International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 11, Number 12 (2018), pp. 1923-1948

http://www.irphouse.com

Construction Cost Overruns in Transmission Grid Projects

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ABSTRACT

This paper analyses construction cost overruns of transmission grid projects in Vietnam. Firstly, attributes causing cost overruns were identified from previous studies through a comprehensive literature review, the reality during the construction phase, and discussions with experts in the power industry. Subsequently, a questionnaire was developed and the data were collected through the survey. Nextly, factor analysis was executed and seven key factors were also extracted, including: Management to human and construction resources; Competence of stakeholders; Policies of the Government; Construction policies; Relationships among main contractors, subcontractors, the workforce; Cost of materials and equipment; and Adverse objective attributes. In addition, from the result of factor analysis, the study ranked the attributes of seven key factors by mean value. The result revealed that attributes causing highest cost overruns are: Incompetence of project manager, Incompetence of construction supervision consultants and design consultants, Unstable interest rates, and Unstable construction policies. Finally, Spearman's rank correlation coefficient was also calculated to analyse the consensus in perspectives of stakeholders on the attributes causing cost overruns in projects. Findings of the study can help project manager, owner, contractor and consultant to propose appropriate solutions to reduce construction cost overruns of transmission grid projects.

Keywords: construction, cost overruns, factor analysis, transmission grid projects, Vietnam

I. INTRODUCTION

Cost overruns during the construction phase of projects in the construction industry is a very common problem. Flyvbjerg et al. (2002) pointed out that large construction projects often face the problem of cost overruns. Shane et al. (2009) asserted that the final cost of projects is usually higher than the estimated cost in so many cases. In addition, Doloi (2011) supposed that construction cost overruns have been the chronic problem in a great number of projects. Construction cost overruns appeared in the construction industry of many countries and in a variety of different construction projects, such as public projects (Arditi et al. 1985), telecommunication projects (Ameh et al. 2010), transportation infrastructure (Berechman and Wu 2006; Omoregie and Radford 2006), highway projects (Creedy 2005), groundwater projects (Frimpong et al. 2003), building projects (Fugar and Agyakwah-Baah 2010; Kaming et al. 1997), road projects (Kaliba et al. 2009), private residential projects (Koushki et al. 2005), and social overhead capital projects (Lee 2008). In Vietnam, cost overruns also occurred in types of construction projects as mentioned above, and transmission grid projects were not the exception. Consequently, this study is conducted to discover attributes causing cost overruns in grid projects of the country to help stakeholders to control these attributes successfully, thereby achieving the success in the construction of grid projects.

Basically, the power industry has a key role in the social and economic development of a country, especially in Vietnam - a developing country. This industry improves the life quality of people by providing the power demand adequately for the production and daily life. However, along with the strong development of power demand in the recent years, there are also emerging problems in the investment of projects in terms of schedule, quality and especially construction costs. Any risks during the construction phase always have strongly negative impacts on costs, hence the completion of grid projects. The volatility of internal and external elements makes projects completed with costs higher than costs planned.

In Vietnam, improving the management of construction costs is a very necessary demand. If construction costs are not controlled closely, transmission projects will be in cost overruns as well as resources will be wasted. Moreover, the construction of grid projects is highly complicated and consists of many attributes causing cost overruns. The determination and evaluation of attributes causing construction cost overruns are practically significant and highly important to achieve the success in executing grid projects to ensure the long-term sustainable development for the country. Consequently, the study is carried out with the following objectives:

- Identify attributes causing construction cost overruns of transmission grid projects in Vietnam.
- Determine the latent structure of the attributes by factor analysis.
- Rank the attributes accoding to perspectives of stakeholders and analyse the consensus in their perspectives on the attributes causing cost overruns in grid projects.

Based on findings found out, project managers, owners, contractors and consultants can specify the attributes of cost overruns from early stages before executing projects to reduce cost overruns of grid projects. Furthermore, also based on findings, stakeholders can propose appropriate solutions to implement and complete projects within the budget as planned initially, enhance the capability in managing the attributes, and understand the nature of cost overruns to achieve the success for transmission projects.

