

## Article

# Analyzing Drivers of Conflict in Energy Infrastructure Projects: Empirical Case Study of Natural Gas Pipeline Sectors

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**Abstract:** Energy infrastructure projects have caused various conflicts between stakeholders, particularly among the residents around construction sites and operators. The conflicts are largely due to the “Not in My Backyard” mentality associated with hazardous projects. In natural gas pipeline (NGP) projects, conflicts have been increasing with the increase in a wider range of linear projects, and they have been worsening because of the lack of clear countermeasures. This study proposes an effective conflict management strategy for NGP projects in Korea. To achieve the objectives, 25 conflict drivers were identified and 143 case-based surveys were conducted to determine the causal relationship between the drivers and the level of conflict using structural equation modeling (SEM). The SEM results show that factors such as economic (e.g., decreased value of the land), construction-related (e.g., disturbance due to using the original route and site), and safety-related characteristics (e.g., concerns about explosions and accidents) are the most important in understanding the causes of conflicts. Based on the causal relationship, five key strategies were proposed to manage the critical conflicts. This study can serve as a basis for implementing better conflict management plans in the future for a more sustainable project execution.

**Keywords:** conflict management strategies; project sustainability; energy infrastructure

## 1. Introduction

Energy infrastructure projects, such as energy transmission line and natural gas pipeline (NGP) projects, have caused numerous conflicts. As energy infrastructure projects require energy storage and pipelines for energy supply, which in turn require large sites and long routes, the site storage facilities and routing of lines are the major issues. Because these factors are determined simply from technical and economic perspectives [1], these projects cause various conflicts among stakeholders, particularly between the government and the residents around the project area who are concerned about the damage to their property and their safety. These conflicts can be categorized into the “Not in My Backyard” (NIMBY) phenomenon. Because NIMBY facilities have negative effects, such as environmental, health, safety, economic, and social impacts, on nearby communities, though with benefits for the larger population [2,3], the issues are difficult to resolve.

Typically, infrastructure can be classified into three types according to its design structures: (1) modular infrastructure; (2) integral infrastructure, and; (3) hybrid infrastructure [4]. Modular infrastructure is an independent, monolithic asset, and each has the highly decomposable structure (e.g., dam, Olympic park, stadium, and waste facility). Integral infrastructure connects multiple

stations and components across long distances, and entire system is more tightly coupled than modular type (e.g., energy transmission system, highway system, and railway system). Hybrid infrastructure is a combination of modular (loosely coupled) and integral (tightly coupled) types (e.g., airport terminal, industrial complex and urban development). Such types of infrastructures have shown different conflict scenarios regarding drivers and their consequences. For example, in the case of dam projects (i.e., modular infrastructure), opposition movements occurred due to the lack of Environmental Impact Assessment (EIA) studies and insufficient public participation related to fishery protection, compensation and expropriation, and land use before the construction stage [5,6]. Whereas, for transportation projects (i.e., integral infrastructure), issues relating to location selection (transportation route and station site), property damage (land infringement and land price decrease) triggered public resistance during the entire project lifecycle [7,8]. These examples show that different types of infrastructure have different types of conflict, thereby requiring project type-specific research for better conflict management.

Regarding energy infrastructure projects, this study focuses on the integral (linear) infrastructure, particularly for natural gas pipeline (NGP) projects. As the natural gas market has been becoming more globalized with environmental and economic advantages, natural gas is expected to grow faster than traditional oil and coal, annually increasing by 1.6% between 2015 and 2035. Over the next 20 years, Asia and Europe will become key markets for global liquefied natural gas (LNG) demand, a variety of NGP projects are in progress and planned at the global level [9]. To date, Japan (108.5 bcm, billion cubic meters), Korea (43.9 bcm), and China (34.3 bcm) were the major importing countries of LNG in 2016 [10]. As the second biggest LNG importer, Korea has established a huge nationwide pipeline network for natural gas supply (4240 km in service and 569 km under construction or planned as of the end of 2014), which can be regarded as a benchmark case for fast-growing countries. NGP projects implemented in Korea have raised concerns among the residents about the dangers of explosion, environmental destruction, and construction noise. Thus, the conflicts have become prominent and have caused huge socioeconomic losses [11]. Despite the increasing obstructions, the government is continuing to plan and execute NGP projects without clear countermeasures [12]. If effective and proactive conflict management strategies are not properly established, the relationship and the conflict between the government and the residents will worsen [13,14]. Despite this situation, previous research regarding NGP projects mostly focuses on specific technical issues such as network flow modeling [15,16] and leak detection/monitoring [17,18] rather than public concerns and social conflicts. In this regard, this study aims to establish an effective conflict management strategy for NGP projects based on the causal relationship between the drivers and the conflicts. The study addresses the following three research questions: (1) What are the conflict drivers in energy infrastructure projects? (2) How and to what extent do the drivers affect the degree of conflict? (3) How can the conflicts be managed and reduced? To achieve the objectives of the study, the conflict drivers for the NGP projects executed in Korea are first derived. Subsequently, the structures of the conflict drivers are determined using confirmative factor analysis. Next, a structural equation model (SEM) is developed to identify any direct or indirect effects of conflict-related factors and to assess the total level of conflict in the sampled case projects. Finally, an effective conflict management strategy is proposed to mitigate or reduce the degree of conflict for a sustainable project execution via the SEM results and supplementary expert interviews.

## 2. Literature Review

### 2.1. Characteristics of the Conflicts Involved in Various Infrastructure Projects

Because of the lack of research on NGP projects, this study reviewed previous studies on similar linear (integral) types of infrastructure, such as electric power transmission, road, and railway systems. Regarding the electric power transmission system, Hong and Choi [19] proposed a feasible risk management plan by analyzing the different risk perceptions among the major parties involved.

