing** actor interdependency and policy instrument adoption within policy networks. **In the case analyzes**, both cases **demonstrated** quality failures, though the extent was less severe in Case 2 than in Case 1. Exogenous factors, such as higher renovation targets and limited government funding in Case 2, compelled local governments to engage residents in contributing a small portion of the renovation costs. This voluntary policy instrument not only alleviated financial pressures but also **enhanced** oversight of renovation quality.

Key findings indicate that goal displacement can occur under mandatory policy instruments within central-local government relationships, with local governments prioritizing renovation area targets over overall project performance, especially quality. Second, while market-based policy instruments adopted by governments can address financial issues in energy renovation projects, the procedural and administrative costs associated with these instruments may undermine their efficiency. Third, resident involvement as a voluntary policy instrument not only alleviates financial pressures on local governments but also **strengthens** the monitoring of renovation quality, echoing the benefits seen in other public participation projects (Yang et al., 2021). However, this approach can impose financial burdens on economically disadvantaged groups.

This research makes several important contributions to the literature. First, it provides **new** insights into quality failures in building energy renovations through the perspectives of actor interdependency and policy instrument adoption within policy networks. This research **advances** policy implementation theories by **revealing** the influencing path between policy results, actor interdependency and policy instrument adoption. Second, it expands policy network theory by applying it **to explain policy failure within a hierarchical governance context**. Policy network theory **originated in Western contexts**, but this research provides new links between policy network and policy failure in hierarchy governance ***systems***. Last, it extends policy implementation research to encompass often-overlooked outcomes such as project quality failures, using policy network theory to highlight these critical issues.

Regarding policy implications, concerning mandatory policy instruments, central government can set flexible renovation area time-schedule targets and include the overall performance of renovation projects in the local government policy implementation evaluation. Second, in terms of the market-based instrument, establishing specific management offices to handle government funding could expedite refunds and improve efficiency. Third, to adopt voluntary policy instruments, policymakers can encourage self-organizations like the Residential Committee to mediate between residents and other stakeholders could enhance trust and communication efficiency. Fourth, as public and private partnerships are common in energy renovation projects, it is necessary to consider establishing specific mechanisms to help information exchange and trust building, which can support **smoother project progress**.

The study, however, has its limitations. First, due to time constraints, only two cases were analyzed, both from North China. Future research **could** include cases from cities with different climate conditions and culture backgrounds to **enhance the generalizability of the findings**. Additionally, to avoid the disadvantage of traditional qualitative research, future research can combine big data analysis and other methods to study energy renovation projects. Second, community types can also influence the energy renovation project process. Future research could include energy renovation projects from other types of

communities, such as informal housing, to **broaden the applicability of the results**. Third, building user behavior can also influence the quality of retrofit projects. According to the study by Spreafico et al. (2025), which explores the use of patents to support prospective life cycle assessment (LCA), future research is expected to incorporate LCA models to conduct full life-cycle analyzes of quality failures in building energy retrofit projects (Ghasemi-Mobtaker et al., 2020). Finally, **developing** sustainable financing mechanisms for energy renovation projects require further discussion in future research (Falcone and Sica, 2023).

CRediT authorship contribution statement

Yuting Qi: Writing – original draft, Methodology, Investigation, Data curation. **Queena K. Qian:** Supervision, Funding acquisition. **Frits M. Meijer:** Validation, Resources. **Henk J. Visscher:** Supervision, Project administration. **Haiyan Lu:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This project is funded by National Natural Science Foundation of China (grant number: 72404067). This research is also funded by China Postdoctoral Science Foundation (2022M710632), the Special Fund Support for Basic Scientific Research Business Expenses of Central Universities, China (project support number: HITHSS.202320), Guangdong Basic and Applied Basic Research Foundation [grant number: 2022A1515110755], Shenzhen Science and technology Program (grant number: JCYJ20240813105130040). This work was also supported by Shenzhen Humanities & Social Sciences Key Research Base for Carbon Emission Peaking and Carbon Neutral Technology, Policy, and Management, Harbin Institute of Technology, Shenzhen.

Appendix I

Appendix I**:** The profile of experts and interview method.

Case	No.	Position	Organization	Date	Educational Background	Years of Professional Experience	Types of Projects Involved
Case 1	1	Officer in Inner Mongolia autonomous region building energy efficiency evaluation Institution	Provincial government	3.8.2019	Bachelor's Degree	12 years	Energy Renovation projects, new buildings
	2	Officer in Hohhot Housing Security and Housing Authority	Municipal government	10.8.2019	Master's Degree	10 years	Energy Renovation projects, new buildings
	3	Officer in Saihan District Construction Quality Supervision Institution	District government	5.8.2019	Bachelor's Degree	8 years	Energy Renovation projects, new buildings, Infrastructure
	4	Project manager in Construction Engineering company of Inner Mongolia	Construction company	5.8.2019	Bachelor's Degree	8 years	Energy Renovation projects, new buildings, Infrastructure
	5	Chief supervisor in Construction Supervision and Consulting company of Inner Mongolia	Supervision company	6.8.2019	Bachelor's Degree	10 years	Energy Renovation projects, new buildings, Infrastructure
	6	Designer in Construction Design company of Inner Mongolia	Design company	18.8.2019	Master's Degree	8 years	Energy Renovation projects, new buildings
Case 2	7	Officer in Inner Mongolia Autonomous Region construction of science and technology promotion and Development Centre	Provincial government	3.8.2019	Bachelor's Degree	12 years	Energy Renovation projects, new buildings
	8	Officer in Hohhot Housing Security and Housing Authority	Municipal government	10.8.2019	Master's Degree	10 years	Energy Renovation projects, new buildings
	9	Officer in Hohhot Housing Security and Housing Authority	Municipal government	10.8.2019	Bachelor's Degree	15 years	Energy Renovation projects, new buildings
	10	Officer in Xincheng District community office	District government	12.8.2019	Master's Degree	8 years	Energy Renovation projects, new buildings
	11	Chief supervisor in supervision company of Inner Mongolia	Supervision company	11.8.2019	Master's Degree	10 years	Energy Renovation projects, new buildings, Infrastructure
	12	Senior designer in Construction design company of Inner Mongolia	Design company	9.8.2019	Master's Degree	11 years	Energy Renovation projects, new buildings
	13	Project manager in construction company of Inner Mongolia	Construction companies	20.8.2019	Bachelor's Degree	10 years	Energy Renovation projects, new buildings, Infrastructure
	14	Resident living in the renovated building of case 2	/	4.8.2019	Bachelor's Degree	\	\
	15	Residential Committee Members working in the renovated building of case 2	Residential Committee	13.12.2024	Bachelor's Degree	\	\

Data availability

Data will be made available on request.

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