II. LITERATURE REVIEW

There are many research topics related to grid projects but this study only focuses on the cost topic. According to the literature review carried out, previous studies of the cost topic are listed as follows: Jiahong (2002) analyzed effects of World Trade Organization (WTO) accession to power engineering cost in China; Weiye and Chen (2002) analyzed different factors affecting power engineering cost and proposed three measures to manage power cost; Defeng (2004) analyzed cost control in power construction engineering; Jie (2005) discussed cost management of power projects. Cost management has moved gradually towards all aspects and processes of the project construction; Xiyong (2005) analyzed main causes leading to over-budgeting problem of grid projects, namely: lack of design items, changes in design, updated construction standards and changed project scope. In addition, countermeasures to control over-budgeting problem were also proposed; Shuang-ping (2006), based on characteristics of grid projects, discussed methods and measures to strengthen the management of projects cost for power companies; Li et al. (2007), based on data analysis of power projects built in the period from 1998 to 2005, studied general trend, range of fluctuation as well as the cost change of these power projects. In addition, causes and characteristics of the cost change of power projects were summarized and some references were also proposed to help power companies control costs better; Yue-qing (2007) analyzed costs and pointed out main causes of the cost change of grid projects; Yuan-ming (2007) identified causes of budgetary overrun for power construction projects, including: considerable deviation in investment estimation and loose examination on design of projects. Then, several solutions were proposed to control the cost of projects: controlling extra-budgetary expenditure, optimizing design, and strengthening settlement management; Wu and Zhijun (2008) suggested the case-based reasoning method supported by Fuzzy mathematics, Analytical Hierarchy Process to use experience of experts for improving the accuracy of cost estimation. A case study was also selected to verify the practicality and scientificity of this method. The case-based reasoning method of cost estimation provides valuable references in the process of making decisions related to costs of grid projects; Zhao et al. (2008) collected data on construction cost of thirty newly-built 35 kV transmission lines of power network in Mongolia from 1998 to 2006 to identify factors that influence the construction cost of these projects. Then, factor analysis and multiple linear regression analysis were carried out to determine the impact level of each factor; Liang et al. (2009) identified main causes affecting the interruption cost of power projects. Then, based on the basis of fuzzy theory, a new method to estimate the interruption cost was developed and applied in case study. The proposed method can describe losses caused by the interruption of projects in different conditions; Wei-ping (2009) analyzed causal relationships between the cost and many key elements in different stages throughout the cycle life of grid construction projects; Zhou and Rong (2009) discussed difficulties in budgetary estimation such as design, external conditions, quantity of materials and equipment in power engineering and some solutions were also proposed for better budgetary estimation; Lu et al. (2010) analyzed and calculated the operating cost of substations of power projects based on cloud model; Li et al. (2010) introduced the composite cost index which reflects the general trend of cost change of power transmission projects. This composite cost index can indicate the level of cost change with a high degree of objectivity for power projects; Shi et al. (2010) analyzed the cost of compensation and site clearance for power transmission projects from 2006 to 2008 and discovered the trend of cost change of site preparation for projects as well as main influencing factors; Liang (2010) compared the cost estimate method for transmission projects based on its main component materials to the common cost estimate methods based on designed engineering quantity, installation quota, service fee quota and software for construction budget. The study applied a case study and demonstrated that the cost estimate method based on main component materials is more simple and reliable and can be applied to optimization and comparison among alternative project schemes, calculation and control of projects initial investment; Zhang et al. (2010) studied the change of grid project cost, discovered major factors affecting the cost and offered some solutions to manage the cost better for power projects; Liu and Jie (2010) analyzed the deficiency and characteristics of cost management in the current power engineering in China; Honglin (2010) discussed the cost management of large-scale power transmission line projects and then provided a few suggestions to improve the cost management of power projects as well as to ensure projects implemented smoothly; Lei (2010) analyzed costs as well as solutions to control costs of 220 kV substation projects in Hubei province, China; Dai and Feng (2011) summarized target, function, implementation and means of cost control for power supply enterprises. The study concluded that in order to control cost better, two primary controls need to be done well, namely: cost control of projects and the control of production cost and capital; Zhang et al. (2011) analyzed causes of cost fluctuation of grid projects construction and then, a few suggestions were provided to limit the cost fluctuation; Lu and Xin (2012) presented a relative cost index for transmission projects, which is advantages in comparising, ranking and evaluating degrees of cost control for transmission line projects; Xu et al. (2012) explained the signification of whole process cost management in large power grid construction projects, proposed plans to its application in these projects as well as interpreted the meaning and control methods of whole process cost management at all stages, including: investment decision stage, design stage, bidding phase, construction stage, and completion stage; Cui et al. (2012) analyzed the cost status of power transformation projects of a company in China and main factors affecting the cost of projects as well as discussed the cost control and disadvantage issues in transformation projects; Niu et al. (2013), based on the fishbone diagram theory, combined with characteristics of grid construction projects, identified cost risk factors in grid construction projects at all stages, including: project decision-making and feasibility study phases, design and bidding phases, construction phase, and completion of final accounts and evaluation phases; Wang and Zi-qian (2015), by analyzing budget and final accounts of power projects 110kV, 220kV, 330kV and 500kV between 2001 and 2010, researched on cost trends of power engineering projects in about ten years and analyzed reasons for the trends. The result of the study indicated that the decrease of power projects cost is due to scale effect, the increase of power projects cost is due to the rise of corridor removal, and trends of projects cost are highly complex.

Clearly, the topic of cost usually revolves around aspects in grid projects such as: factors affecting costs, the control and management to costs, the fluctuation and change of costs, improving the accuracy of cost estimation, difficulties in the budgetary estimation, cost of the compensation and site clearance, trend of the cost change of site preparation, solutions to manage costs, general trends of the cost change, the deficiency and characteristics of the cost management, implementation and means to control costs. Many of those studies are on factors affecting operation costs or estimated costs of projects. On the other hand, there are also several studies on factors causing construction cost overruns or affecting the change of construction costs of grid projects but mostly, they only analyze factors or causes qualitatively, for instance, studies of Xiyong (2005), Li et al. (2007), Yuan-ming (2007), Zhang et al. (2010), Zhang et al. (2011), Niu et al. (2013). Only the study of Zhao et al. (2008) performed quantitative research methods as developed a survey questionnaire to collect data on factors that affect construction costs of 35kV grid projects in Mongolia between 1998 and 2006, then factor analysis and multiple linear regression were applied to determine the impact level of each factor.

However, there are no any studies on grid projects that rank attributes causing construction cost overruns accoding to perspectives of stakeholders, namely: owner, consultant, contractor, supplier, and project manager. In addition, previous studies did not complete a comprehensive literature review as in this study on attributes causing cost overruns in many countries in the world and in many types of different construction projects. Finally, a part of this study is to analyse the consensus in perspectives of stakeholders on attributes of cost overruns, which is still not verified in former studies in grid projects. All these gaps as outlined above will be filled in this study.

III. RESEARCH METHODOLOGY

This study extends the current understanding on construction cost overruns in transmission grid projects. Initially, a literature review was done from previous studies in various regions in the world and in many different types of projects. Through the literature review, preliminary attributes causing cost overruns were identified.

Subsequently, from discussions with experts such as owners, contractors, project managers, managers of consulting firms who have many years of experience in the power industry and from the reality during the construction phase of projects, attributes are inappropriate with the context and characteristics of the power industry in Vietnam were eliminated. Therefore, only attributes actually caused cost overruns of grid projects were retained. These attributes were grouped into main groups, namely: policies, natural conditions, economy and finance, resources, robbery and collusion, and stakeholders (Table 1). After that, the survey questionnaire was developed based on these attributes. Through the questionnaire, the study aims to discover perspectives of owner, contractor, consultant, and supplier on the problem of construction cost overruns in grid projects.