They stated that transparency of information and mutual trust are important factors in resolving conflicts, because conflicts usually arise from an imbalance in the information. In another study, Cho [20] proposed a conflict resolution plan on the basis of the causes of prolonged conflicts in the construction of power transmission lines. The main causes of these conflicts include lack of countermeasures, failure to respond to the requests of the residents due to lack of trust in the operators, different perceptions in the consultation process for compensation, lack of authority in terms of a negotiator, legal and institutional limitations for public participation, problems in administrative procedures, and lack of effort by the local government in resolving conflicts. Regarding a railway project, G. Kim and J.H. Kim [21] classified the causes of conflicts into three categories. First, they correlated the conflicts with the compensation in terms of land expropriation, additional reimbursement of the residual land, and relocation expenses of the existing residents. Second, they considered the failures during the construction and facility management phases (noise and vibration due to construction, lack of sunshine, infringement of prospect rights, and crack formation in neighboring buildings) as the major causes of conflicts. Finally, they correlated the conflicts with the administrative procedures and concluded that the conflicts were due to the lack of agreement with the residents regarding route selection. Most importantly, regarding the NGP project, issues on facility siting/mobilization [22,23] and cross-border energy security [24,25] have triggered social conflicts among stakeholders and have been addressed by several researchers. Boudet and Ortolano [22] analyzed two cases of LNG facility siting in California and concluded that the combination of four elements (threat, political opportunity, resources and appropriation, and loss of trust) are crucial for social movement and mobilization. Subsequently, Boudet [23] extended the research scope to the national level and extracted key mechanisms of regional mobilization against LNG facility in the United States. Also, as the scope of NGP networks grows across multiple countries, cross-border conflict issues due to energy security were addressed focusing on Southeast Asian countries [24] and Iran-Pakistan-India [25]. In addition to the above studies by infrastructure type, the authors further investigated the literature related to public concerns and NIMBY phenomena in a broader perspective. Keir et al. [26] used procedural justice framework to analyze the public perception of the decision-making process as a main reason for conflict. The poor quality of the decision-making process from seven drivers (public accountability, environmental impacts, local economic impacts, esthetics, alternatives, health concerns, and property values) was found important in opposition to the power transmission lines project. Keir and Ali [27] also suggested that opposition behavior could be mitigated through consensus-building effort such as gaining the participation of key stakeholders, paying attention to trust. As the local opposition is conceived as a form of place-protective action. Devin-Wright [28] proposed a framework of place change to understand local opposition to energy technology projects in psychological aspects. Elliot and Wadley [29] also identified the resident's perceptions (concerns) about damages from the electric-magnetic field, including accident and safety, visual and noise intrusion, environmental damage and property interference. Porsius et al. [30] identified that residents' destructive experiences were main focus around negative expectations of living near the new high voltage power lines (HVPL) and often perceived injustice of the planning process and its outcomes, because mutual communications were not satisfied with their information needs.

In short, there have been diverse causes of conflicts that are directly or indirectly related to NGP projects, including limited resident participation, disregard of resident opinions, complaints about route selection, imbalanced information disclosure, inadequate land compensation, environmental damage, feasibility of a given project, and daily inconveniences due to noise and vibrations. Research implications such as transparency of information disclosure, civil participatory institutions, a formation of consultant groups, and enactment of conflict support can interact to resolve conflicts. More fundamental approaches have been made to identify the cause of conflict in a viewpoint of psychological aspects. From the research question, "why do public object?" rather than "What makes

conflict”, various causes of oppositional behavior such as risk perception, lack of consensus building effort are identified and explained in the following section.

## 2.2. Research Overview on Managing Conflicts

Disputes can arise if the concerns of the community are not carefully analyzed and addressed. Previous studies have concluded that conflicts are one of the main factors affecting the success of a project [31,32]. In particular, Patanakul et al. [31] identified six key characteristics from 39 large-scale government projects and recommended a method of improving the project performance in consideration of the characteristics of the projects. They performed a qualitative case analysis and incorporated conflict-related factors such as stakeholder engagement and alignment issues for the successful governance of large-scale projects. Isik et al. [32] investigated the effects of resources and strategies on the performance of construction companies and indicated that the strength of the relationships with other parties indirectly affects the performance. By considering conflicts as a performance-related factor, several studies have highlighted the importance of creating a consensus and sharing the main objectives [33–35]. In particular, Wei et al. [33] investigated the effect of creating a consensus between stakeholders and project environment on the conflicts. The results show that the discrepancies of opinion regarding project sustainability criteria are prevalent among certain types of stakeholder groups, suggesting that special attention should be paid to cases wherein multiple stakeholder groups are assigned the same priorities. Li et al. [34] emphasized that policy and decision-makers should resolve most conflicts that arise throughout the lifecycle of major public infrastructure and construction projects to maximize the chances of project completion. Similarly, Yu and Leung [35] proposed several practical recommendations to encourage active engagement and improve the performance of public engagement activities, including gauging and collecting public opinions regarding the causes of conflicts. Most previous studies have defined conflicts as causes of disputes; in such studies, dispute-related factors have been derived from case studies, and the effects of these factors on the projects have been analyzed [5,36,37]. Acharya et al. [38] identified and explored conflict drivers that had not been clearly assigned as risk factors of construction projects. Boudet et al. [39] derived conflict-related factors of infrastructure projects for a developing country and proposed a quantitative causal relationship between conflicts using a fuzzy-set qualitative comparative analysis methodology. Other studies have analyzed the causes and effects of the conflict with regard to projects using SEM and partial least squares SEM [36,40]. The fundamental conflict factors that affect contract disputes have been quantified and how conflicts affect the project performance have been thoroughly understood.

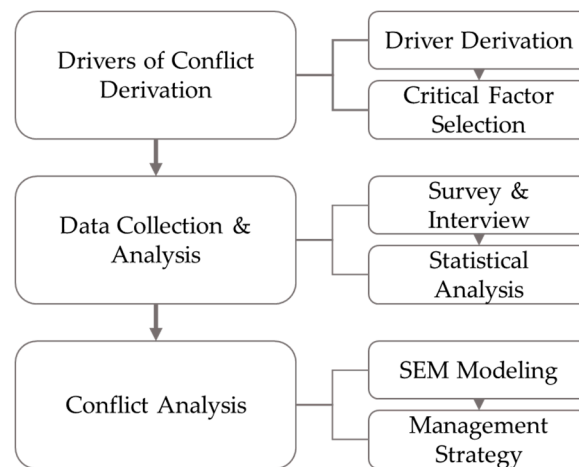
In previous studies, various efforts have been made to effectively manage conflicts in construction projects. Although previous studies have long been contributing to extending the body of knowledge, they have several limitations. Investigating the importance of conflicts has become one of the influencing factors in the given project. However, prior research on the NGP project has mainly focused on technical issues and social conflict problems are rarely discussed in the literature. By considering the characteristics of specific projects, a better conflict management plan can be implemented for a sustainable project execution. Previous studies have failed to fully extend their research to quantitatively propose an effective conflict management strategy and provide alternatives to resolving conflicts. To address this issue, this study aims to explicitly investigate the relationship between the drivers and the conflict and propose an effective conflict management strategy for the NGP projects implemented in Korea.

## 3. Research Methodology

### 3.1. Research Framework

Figure 1 shows the procedure of this study. First, the conflict drivers in NGP projects are derived from extensive literature reviews. Five domain-specific experts were invited to evaluate and select

critical factors pertaining to the conflict level in the NGP projects. Second, a case-based survey is conducted to collect information about the drivers and to investigate the relationship between the conflict-related factors and the conflict level. A statistical analysis is then performed to filter the irrelevant factors from each level of significance. Third, the conflict mechanisms regarding the NGP project are further analyzed using the SEM to identify the pathways of cause-effect relationships of the conflict mechanisms and select an appropriate management strategy. Finally, an effective management strategy for controlling the critical drivers is proposed based on the key results of the SEM, including the feedbacks given by the experts.



**Figure 1.** Research framework. Structural equation modeling (SEM).

### 3.2. Conflict Drivers in Natural Gas Pipeline Projects

The conflict drivers were derived from two phases of literature reviews and expert feedbacks. In Phase 1, overall, 58 conflict factors were first derived pertaining to “general type but environmentally sensitive facilities,” such as military facilities, landfills and treatment plants, funeral halls, and land reclamation projects. The critical conflict factors include decreased land value, insufficient information regarding project implementation, and concerns of environmental damage. Regarding linear-type projects, such as railroad and road facilities, 37 factors were derived in a similar manner, including land expropriation, requirements for re-routing or planning/relocating a new railway station, poor design, lack of public involvement, noise and vibration, and dust formation during construction. Moreover, 23 conflict factors were derived from projects pertaining to electrical power transmission lines that are similar to NGP projects, including insufficient compensation, route selection, and hazards due to electromagnetic waves. In addition to the aforementioned facilities, 21 conflict factors pertaining to NGP projects were derived from content analyses of the media and interviews with five industry practitioners, because of the lack of studies that focus on NGP projects. Some factors such as explosion of facilities, misunderstanding of facility usage, and invasion of private property are considered different from those involved in general projects. Thus, 139 conflict factors were derived from four types of facilities such as general, road/railroad, transmission line and NGP projects.

In Phase 2, 25 critical conflict drivers were selected with the consultation of five experts who had been working on NGP projects for more than 10 years. Among the five experts, two were from the civil engineering field, one was from the architectural engineering field, one was from the mechanical engineering field, and one was from the electrical engineering field. They were required to choose a conflict factor most relevant to the NGPs. In the series of feedback processes, various drivers were considered; however, some of the factors were modified, filtered, or combined if they were unclear or confusing, because some of them were similar. As a result, Table 1 shows the list of 25 conflict drivers and their sources by considering various types of facilities.



**Table 1.** Conflict drivers and their sources. Natural gas pipeline (NGP); liquefied natural gas (LNG).

	Conflict Drivers (#25)	General [21,28,34]	Road/Rail Road [41,42]	Transmission Line [19,20,26,27,29,30]	NGP [11,22,23]
Q1	Invasion of pipeline onto private land	O		O	O
Q2	Concerns regarding the decreased value of the land around the facility site	O		O	O
Q3	Impediments to area development caused by the supply station	O	O	O	
Q4	Dissatisfaction regarding issues, such as land compensation for construction	O	O	O	
Q5	Damage to nearby houses and facilities	O	O	O	O
Q6	Traffic congestion and the inconvenience of passing	O			O
Q7	Lack of explanation about the project (information disclosure, public participation, etc.)	O	O	O	O
Q8	Different views of the central and local governments	O	O		O
Q9	Concerns about safety and possible accidents (explosions, etc.)	O		O	O
Q10	Lack of necessity and feasibility of the business	O	O	O	O
Q11	Permission, land expropriation, property appraisal, etc.	O	O	O	
Q12	Pipeline route selection		O	O	O
Q13	Supply station site selection		O	O	O
Q14	Poor design (select method, detect obstacle)	O	O	O	
Q15	Impracticality of the project because of the excessive reduction of construction duration	O	O		
Q16	Disturbance to the use of the original route because of the supply station or the narrowness, closure, etc., of pipelines	O		O	O
Q17	Damage to local images, tourist sites, etc.	O		O	
Q18	Victimized consciousness of residents, who feel excluded by the gas supply			O	O
Q19	Confusing features of gas (LPG (Liquefied Petroleum Gas) and LNG)				O
Q20	Misunderstanding the issues involved with the supply station (e.g., storage or gas station)				O
Q21	Local features and emotions of local residents	O	O	O	
Q22	Danger of the supply station and pipeline explosion				O
Q23	Damage to the environment around the supply station		O	O	O
Q24	Concern regarding damage to the ecosystem during construction and operation	O	O	O	O
Q25	Concern regarding violating rights	O	O	O	O