Nextly, questionnaires were distributed to the participants. After the data gathered, Cronbach's alpha coefficient was calculated to assess the reliability of the given dataset. Factor analysis was also done to explore the latent structure of attributes. Based on the result of factor analysis, main factors causing construction cost overruns in transmission projects were identified. Another important analysis conducted is ranking the attributes of factors specified from factor analysis. As a result, the study can indicate what attributes cause cost overruns highly, moderately and lowly. Finally, to analyse the consensus in perspectives of stakeholders on attributes of cost overruns, Spearman's rank correlation coefficient was calculated to confirm result of the ranking.

IV. ATTRIBUTES CAUSING CONSTRUCTION COST OVERRUNS IN TRANSMISSION GRID PROJECTS

As explained above, although there are so many attributes causing construction cost overruns in projects from former studies, this study only considers attributes which are in proportion to the nature and context in the construction process of grid projects in Vietnam. Table 1 below lists the attributes of cost overruns in the study.

Table 1. Attributes causing construction cost overruns in transmission grid projects

<table>
<tr><th>Group</th><th>Authors</th></tr>
<tr><td>Related to policies</td><td></td></tr>
<tr><td>Unstable construction policies (laws, decrees and circulars)</td><td rowspan="3">Elinwa, A.U., Buba, S.A., 1993; Baloi, Daniel, and Andrew DF Price (2001); Baloi, D., and Price, A. D. F. (2003); Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Olawale, Y.A. and M Sun, 2010; Mahamid, Ibrahim (2014)</td></tr>
<tr><td>Inconsistent guideline of regulations to the reality</td></tr>
<tr><td>Inappropriate compensation and site clearance policies</td></tr>
</table>

Group	Authors
Unstable wage policies	
Unstable labor policies	
Import and export policies	
Tax policies	
Related to natural conditions	
Weather conditions	Arditi, David, Guzin Tarim Akan, and San Gurdamar (1985); Okpala, D.C. and A.N. h e k w q 1988; Dlakwa, M. M., and M. F. Culpin (1990); Elinwa, A.U. and S.A. Buba, 1993; Chan and Kumaraswamy (1997); Akinci, B., and Fischer, M. (1998); Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Okpala, D.C. and A.N. h e k w q 1988; Chimwaso, D.K., 2000; Baloi, Daniel, and Andrew DF Price (2001); Jackson, S., 2002; Baloi, D., and Price, A. D. F. (2003); Frimpong, Y., Oluwoye, J. and Crawford, L. (2003); Trost and Oberlender (2003); Flyvbjerg et al. (2003); Iyer, K. C., and Jha, K. N. (2005); Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Lee, Jin-Kyung (2008); Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Kaliba, C., Muya, M. and Mumba, K. (2009); Ali, A.S. and S.N.Kamaruzzaman, 2010; Olawale, Y.A. and M Sun, 2010; Mahamid, Ibrahim (2014); Cheng, Ying-Mei (2014); Shehu, Zayyana, Intan R. Endut, and Akintola Akintoye (2014)
Earthquakes and landslides	
Explosion and fire	
Adversely geological conditions	
Historical, cultural and religious monuments and residential areas	
Environmental impacts on space around projects	
Archaeological detections	
Related to economy and finance	
Inflation	Arditi, David, Guzin Tarim Akan, and San Gurdamar (1985); Okpala, D.C. and A.N. h e k w q 1988; Elinwa, A.U. and S.A. Buba, 1993; Kaming, P.F.,P.O. Olomolaiye,G.D.Holt and F.C. Harris, 1997; Akinci, B., and Fischer, M. (1998); Samset, K. (1998); Baloi, Daniel, and Andrew DF Price (2001); Jackson and Steven (2001); Jackson, S., 2002; Baloi, D., and Price, A. D. F. (2003); Frimpong, Y., Oluwoye, J. and Crawford, L. (2003); Trost and Oberlender (2003); Creedy, G., 2005; Koushki, P. A., Khalid Al-Rashid, and Nabil Kartam (2005); Omoregie, A. and D. Radford, 2006; Azhar, N., R.U. Farooqui and S.M. Ahme4 2008; Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Kaliba, C., Muya, M. and Mumba, K. (2009); Ameh, O.J., A.A. Soyingbe and K.T. Odusami, 2010; Ali, A.S. and
Unstable interest rates	
Exchange rates	
Price fluctuation of raw materials (sand, stone, iron, cement, copper and aluminum)	
Price fluctuation of finished raw materials (protective panel cabinets, accessories, iron pillars and wires)	
Fluctuation of labor cost	
Cost of construction	