### 3.3. Data Collection

The selection of the case projects for the survey was based on the following criteria. The first criterion involved selecting NGP projects that experience similar conflicts and exhibit regional characteristics normally found in linear facilities; such projects that are small and limited to a specific region were excluded. The second criterion involved selecting projects that were already completed and projects wherein major conflicts were largely resolved. This criterion was devised to improve the reliability of the survey. The third criterion was based on the suitability of the data for collection. To improve the uniformity and ease of collecting specific data from the respondents, the case projects selected were the ones completed in the last decade. Finally, 36 projects were selected out of total 47 NGP projects based on three criteria (conflict characteristic, project completion year, and data

availability), which make up the 1422 km length of the NGP. The average project duration of the selected project is 3.1 years, and an average of 4.36 conflict cases occurred. The relative importance of conflict drivers (independent variables) was measured based on the possibility of conflict occurrence and the effect on project performances in terms of cost and schedule on a five-point Likert scale (very low, low, medium, high, very high). Level of conflict was also measured on a five-point Likert scale (very low, low, medium, high, very high) taking into account total level of conflict significance during project progress. The questionnaire was designed so that the importance of conflict drivers was measured at the initial stage of the given project and level of conflict was measured at the end of the same project, which makes longitudinal data setting.

The survey participants were required to have at least five years of experience with the projects. Because some knowledge of the conflict was requested, a judgment sampling (purposive sampling) method, which is one of the non-probability sampling methods, was employed for the survey. This sampling method involves the purposive or deliberate selection of particular units to constitute a representative sample. The judgement sampling technique is often used in qualitative research with the objective of developing hypotheses instead of generalizing larger populations [43]. In accordance with the criteria of survey participant selection, 238 individuals were selected from 36 NGP case projects; the responses were received from 143 participants, with a response rate of 60.1%. Table 2 shows the detailed description of the survey. In addition, in-depth follow-up interviews were subsequently conducted to ensure their active participation and obtain other subjective opinions from the respondents.

**Table 2.** Survey overview.

Method	Email, Face-To-Face Interview
No. of distributed	238 (Owner 128, Engineering firm 48, Construction firm 62)
No. of respond	143 (Owner 115, Engineering firm 19, Construction firm 9)
Response rate	60.1%

## 4. Analysis and Structuring of Conflicts in NGP Projects

### 4.1. Correlation Analysis

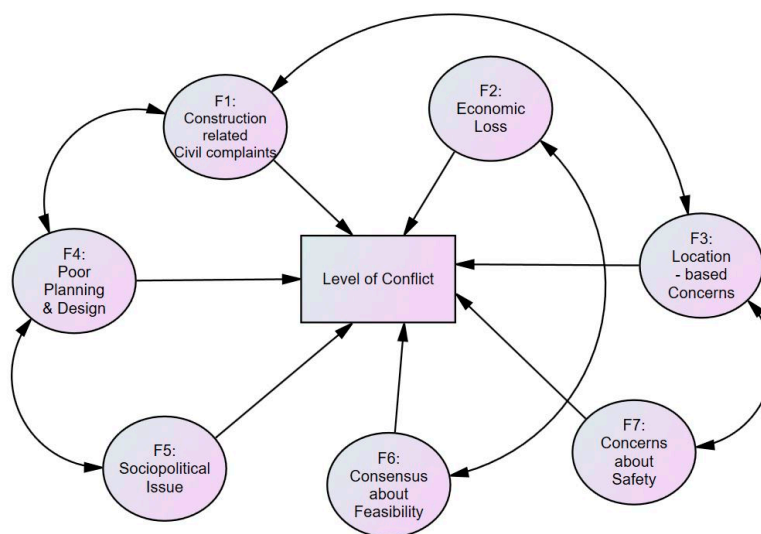
A correlation analysis was performed to determine the correlations between the level of conflicts and the 25 conflict drivers related to the 36 NGP projects. This was done with the objective of questioning the extent to which the level of conflict in a given project was affected by each of the 25 drivers. If the correlation coefficient was above  $\pm 0.4$ , it is regarded as correlated [44]. The results show that most of the factors examined were determined to be related to the conflicts that have a significant effect on the overall level of conflict, such as Q1 (pipeline invasion onto private land), Q5 (damage to nearby houses and facilities; because the pipeline is mainly built along the road, there are only a few cases of direct invasion), and Q13 (supply station site selection; because the supply station site lies on the path of the pipeline, the correlation coefficients were below  $\pm 0.4$  and, thus, were removed from further analysis).

### 4.2. Analytical Framework and Hypothesis Development

Figure 2 shows the conceptual relationship between conflict factors based on the previous research and the in-depth experts interviews at the data collection stage. First, civil complaints during the construction stage could seriously influence the relationships between contractor and residents (F1: [5,22]). Residents' concerns about economic loss of each individual and decreased value of regional area could also give the negative effect to residents' perception (F2: [26,30,45]). Secondly, location-based concerns, due to a wider range of NGP projects, could increase the negative perception of residents (F3: [28,29,45]). Associated with this factor, poor project implementation at planning and design stage without considering surrounding environment could cause another concern (F4: [5,34]).

Thirdly, sociopolitical issue among governments, project owners, contractors and residents (F5: [22,34]), and lack of consensus regarding the legitimacy or feasibility of a project (F6: [22,26,45]) could be the main factors that intensify the conflict. Lastly, concerns about safety and threat from NGP (explosion and environmental damage) could also increase the negative perception of the resident, as a cause of conflict (F7: [22,29,45]). Though these seven conflict factors are assumed as endogenous, these factors could be correlated to each other, implying that the level of conflict is not independently affected by the seven endogenous factors. For example, construction related civil complaints (F1) are related with location-based concern (F3) and poor planning and design (F4), because observed variables in these stages are linked to routing and locating issues. Location-based concern (F3) is also related to concerns about safety (F7), because safety concerns are mainly attributed to damages around the LNG facility. Poor planning and design (F4) and sociopolitical issues (F5) are presumably related to each other, as the excessive requirements for time reduction by local governments can lead to poor design. Economic loss (F2) and consensus about feasibility (F6) are also related, because the lack of residents' participation can be regarded as both cause and consequence for concerns about economic loss. From this point of view, the authors establish the following research hypotheses:

- (1) The level of NGP project conflict is directly influenced by seven factors, namely, construction related civil complaints (F1), possible economic loss (F2), location-based concerns (F3), poor planning and design before construction (F4), sociopolitical issue (F5), lack of consensus about feasibility (F6), and lack of consensus about safety (F7);
- (2) The seven conflict factors are correlated, implying that the level of conflict is not independently affected by the seven endogenous factors.



**Figure 2.** Conceptual relationship between conflict factors.

These hypotheses are tested and validated using confirmatory factor analysis and structural equation modeling in the following sections.

#### 4.3. Confirmatory Factor Analysis

The objective of the factor analysis is to facilitate empirical modeling by reducing the number of variables and including the right type of information in the factors. In addition, this study used a bootstrapping (1000 times) technique to increase the statistical significance. Using the factor analysis, 22 drivers were clustered into a group of seven factors, as listed Table 3.

The factor loadings for all the factors were greater than 0.4, thereby demonstrating that the factor analysis is appropriate [46]. To confirm the factor analysis results, Kaiser-Meyer-Olkin (KMO)



and Bartlett's tests were conducted to reveal the correlation between the variables. The KMO value represents the appropriateness of the samples and has a range of 0–1. A KMO value greater than 0.5 is suitable for factor analysis [47].

**Table 3.** Results of confirmatory factor analysis.

Conflict Drivers		Estimate	p-Value
F1 = Construction related civil complaint	Q16	0.850	0.000
	Q12	0.581	0.000
	Q6	0.513	0.000
F2 = Economic loss	Q2	0.712	0.000
	Q4	0.635	0.000
	Q17	0.566	0.000
	Q3	0.539	0.000
F3 = Location-based concern	Q21	0.741	0.000
	Q22	0.684	0.000
	Q19	0.661	0.000
	Q20	0.594	0.000
F4 = Poor planning and design	Q25	0.888	0.000
	Q14	0.738	0.000
	Q24	0.529	0.000
	Q11	0.487	0.000
F5 = Sociopolitical issue	Q15	0.833	0.000
	Q8	0.520	0.000
F6 = Consensus about feasibility	Q7	0.654	0.000
	Q18	0.654	0.000
	Q10	0.552	0.000
F7 = Concerns about safety	Q23	0.670	0.000
	Q9	0.636	0.002

In this study, Table 4 shows that the result of the KMO test was 0.826, which is relatively high. The result of the Bartlett's test, which helps in obtaining a correlation matrix between the variables, is 491.564 (degree of freedom (DoF)  $f = 215$  and  $p = 0.000$ ). This satisfies the appropriateness of fit and the chi-square/DoF. Consequently, the variables and the number of project cases used are suitable for meeting the required conditions of the factor analysis.

**Table 4.** Confirmatory factor analysis normality assessment.

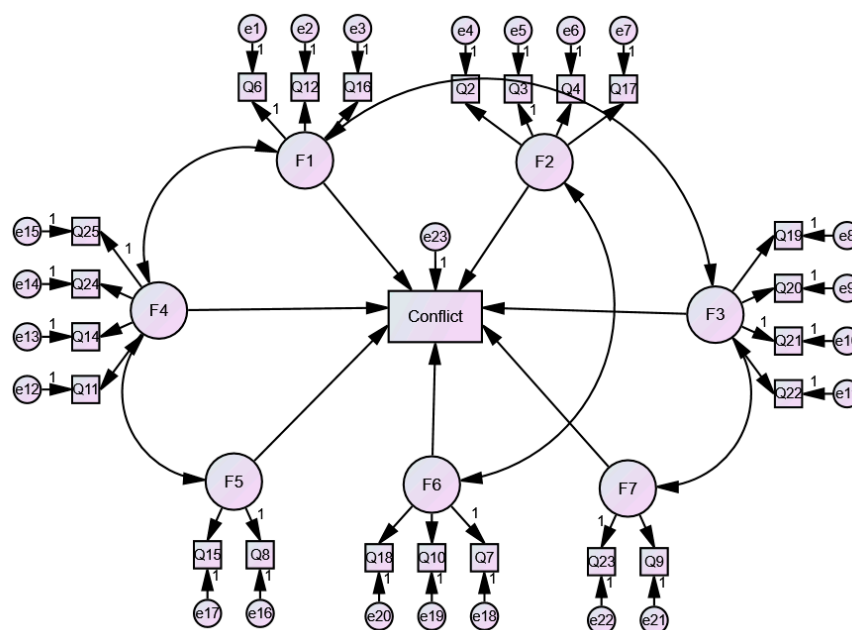
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		0.826
Bartlett's Test of Sphericity	Approx. Chi-Square	491.564
	Degrees of Freedom	215
	sig.	0.000