Group	**Authors**
machinery Cost of insurance Transportation cost of materials and equipment to construction sites	S.N.Kamaruzzaman, 2010; Fugar, F., Agyakwah-Baah, A., 2010; Memon, A.H., I.A. Rahman, M.R. Abdullah and A.A.A. Azis, 2010;_Olawale, Y.A. and M Sun, 2010; Cheng, Ying-Mei (2014); Mahamid, Ibrahim (2014); Ismail, Ismaaini, Aftab Hameed Memon, and Ismail Abdul Rahman (2014); Shehu, Zayyana, Intan R. Endut, and Akintola Akintoye (2014)
Related to resources	
Shortage of qualified workforce Inadequate sources of materials and equipment Materials and equipment imported from foreign countries Lack of materials and equipment Late delivery of materials and equipment Systems of transportation	Arditi, David, Guzin Tarim Akan, and San Gurdamar (1985); Okpala, D.C. and A.N. h e k w q 1988; Dlakwa, M. M., and M. F. Culpin (1990); Elinwa, A.U., Buba, S.A., 1993; Baloi, Daniel, and Andrew DF Price (2001); Baloi, D., and Price, A. D. F. (2003); Frimpong, Y., Oluwoye, J. and Crawford, L. (2003); Long, N. D., Ogunlana, S., Quang, T., Lam, K. C., 2004; Kousliki, P.A. and N. Kartam, 2004; Creedy, G., 2005; Iyer, K. C., and Jha, K. N. (2005); Koushki, P. A., Khalid Al-Rashid, and Nabil Kartam (2005); Stoner, J.A.F., Freeman, R.E. and Gilbert, D.R. (2005); Omoregie, A. and D. Radford, 2006; Harisaweni, 2007; Moura, H.P.,J.C. Teixeira andB. Pires, 2007; Sambasivan, M., Soon, Y. W. 2007; Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Ali, A.S. and S.N.Kamaruzzaman, 2010; Fugar, F., Agyakwah-Baah, A., 2010; Olawale, Y.A. and M Sun, 2010; Alinaitwe, Henry, Ruth Apolot, and Dan Tindiwensi (2013); Cheng, Ying-Mei (2014); Ismail, Ismaaini, Aftab Hameed Memon, and Ismail Abdul Rahman (2014); Mahamid, Ibrahim (2014); Shehu, Zayyana, Intan R. Endut, and Akintola Akintoye (2014)
Related to robbery and collusion	
Security in construction sites Robbery Corruption on the quality and quantity of materials and equipment of stakeholders Collusion among stakeholders on estimated costs and settled costs of	Arditi, David, Guzin Tarim Akan, and San Gurdamar (1985); Okpala, D.C. and A.N. h e k w q 1988; Elinwa, A.U., Buba, S.A., 1993; Baloi, Daniel, and Andrew DF Price (2001); Baloi, D., and Price, A. D. F. (2003); Olawale, Y.A. and M Sun, 2010; Mahamid, Ibrahim (2014)

Group	**Authors**
projects	
Related to stakeholders	
Complexity and overlap of project management structure	Arditi, David, Guzin Tarim Akan, and San Gurdamar (1985); Okpala, D.C. and A.N. h e k w q 1988; Green (1989); Dlakwa, M. M., and M. F. Culpin (1990); Hicks, J. C. (1992); Elinwa, A.U., Buba, S.A., 1993; Mansfield, N. R., Ugwu, O. O., and Doran, T. (1994); Skitmore and Wilcock (1994); Chan, D. W. N., and Kumaraswamy, M. M. (1997); Kaming, P.F.,P.O. Olomolaiye,G.D.Holt and F.C. Harris, 1997;Akinci, B., and Fischer, M. (1998); Akintoye (2000); Chimwaso, D.K., 2000; Jackson and Steven (2001); Bubshait, A.A. and Al-Juwait, Y.A. (2002); Jackson, S., 2002; Knight, Karla, and Aminah Robinson Fayek (2002); Baloi, D., and Price, A. D. F. (2003); Flyvbjerg et al. (2003); Frimpong, Y., Oluwoye, J. and Crawford, L. (2003); Kousliki, P.A. and N. Kartam, 2004; Long, N. D., Ogunlana, S., Quang, T., Lam, K. C., 2004; Creedy, G., 2005; Iyer, K. C., and Jha, K. N. (2005); Koushki, P. A., Khalid Al-Rashid, and Nabil Kartam (2005); Berechman, J. and Wu, Q. (2006); Cheung et al. (2006); Omoregie, A. and D. Radford, 2006; Alinaitwe, H.M., Mwakali, J.A. and Hansson, B. (2007); Oladapo, A.A., 2007; Harisaweni, 2007; Moura, H.P.,J.C. Teixeira andB. Pires, 2007; Sambasivan, M., Soon, Y. W. 2007.; Azhar, N., R.U. Farooqui and S.M. Ahme4 2008; Le-Hoai, L., Y.D. Lee and J.Y. Lee, 2008; Masambaji, C.N. and Ssegawa, J.K. (2008); Doloi (2009); Enshassi, A., Al-Najjar, J., and Kumaraswamy, M. (2009); Ali, A.S. and S.N.Kamaruzzaman, 2010; Ameh, O.J., A.A. Soyingbe and K.T. Odusami, 2010; Fugar, F., Agyakwah-Baah, A., 2010; Memon, A.H., I.A. Rahman, M.R. Abdullah and A.A.A. Azis, 2010; Olawale, Y.A. and M Sun, 2010; Rahman, Ismail Abdul, Aftab Hameed Memon, and Ahmad Tarmizi Abd Karim (2013); Cheng, Ying-Mei (2014); Ismail, Ismaaini, Aftab Hameed Memon, and Ismail Abdul Rahman (2014); Mahamid, Ibrahim (2014); Memon, A. H., Abdul Rahman, I., Aziz, A., & Asmi, A. (2014); Shehu, Zayyana, Intan R. Endut, and Akintola Akintoye (2014)
Incompetence of project manager	
Deficiencies in planning and scheduling	
Inaccurate estimation	
Ineffective cooperation between owner and project manager	
Ineffective cooperation between main contractors and subcontractors	
Inadequate supervision and inspection in construction sites	
Poor control of costs in construction sites	
Waste of materials and equipment in construction sites	
Relationship between managers and employees of construction contractors	
Working conditions and facilities in construction sites	
Financial difficulties of stakeholders	
Incompetence of main contractors and subcontractors	
Incompetence of construction supervision consultants and design consultants	

V. THE SURVEY QUESTIONNAIRE AND CHARACTERISTICS OF THE SAMPLE

In the study, the survey questionnaire is divided into two parts: the first part mentions main attributes causing construction cost overruns in grid projects to discover perspectives of stakeholders on the risk level of attributes on the Likert scale of 5 points according to the descending: 5 (extremely high), 4 (high), 3 (moderate), 2 (low), 1 (extremely low). The second part is structured to collect information of respondents such as work experience, positions involved in projects, types of project funding. After considering carefully the questionnaire developed, questionnaires were distributed to the participants.