#### 4.4. Structural Equation Modeling

As mentioned previously, the causes of conflict regarding the NGP projects are diverse. To resolve these conflicts, it is important to classify and prioritize the causes of conflict and the levels of conflict using a systematic method. As the questionnaire was designed so that the independent variable was measured at the initial stage of the given project and the dependent variable was measured at the end of the project, the result of SEM represents not only correlation but also the causal relationship between drivers and level of project conflict by reflecting time sequence. In addition, SEM has several advantages as a tool for identifying the relationships between the different variables. First, in the SEM, some variables of prime interest are assumed unobservable, and therefore termed latent

variables [36]. Second, the goal is to access the unobservable constructs (the latent variables) and model the dependence relationships between the constructs (the structural equations), rather than between the direct measures themselves, using multiple measures [48]. In this study, the SEM approach is used to investigate the relationship between latent variables in an empirical way. Because the conflict drivers are closely related to each other (not independent), they need to be analyzed by the dependency.

To establish the SEM, the observed or measured exogenous variables are first arranged, as indicated using rectangles. The variables are then labeled with the letter Q followed by a question number. The variables are then labeled with the letter Q followed by a question number. The rectangles with the letter e indicate the measurement errors of the observed variable. When measurement errors in independent (observed) variables are incorporated into a regression equation, the variances of the measurement errors in the regressors are transmitted to the model error, thereby inflating the model error variance [49]. The unobserved latent variables, indicated using ellipses, represent the substantive characteristics of the conflict drivers that cannot be observed directly (labeled with an F), which were obtained from the factor analysis. The relationship between the observed and latent variables was based on a regression model of the two variables. A double-headed arrow is used to indicate a correlation and a single-headed arrow is used to indicate a cause-effect relationship. To establish the SEM, seven latent variables and 22 observable variables that satisfy the statistical significance were selected and, subsequently, arranged. Figure 3 shows the SEM results.



**Figure 3.** Schematic of structural equation model. Construction-related civil complaints (F1); economic loss (F2); location-based concerns (F3); poor planning and design (F4); sociopolitical issues (F5); consensus about feasibility (F6); concerns about safety (F7).

The final model was modified based on the specifications of the base model. The following seven latent factors, which were obtained in the confirmatory factor analysis, were found to directly affect the level of conflict: construction-related civil complaints (F1); economic loss (F2); location-based concerns (F3); poor planning and design (F4); sociopolitical issues (F5); consensus about feasibility (F6), and; concerns about safety (F7). The correlation between the variables was necessary to obtain a model with a good fit. For example, the unexplained portions of the measurement variables e2 and e22 and their respective indicators of construction-related civil complaints (F1) and concerns about safety (F7) are correlated. In other words, route selection (Q12) and damage to the environment around the supply station (Q23) are related. Thus, the construction factor (F1) is likely to affect the

damage to the environment factor (Q23). In contrast, the latent variables of the construction-related civil complaints (F1) and concerns about safety (F7) did not have a direct correlation for a good model fit. That is, the elements of construction-related civil complaints (F1) are related to the disturbance of using the original route (Q16), pipeline route selection (Q12), and traffic congestion and disturbance of passing (Q6). However, the elements of safety (F7) are related to the concerns about safety and possible accidents (Q9) and to the damage inflicted on the environment around the supply station (Q23). To test the validity of the developed model, this study incorporated four widely used indices [50]. Among the four indices, the RMSEA (Root Mean Square Error of Approximation) (0.095, lower than 0.1) and GFI (Goodness of Fit Index) (0.811, higher than 0.8) are in good—accordance with the results of the developed model. The RMSR (Root Mean Square Residual) (0.09, lower than 0.08) and AGFI (Adjusted GFI) (0.732, higher than 0.8) are slightly below the standard. Nevertheless, the values of the RMSR and AGFI are somewhat acceptable for the accumulation of data and the modification of the model. Accordingly, the result of SEM analysis can be regarded as tolerable for most indices.

#### 4.5. Effect of Drivers

As listed in Table 5, the construction factor (F1) is measured based on the responses to the three factors Q6, Q12, and Q16. The construction factor has the most influence on the response to factor Q16 (coefficient of 1.86), followed by question Q12 (coefficient of 1.35), and question Q6 (coefficient of 1.00). In the order of decreasing influence, the construction-related factors are as follows: the disturbance of using the original route because of the supply station or pipeline narrowness and closures; pipeline route selection, and; traffic congestion and inconvenience during movement.