Data collection is implemented through sending questionnaires and email to stakeholders of projects, namely: owner, consultant, contractor, supplier and project manager. The number of respondents is 261, including 22 respondents by electronic mail (in total of 40 questionnaires deliveried) and 258 respondents by direct survey (in total of 330 questionnaires sent) but there were 19 invalid questionnaires. The descriptive statistics of the sample collected are illustrated in Table 2 as follows:

Table 2. Characteristics of the sample

Years of experience	%	Positions involved in projects	%	Fund of projects	%
2 to 5	7.3	Owner	14.2	Budget of the State	5.4
5 to 10	51	Consultant	14.9	Business investment capital	9.6
10 to 20	26.4	Contractor	18.8	Official Development Assistance (ODA)	81.2
Over 20	15.3	Supplier	6.5	100% foreign capital	2.7
		Project manager	45.6	Venture capital	1.1

In Table 2, work experience of respondents in grid projects involves: 7.3% of respondents are from 2 to 5 years of experience, 51% between 5 and 10 years, 26.4% from 10 to 20 years and 15.3% more than 20 years of experience. Obviously, there is more than 90% of respondents having more than 5 years of experience, so the data collected has the high reliability for analyses.

Positions involved in projects are as follows: 14.2% of respondents are owner of projects, 14.9% of consultant, 18.8% of contractor, 6.5% of supplier and 45.6% of project manager. This points out that the data collected has the significant objectivity because it gets a variety of perspectives of all stakeholders in grid projects.

VI. FACTOR ANALYSIS

After the data collected, the study evaluated the reliability of the given dataset by Cronbach's alpha coefficient. Several attributes were removed because Item-total correlation coefficients were lower than 0.3. Finally, Cronbach's alpha coefficient is equal to 0.85, so the dataset is statistically reliable. Subsequently, factor analysis was used to shorten information of all attributes with mutual correlations into the dataset but still containing most of the information of observed attributes (Tabachnick and Fidell 2007). The study used KMO and Bartlett's Test to examine whether observed attributes are mutually correlated or not. If they are mutually correlated, the dataset is suitable for factor analysis. Requirements for factor analysis are that: KMO coefficient must be higher than 0.5, Sig. lower than 0.05, factor loading higher or equal to 0.5, and total variance explained greater than 50%. In addition, disparity among factor loading coefficients of an attribute loading simultaneously on factors must be greater than 0.3 to ensure the distinct value among factors (Tabachnick and Fidell 2007). The result shows that KMO coefficient is equal to 0.799 (higher than 0.6) and Bartlett's Test is statistically significant (Sig. lower than 0.05), so attributes are mutually correlated. Therefore, the data collected is appropriate for performing factor analysis.

The process of conducting factor analysis also eliminated unappropriate attributes based on the criteria stated above. The result of factor analysis indicates that total variance explained is equal to 71.5% (higher than 50%), thereby seven factors extracted can represent 71.5% of the initial data (Table 3).

Table 3. Variance explained by factors extracted and factor loading of attributes

	Factors							Variance explained (%)
	1	2	3	4	5	6	7	
Archaeological detections	0.83							34.9
Earthquakes and landslides	0.78							
Price fluctuation of raw materials (sand, stone, iron, cement, copper and aluminum)	0.76							
Weather conditions	0.73							
Inflation	0.67							
Unstable interest rates	0.64							
Adversely geological conditions	0.61							
Lack of materials and equipment		0.85						9.7
Late delivery of materials and equipment		0.80						
Materials and equipment imported from foreign countries		0.80						
Collusion among stakeholders on estimated costs and settled costs of projects		0.80						
Corruption on the quality and quantity of materials and equipment of stakeholders		0.70						
Inadequate sources of materials and equipment		0.63						
Shortage of qualified workforce		0.59						
Incompetence of construction supervision consultants and design consultants			0.80					7.6

	Factors							Variance explained (%)
	1	**2**	**3**	**4**	**5**	**6**	**7**	
Incompetence of main contractors and subcontractors			0.72					
Incompetence of project manager			0.72					
Inaccurate estimation			0.57					
Inadequate supervision and inspection in construction sites			0.54					
Unstable labor policies				0.86				5.9
Unstable wage policies				0.64				
Tax policies				0.59				
Exchange rates				0.57				
Fluctuation of labor cost				0.50				
Inappropriate compensation and site clearance policies					0.75			5.2
Unstable construction policies (laws, decrees and circulars)					0.70			
Import and export policies					0.57			
Inconsistent guideline of regulations to the reality					0.56			
Relationship between managers and the workforce of construction contractors						0.74		4.3
Ineffective cooperation between main contractors and subcontractors						0.73		
Price fluctuation of finished raw materials (protective panel cabinets, accessories, iron pillars and wires)							0.68	3.9
Transportation cost of materials and equipment to construction sites							0.57	
Cost of construction machinery							0.56	
Total variance explained (%)								**71.5**

Based on characteristics of attributes of factors, the study renames factors, namely: Adverse objective attributes; Management to human and construction resources; Competence of stakeholders; Policies of the Government; Construction policies; Relationships among main contractors, subcontractors, the workforce; and Cost of materials and equipment.

VII. DISCUSSION OF THE FACTOR ANALYSIS RESULT

Factor 1: Adverse objective attributes

Vietnam is located in the tropical monsoon area, one of the five stormy regions in Asian Pacific, and often faces different types of natural disasters. Thus, this has caused huge losses to property and infrastructure of the economy as well as result in adverse environmental impacts. According to the report on Global Climate Risk Index 2010 announced by Germanwatch Organization, Vietnam is one of the ten countries affected largely by natural disasters. Consequently, it is not difficult to understand that the construction of grid projects has been impacted severely by earthquakes and landslides, bad weather and geological conditions, and ultimately, leading to construction cost overruns of projects.

The other disadvantageously objective attributes concern the economic aspect causing cost overruns, are: price fluctuation of raw materials, inflation, and unstable interest rates. Indeed, raw materials is one of the most critical elements in the implementation of projects. If cost of raw materials fluctuates, certainly there will be a inevitable construction cost overrun.

In addition, inflation and unstable interest rates must be mentioned. In recent years, inflation and unstable interest rates impact negatively on the development of Vietnam in general and of the power industry in particular. The inflation rate is likely to rise continuously and will have a significant impact on construction costs, such as: cost of materials and equipment, wage cost and management cost. This will undermine the growth in the medium and long term of the power industry. Therefore, unstable interest rates and inflation are always the two leading attributes causing cost overruns.

Factor 2: Management to human and construction resources

In Vietnam, construction costs of grid projects usually include 60-70% of materials and equipment cost, 10-20% of labor cost and 10-20% of machinery cost (Department of Sales, Vietnam Power Corporation). Therefore, construction resources are often the matter concerned firstly and meeting the demand on resources is always the big problem as projects implemented. However, due to difficult conditions in the construction phase related materials and equipment as: lack of materials and equipment, late delivery of materials and equipment, materials and equipment imported from foreign countries, and inadequate sources of materials and equipment; projects often do not have enough materials and equipment used for the construction process. This results in delays and probably in construction cost overruns of projects. Obviously, the difficulties related to materials and equipment are largely due to inefficiencies in planning procurement and the poor management of managers.

For human resources, shortage of qualified workforce makes works completed with undesired quality and consuming more time to finish them. On the other hand, the fact that stakeholders are not monitored and examined regularly. Specifically, issues such as: collusion and corruption which always occur in estimating and settling costs of grid projects. Second, it is corruption on the quality and quantity of materials and equipment of stakeholders. Persistent problems above always make projects in the state of cost overruns. In general, all the attributes of this factor manifest the characteristic of poor management to human and construction resources of project manager, contractor, and consultant.

Factor 3: Competence of stakeholders

Project management plays a very crucial role to make the success of grid projects. This is an important element but unfortunately, most of the stakeholders, namely: project manager, contractor and consultant, still underestimate or are poor in the competence of project management. Planning and controlling grid projects emphasize on competence of project manager in understanding scope of projects clearly, maintaining cash flow steadily throughout projects, and making decisions accurately and timely. This competence is very important to control cost overruns but project managers does not really manage these problems well.

For contractors, ineffective sites management mentions problems such as wasteful use of resources, control of materials and equipment, low labor productivity, scheduling and estimating costs for activities inaccurately, and selecting unappropriate construction methods on sites. This shows that ineffective management impact negatively on contractors in completing works, thus causing cost overruns for projects. The effectiveness of contractors also has impacts on construction costs of grid projects. Lack of management skills and technical ability are reasons for ineffectiveness of contractors in stabilizing construction costs. Although maintaining effectiveness of activities is the responsibility of contractors during the construction phase, the responsibility to select qualified contractors is under the authority of project manager.

Incompetence of design consultants to understand demands of owners and provide owners with advices on issues concerning design as well as incompetence of construction supervision consultants to supervise and inspect activities in the construction phase, make projects carried out differently to desire of owners, so reworks often occur and construction costs are in overrun.

For inaccurate estimation, the contractor is the last responsible stakeholder for inaccurate estimation causing cost overruns but project manager and owner are also responsible for this problem, partly due to lack of qualified estimators and estimation managers.

Factor 4: Policies of the Government

Policies of the Government are one of the main factors causing construction cost overruns of grid projects, including: unstable labor policies, unstable wage policies, and tax policies. These unstable policies make uncertainties for activities and plans of contractors in executing projects. Moreover, the increase of exchange rates also affects price of raw materials (sand, stone, iron, cement, copper and aluminum) and price of finished raw materials (protective panel cabinets, accessories, iron pillars and wires) sharply. Electrical materials and equipment used for transmission projects are often produced by high technology, so most of them are imported from foreign countries and account for 60% - 70% of the proportion of projects budget. Therefore, exchange rates impact significantly on construction costs of projects.

Factor 5: Construction policies

The compensation and site clearance are also works of economic and social fields, so in order to implement effectively, require the close coordination among stakeholders, the local government, the resident around projects. To develop transmission grid projects, in addition to technical and capital issues, the compensation and site clearance are particularly important, deciding the success of projects. When the compensation is implemented smoothly, the site clearance will be performed quickly and corridors are cleared. This creates advantage conditions for construction as well as safety of grids as projects are completed and put into operation. Many transmission projects have huge investment capital but the compensation and site clearance are not done effectively, so the construction is still delayed. This wastes time and availability of workforce, especially increase of construction costs.

For import and export policies such as quota. In Vietnam, quota occasionally restricts the quantity of materials and equipment for grid projects under regulations of the state, which are imported from other countries in a certain time period. In addition, unstable construction policies (laws, decrees and circulars) and inconsistent guideline of regulations to the reality sometimes make construction plans altered and increase risks and costs during the construction phase.

Factor 6: Relationships among main contractors, subcontractors, the workforce

Main contractors are responsible for the construction of grid projects but they rely upon subcontractors to perform a part of projects. However, cooperations in their works often do not achieve desired results and this leads to cost overruns. Therefore, to achieve successful projects, main contractors and subcontractors must develop long-term and effective relationships. On the other hand, several main contractors focus highly on maximizing their profits. They select subcontractors with lowest construction costs and usually squeeze costs, so subcontractors confront financial difficulties regularly. With this attitude, this is not an effective way to maintain the relationship between them. Many situations that main contractors and subcontractors work together without detailed plans and programs.