**Table 5.** Estimated regression results of the SEM model.

		SEM Regression Weight	Coefficient Estimate	Standard Error	p-Value (<0.05)
Conflict	←	Construction related civil complaint (F1)	0.145		
Conflict	←	Economic loss (F2)	0.326		
Conflict	←	Location-based concern (F3)	0.034		
Conflict	←	Poor planning and design (F4)	0.006		
Conflict	←	Sociopolitical issue (F5)	0.102		
Conflict	←	Consensus about feasibility (F6)	0.198		
Conflict	←	Concerns about safety (F7)	0.192		
Q6	←	Construction related civil complaint (F1)	1.000		
Q16	←	Construction related civil complaint (F1)	1.864	0.355	0.000
Q12	←	Construction related civil complaint (F1)	1.353	0.277	0.000
Q3	←	Economic loss (F2)	1.000		
Q17	←	Economic loss (F2)	0.860	0.185	0.000
Q2	←	Economic loss (F2)	1.176	0.227	0.000
Q4	←	Economic loss (F2)	0.941	0.190	0.000
Q21	←	Location-based concern (F3)	1.000		
Q19	←	Location-based concern (F3)	0.843	0.127	0.000
Q22	←	Location-based concern (F3)	0.979	0.144	0.000
Q20	←	Location-based concern (F3)	0.937	0.155	0.000
Q25	←	Poor planning and design (F4)	1.000		
Q11	←	Poor planning and design (F4)	0.694	0.124	0.000
Q24	←	Poor planning and design (F4)	0.599	0.098	0.000
Q14	←	Poor planning and design (F4)	1.000	0.114	0.000
Q8	←	Sociopolitical issue (F5)	1.000		
Q15	←	Sociopolitical issue (F5)	1.446	0.420	0.000
Q10	←	Consensus about feasibility (F6)	0.829	0.175	0.000
Q18	←	Consensus about feasibility (F6)	1.091	0.211	0.000
Q7	←	Consensus about feasibility (F6)	1.000		
Q23	←	Concerns about safety (F7)	1.000		
Q9	←	Concerns about safety (F7)	1.292	0.408	0.002

The economic factor (F2) is measured based on the responses to the four factors Q2, Q3, Q4, and Q17, which correspond to the concerns regarding the decreased value of the land around the facility site (coefficient of 1.18), impediments to area development due to the supply station (coefficient of 1.00), dissatisfaction regarding issues of land compensation for construction (coefficient of 0.94), and damage to local images, tourist sites, and so forth (coefficient of 0.86), respectively. The location-based factor (F3) is measured based on the responses to the four factors Q19, Q20, Q21, and Q22, which correspond

to the local features and emotions of local residents (coefficient of 1.00), dangers of supply station and pipeline explosions (coefficient of 0.98), misunderstanding the issues involved with the supply station (storage or gas station) (coefficient of 0.94), and confusing gas features (LPG and LNG) (coefficient of 0.84), respectively. The planning and design factor (F4) is measured on the basis of the responses to the four factors Q11, Q14, Q24, and Q25, which, respectively, correspond to poor design (selection method and detection of obstacles) (coefficient of 1.00), concern about violating rights and obstructing sunshine due to the supply station fence (coefficient of 1.00), permission, land expropriation, and property appraisal (coefficient of 0.69), and concern about damage to the ecosystem during construction and operation (coefficient of 0.599). The sociopolitical factor (F5) is measured based on the responses to the two factors Q8 and Q15, which correspond to the impracticality of the project due to excessive reduction of the construction duration (coefficient of 1.45) and different views of the central and local governments (coefficient of 1.00), respectively. The feasibility factor (F6) is measured based on the responses to the three factors Q7, Q10, and Q18, which correspond, respectively, to the victimized consciousness of the residents who feel excluded from the gas supply (coefficient of 1.09), lack of explanation about the project (information disclosure and public participation) (coefficient of 1.00), and lack of necessity and feasibility of the business (coefficient of 0.83). The safety factor (F7) is measured based on the responses to the two factors Q9 and Q23, which correspond to the concern about safety and possible accidents (explosions) (coefficient of 1.29) and damage to the environment around the supply station (coefficient of 1.00), respectively. A unit increase in each latent variable (construction, economic, location-based, planning and design, sociopolitical, feasibility, and safety) will have approximately twice the influence on the factors with coefficients of approximately 1.00. The coefficients for the measurement model component of the conflicts are nonzero with a confidence level of at least 95%. Hence, a good model fit can be assumed.

## 5. Discussions for Effective Conflict Management Strategy

The results of the structural analysis of the conflicts show that the causes of conflict related to NGP projects are diverse. Hence, a conflict management strategy is proposed based on the causal relationship between the drivers and is applied to prevent the conflicts from spreading for a more sustainable project execution. The management strategy of the conflicts, in accordance with their root causes and pathways of conflict propagation, was extracted for practical utilization and verified by interviewing three experts having more than 10 years of experience, including operators and contractors.

### 5.1. Responsible Departments for Conflict Management with an Adequate Budget Support

The drivers related to economic factors, such as Q2, Q3, Q4, and Q17, can be managed effectively by relevant and responsible conflict management departments with an adequate budgetary support. Conflicts can occur from the early stages of a project until its completion, particularly in the cases wherein people have NIMBY mentality, because of hazardous gas facilities. Thus, conflicts should be managed technically and for the long term rather than for the short term. To identify the diverse causes of conflicts and to manage them actively, prior experience should be considered, and the person in charge of negotiation should have the required authority. Although it is necessary to implement the conflict management strategy within a department with the designated responsibility, most departments with this responsibility have been functioning temporally and react only after conflicts have occurred. Such departments tend to be preoccupied with some other work, making conflicts that could have otherwise been easily resolved to continue for the long term and causing substantial problems due to the shortage of time, lack of skill, and lack of negotiation authority. In addition, an appropriate budget for preventing conflicts should be provided to the departments responsible for managing the conflicts. So far, the budget support system for resolving conflicts has been insufficient for the Korean government and other related public agencies, despite the high cost and time associated with resolving such conflicts.

### 5.2. Rethinking the Balance of Cost and Benefits

To reduce the feasibility-related factors, such as Q7, Q10, and Q18, which affect the entire project in the prediction model, the following approaches can be applied to gradually relieve the level of conflict. Conflicts are usually caused not only by gas facilities but also by many public projects because of a cost-benefit imbalance. In addition, regional views and self-centeredness (e.g., NIMBY mentality) add to the problem. If a view to the public interest is emphasized excessively, conflicts with residents can become an irreversible problem. To address this problem, a win-win strategy for operators (including contractors) and residents is necessary. For example, an operator and a project beneficiary can be each given a part of the profits of the given project to reinvest in gas facilities in the area or assist residents financially. To do this, corporate social responsibility should be enhanced by establishing and enacting standards and institutions. Finally, to prevent some of the residents from being alienated, the local government should employ policies such as supporting residential use of and access to areas that cannot be easily supplied with natural gas because it would be economically unfeasible.