Furthermore, communication is very important in the cooperation among main contractors, subcontractors, the workforce. It allows the continuous connection to comply with responsibilities and roles in grid projects. Nevertheless, deficiencies in communication among them in the construction process hinder their ability to meet schedule and goals, so leading to delays and conflicts affecting activities on sites, and thereby construction cost overruns of grid projects. Therefore, building a appropriate communication process is their shared responsibility.

Factor 7: Cost of materials and equipment

For price fluctuation of finished raw materials (protective panel cabinets, accessories, iron pillars and wires), this attribute is partly due to monopoly of suppliers. Suppliers recognize that demands of projects for finished raw materials rise but production capability of the country does not respond promptly. Consequently, suppliers store finished materials for a long time, their aim is to push price higher.

Another problem, grid projects in the south of Vietnam are usually constructed in locations that are far from residential areas, so the transportation of materials and equipment to sites has many difficulties and gets more cost. Moreover, infrastructure conditions, which are not advantageous in some areas, make time for transportation of materials and equipment becoming longer. In addition, in many cases, materials and equipment are damaged due to careless transportation and installation but there are no alternative materials and equipment.

For cost of construction machinery, in grid projects, types of construction machinery are often used inappropriately as planned initially based on performance of each type of machinery. Redundant machinery allocation increases operation costs, which in part increases construction costs of projects.

VIII. RANKING THE ATTRIBUTES CAUSING CONSTRUCTION COST OVERRUNS IN GRID PROJECTS

The study ranked the attributes of seven key factors extracted from the result of factor analysis that cause construction cost overruns based on mean value. Mean value used to rank the attributes was divided into 6 groups: overall, owner, consultant, contractor, project manager and supplier (Table 4).

Table 4. Mean and rank of the attributes causing construction cost overruns

	Overall		Owner		Consultant		Contractor		Project manager		Supplier	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Incompetence of project manager	3.97	1	4.00	2	3.92	2	3.98	1	3.93	3	4.29	2
Incompetence of construction supervision consultants and design consultants	3.97	2	4.11	1	4.05	1	3.86	2	3.92	4	4.06	7
Unstable interest rates	3.90	3	3.92	5	3.87	3	3.80	3	3.95	1	3.88	9
Unstable construction policies (laws, decrees and circulars)	3.85	4	3.97	3	3.85	5	3.61	7	3.91	5	3.88	10
Inappropriate compensation and site clearance policies	3.82	5	3.86	7	3.85	6	3.55	10	3.93	2	3.71	14
Collusion among stakeholders on estimated costs and settled costs of projects	3.82	6	3.95	4	3.85	4	3.71	4	3.76	6	4.24	4

	Overall		Owner		Consultant		Contractor		Project manager		Supplier	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Inflation	3.77	7	3.78	11	3.72	9	3.69	5	3.76	7	4.12	6
Incompetence of main contractors and subcontractors	3.72	8	3.84	8	3.79	7	3.61	6	3.70	8	3.82	11
Archaeological detections	3.72	9	3.92	6	3.69	10	3.57	8	3.65	9	4.35	1
Corruption on the quality and quantity of materials and equipment of stakeholders	3.67	10	3.81	9	3.72	8	3.49	11	3.61	10	4.12	5
Inadequate supervision and inspection in construction sites	3.66	11	3.78	12	3.64	12	3.57	9	3.61	11	3.94	8
Lack of materials and equipment	3.59	12	3.78	10	3.67	11	3.35	16	3.51	13	4.29	3
Earthquakes and landslides	3.52	13	3.70	13	3.51	17	3.43	13	3.46	17	3.76	13
Price fluctuation of raw materials (sand, stone, iron, cement, copper and aluminum)	3.50	14	3.43	21	3.41	24	3.41	14	3.58	12	3.53	20
Materials and equipment imported from foreign countries	3.48	15	3.59	14	3.54	14	3.24	20	3.50	15	3.65	15
Inaccurate estimation	3.48	16	3.57	15	3.49	21	3.47	12	3.44	18	3.53	19
Late delivery of materials and equipment	3.46	17	3.54	16	3.51	15	3.22	22	3.49	16	3.59	16
Inconsistent guideline of regulations to the reality	3.43	18	3.54	17	3.49	18	3.20	23	3.51	14	3.18	27
Fluctuation of labor cost	3.40	19	3.51	18	3.56	13	3.31	17	3.34	22	3.47	22
Ineffective cooperation between main contractors and subcontractors	3.40	20	3.41	22	3.49	20	3.39	15	3.39	19	3.24	26
Relationship between managers and the workforce of construction contractors	3.38	21	3.46	20	3.49	19	3.27	19	3.34	21	3.53	18
Weather conditions	3.35	22	3.46	19	3.41	22	3.14	25	3.39	20	3.35	24
Adversely geological conditions	3.35	23	3.41	24	3.41	23	3.31	18	3.26	24	3.82	12
Price fluctuation of finished raw materials (protective panel cabinets, accessories, iron pillars and wires)	3.30	24	3.41	23	3.51	16	3.24	21	3.18	27	3.59	17

	Overall		Owner		Consultant		Contractor		Project manager		Supplier	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Exchange rates	3.27	25	3.27	27	3.18	28	3.16	24	3.32	23	3.41	23
Tax policies	3.24	26	3.32	26	3.31	25	3.14	26	3.24	25	3.12	28
Shortage of qualified workforce	3.21	27	3.35	25	3.26	26	3.12	27	3.14	29	3.47	21
Inadequate sources of materials and equipment	3.19	28	3.22	28	3.23	27	3.08	28	3.20	26	3.29	25
Unstable wage policies	3.11	29	3.16	31	3.13	29	3.00	29	3.13	30	3.12	30
Import and export policies	3.09	30	3.19	30	3.10	30	2.92	30	3.16	28	3.12	32
Transportation cost of materials and equipment to construction sites	3.02	31	3.19	29	3.05	31	2.76	31	3.04	31	2.94	29
Cost of construction equipment	2.83	32	3.03	32	2.90	32	2.69	32	2.78	33	2.88	31
Unstable labor policies	2.69	33	2.70	33	2.79	33	2.51	33	2.80	32	2.18	33