### 5.3. Introduction of a Land-Purchasing System and a Solution for Residual Land Applications

The introduction of a land-purchasing system and a solution for the remaining land are expected to relieve drivers such as Q2, Q3, Q20, and Q22. A land-purchasing system is necessary. The owners of the land around gas supply facilities should be able to sell their land to operators if the land value decreases or if dealing in real estate proves to be difficult because of the presence of dangerous gas supply facilities. After a consultation between the operator and the local government, the local government is recommended to build cultural or sports facilities that would be open to the public, such as fitness centers, on the land provided by the operators. This measure would help reduce misunderstanding among the residents regarding the facilities. Furthermore, if the remaining land remains unsold, an alternative solution should be employed to purchase the land and build resident-friendly facilities. Because the purchasing standard for the remaining land is currently unclear, relatively less effort has been put for purchasing the remaining land according to the subjective judgment of the decision-maker. Therefore, quantitatively and qualitatively clear standards for purchasing the remaining land should be established, and damages inflicted to residents regarding the remaining land should be minimized.

### 5.4. Region-Friendly Design and Construction

The number of factors related to the design and construction among the 25 conflict-related factors identified is 10. The factor related to construction is determined to be the fourth most influential factor based on the regression analysis. These conflicts largely occur during the construction period, such as those during pipeline or supply station construction. In particular, Q12 (pipeline route selection) has a relatively high occurrence and a high level of related conflict; thus, the design and construction procedures should be implemented carefully. The conflict drivers related to the selection of natural gas supply station sites are believed to have the largest effect on the frequency and level of conflict. Therefore, in addition to legal, institutional, and technical considerations, the following factors should be investigated and analyzed thoroughly: the surrounding environment (e.g., farms, tourist sites, and religious facilities), village construction history, lifestyle of the residents, and remaining land near the supply-station construction sites.

### 5.5. Reinforcing Public Relations and Changing Cognition

The most severe location-based conflict sub-factors, such as Q19, Q20, Q21, and Q22, are largely due to misunderstanding and distrust. These factors should be solved, at least to a significant extent, at an early stage by strengthening promotional activities and changing individual perceptions. The functions of a gas supply station include measuring the natural gas supply and blocking or venting the natural gas in the event of an emergency; this is because the facility is responsible for the overall safety. However, most residents rarely sympathize with these functions or with the requirements of gas supply



facilities. The people of Korea have had a negative perception of gas facilities because of a few accidents. Previous methods of persuading and enlightening the residents have included giving presentations and distributing brochures. However, these methods have proven to be ineffective; more active and constant publicity regarding the needs and safety of the natural gas facility, such as mass media campaigns or lectures by experts, is necessary. If an external agency conducts publicity campaigns, it may be easier to gain resident approval by ensuring objectivity and reliability. Further, the mindset of the operators must be changed. Projects should be executed in consideration of the public, as they are public projects. The residents may feel neglected if sufficient attention is not paid to their needs. Therefore, the stakeholders, including operators and contractors, should participate in an educational program conducted by a specialized organization to change the perceptions of the public and resolve any conflict; moreover, an appropriate conflict management strategy must be implemented.

## 6. Conclusions

This study analyzed the conflicts due to energy infrastructure projects and proposed an effective management strategy for sustainably executing projects by analyzing conflict cases in NGP projects. A total of 25 conflict drivers related to NGP projects were extracted from literature, media reports, and interviews with experts. Using the extracted drivers, a survey was conducted considering 36 completed projects. The SEM was used to analyze the causal relationships related to the conflicts by considering the relationships between the variables. Seven latent variables (construction, economic, location-based, planning and design, sociopolitical, feasibility, and safety) comprising 22 drivers were found to affect the total level of conflict, both directly and indirectly. Based on the results of the analysis, an effective management strategy for the drivers was established by taking interviews of experts from relevant fields. From the conflict analysis, the causes of conflict were outlined and the effects of the drivers in terms of the conflict level were determined for NGP projects. More specifically, this study found that routing and locating of the NGP facility, safety concerns about damages around the LNG facility, poor planning and design issues, and potential economic loss are the most common and influential causes of conflict for NGP projects. Taking advantage of SEM, this study presented the empirical relationship between various conflict drivers and level of project conflict, as illustrated in Figure 3. The authors expect that our research findings could contribute to a better understanding of conflicts in NGP projects. With the critical conflict factors and proposed strategies summarized in the discussion section, future NGP projects can be well equipped and implemented with conflict management plans to resolve conflicts more proactively and efficiently. On the other hand, a limitation of this study is that the opinions of various stakeholders in the field of natural gas were not entirely considered in the conflict impact analysis. This limitation may affect the causes of conflicts, and therefore, the conflict management strategies. In addition, the number of operators was more than the number of contractors (constructors and designers) in our survey. Considering such limitations, our future study will incorporate wider opinions from more diverse stakeholders (e.g., local residents, governments, and non-governmental organizations (NGOs)) and needs to discuss specific plans to apply the management strategy efficiently and implement in-depth case studies to investigate the effectiveness of the proposed strategy. Moreover, to improve the understanding of conflicts, both quantitative and qualitative methods should be applied. An appropriate mix of the qualitative methods could provide a substantive and meaningful avenue for further studies.

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