In Table 4, according to overall perspective, almost all attributes have mean value greater than 3, only 2 attributes have mean value less than 3 (Cost of construction equipment and Unstable labor policies). Meanwhile, based on other perspectives, results are also highly similar to that of overall perspective: there is only 1 attribute that mean value is lower than 3 in accordance with perspective of the owner, 2 attributes based on perspective of the consultant and project manager, 3 attributes and 4 attributes according to perspective of the supplier and the contractor, respectively. This proves that most of the attributes really cause construction cost overruns highly for grid projects accoding to perspectives of stakeholders.

Overall perspective reveals that Incompetence of project manager gets the first rank as the attribute causes highest cost overruns, and the contractor also have the same evaluation. Meanwhile, the owner, the consultant, and the supplier assess this attribute at the second rank and Project Management Board ranks it at the third.

In contrast, Incompetence of construction supervision consultants and design consultants is recognized as the riskiest attribute based on perspective of the owner and the consultant, which is evaluated at the second rank according to overall and contractor perspectives, and only assessed at the fourth and seventh rank in accordance with project manager and the supplier.

Nextly, according to project manager, Unstable Interest rates is the riskiest attribute on construction costs, other stakeholders also have the highly similar evaluation. However, the supplier only rank this attribute at the ninth.

Finally, based on perspective of supplier, Archaeological detections really causes highest cost overruns whilst other stakeholders do not agree with this assessment. Indeed, in accordance with overall perspective and project manager, this attribute is only ranked at the ninth, the owner is at the sixth, the consultant is at the tenth, and the contractor is at the eighth.

Whilst Unstable labor policies is ranked as the second lowest risky attribute (at the thirty-second rank) on construction costs by project manager; owner, consultant, contractor, supplier and overall perspective totally agree that it is the lowest risky attribute on costs. For Cost of construction equipment, four stakeholders rank it at the thirty-second, supplier and project manager assess it at the thirty-first rank and thirty-three rank, respectively. Clearly, these two attributes are always ranked at the lowest ranks.

Moreover, as considering the attributes from the highest rank to the lowest rank of all stakeholders, it can be easily to recognize that although ranks of the attributes change among stakeholders, this change is not significant. If considered carefully, this change follows the rule: according to overall perspective, if which attributes get highest or lowest ranks, generally based on perspectives of stakeholders, they are still evaluated as highest or lowest risky attributes on construction costs of transmission grid projects. This also shows that perspectives of all stakeholders achieve the high consensus. In the next section, Spearman's rank correlation coefficient will be calculated to prove this statement.

IX. SPEARMAN'S RANK CORRELATION COEFFICIENT

Table 5. Spearman's rank correlation coefficient

r	The owner	The consultant	The contractor	Project Management Board	The supplier
Owner	1	0.97	0.93	0.95	0.88
Consultant		1	0.91	0.92	0.87
Contractor			1	0.92	0.87
Project manager				1	0.81
Supplier					1

In Table 5, correlation coefficients among the stakeholders of grid projects are significantly high, approximately 0.9; even the correlation coefficient between the owner and the consultant is equal to 0.97, between owner and project manager is 0.95, nearly 1. This presents all stakeholders basically recognize that: Incompetence of project manager, Incompetence of construction supervision consultants and design consultants, Unstable interest rates, Unstable construction policies, and Inappropriate compensation and site clearance policies, cause highest construction cost overruns. In addition, Unstable wage policies, Import and export policies, Transportation cost of materials and equipment to construction sites, Cost of construction equipment, and Unstable labor policies cause lowest construction cost overruns. To sum up, perspectives of all stakeholders achieve the high consensus on the problem of construction cost overruns in transmission grid projects.

X. CONCLUSION

This study analyses the problem of construction cost overruns in transmission grid projects. First of all, attributes causing construction cost overruns were specified from the reality during the construction phase of projects, from previous studies, and from discussions with experts in the power industry. The data for analyses of the study was collected through survey questionnaires. Subsequently, factor analysis was performed and seven main factors were also extracted, including: Management to human and construction resources; Competence of stakeholders; Policies of the Government; Construction policies; Relationships among main contractors, subcontractors, the workforce; Cost of materials and equipment; and Adverse objective attributes. Moreover, from the factor analysis result, the study ranked the attributes of seven main factors based on mean value. The result revealed that attributes causing highest construction cost overruns are: Incompetence of project manager, Incompetence of construction supervision consultants and design consultants, Unstable interest rates, Unstable construction policies, and Inappropriate compensation and site clearance policies, cause highest construction cost overruns. Ultimately, Spearman's rank correlation coefficient was also calculated and the result pointed out that perspectives of stakeholders on attributes causing cost overruns in transmission grid projects have the high consensus.

Further, the findings of this study may become the basis for future studies on attributes causing construction cost overruns in grid projects in different regions. However, further studies need to perform literature review to determine exactly attributes causing cost overruns that correspond with characteristics of the construction phase in those regions, and so, findings of further studies can be compared to the findings of this study to discover differences in perspectives on the problem of cost overruns in the power industry in various countries.

Acknowledgements

The authors would like to express the gratitude to Ms. Nguyen Thanh Thuy, a manager who is working in Southern Power Corporation (EVN SPC), Vietnam for the data collection. This work was supported by the Pukyong National University Research Abroad Fund in 2017(C-D-2017-0972).

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