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Cost Management of Gas-Fired Plant Construction: A Case Study of National Integrated Power Project, Abia State, Nigeria

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Abstract: ***This study involves the identification and management of factors that are perceived to engender high project costs variation and overrun of gas plant using the construction of a 506MW gas fired power plant situated in Abia State, built as part of government's concerted effort towards increasing generation capacity whilst the power sector undergoes reforms as a case study. In this study, SWOT analysis in conjunction with industry expert interviews were carried out to identify perceived factors and risks that could lead to cost overrun and subsequently generating questionnaires to measure the industry view of the extent to which these factors are thought to impact on costs. The research methods applied for analyzing the data were the Kendall's statistic of concordance (w) and the Principal Component Analysis (PCA).The Kendall's w showed 146% level of agreement which was unrealistic, while the PCA showed 58% of agreement Therefore, it was discovered that there was more agreement or concordance towards some categories of risk factors than others concerning impactful costs. Economic related factors showed 66.9% level of agreement, political related factors showed 51.5% level of agreement, construction specific factor showed 44% level of agreement and Estimator cost factor related activities showed 37.4% level of agreement. Economic related risk factors were found to be the major cause of cost escalation. Risk and cost management approaches were then proffered that could minimize the effect of these risk factors on future power plant construction projects.***

Keywords: Gas Fired Power Plant, SWOT Analysis, Kendall's Statistic, and Principal Component Analysis, Abia State.

I. INTRODUCTION

Project cost overruns or escalation can be referred to as the digression of terminal project costs (post construction) from the original budget (Dawood et al., 2001). A number of factors such as design or scope changes, increase in cost of materials, labour and economic factors that increase the final total cost above initial predicted cost accounts for cost overruns. Results from first-hand studies indicate that some critical factors are responsible for project cost overruns, namely poor site management, price fluctuations due to inflation and exchange rates, schedule delay, cash flow, delayed payment to contractors, poor quality workmanship, budget shortfall, and project schedule variation (Mukuka , 2014). In line with work by Sovacool (2014), cost analysis was carried out on four hundred and one (401) power plants and transmission projects in fifty-seven (57) countries built within the period of 1936 – 2014. The findings revealed that costs were underestimated in at least three out of every four projects, and just about thirty-nine (39) of the projects were devoid of cost over- and under-runs. Land use and permits, risks premiums, and contingencies were identified as some of the soft costs within these expenses. The work also emphasized that the prevalence and size of the overruns varied by capacity, location and fuel source. Notwithstanding these findings, it can be said that cost of electricity projects is challenging to forecast.

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Studies reveal a connection between the level of assessed project cost and the cost variation. It implies that the higher the cost, the less correct the estimate. An analysis by Emuze and Ravu (2014) has also indicated that cost overruns is associated with major projects and is a hindrance to increase of infrastructure projects in Africa. It also asserts that contract value, complexity and competitive tendering contribute substantially to project cost overruns. Whatever the case (cost overrun or underrun), the focus or objective of the enterprise should be the optimal use of funds through efficient allocation and management, which is obtained through planning, control of costs and schedules. Hence the need for application of cost management principles.

Cost management is therefore an aspect of cost accounting that analyses cost information relevant for planning, controlling and decision making (Hansen and Mowen, 2006). It is crucial regarding the import of continuous enhancement of the business and planning the costs (costs of resources) of doing business. Each projects within an organization is required to have a customized cost management plan, with management as a whole integrating cost management into their enterprise business model. If effectively implemented, the result is lean management rolling over to added profits. Applying cost management in the context of a single project for instance, the perceived expenditures are identified, measured and approved prior to purchasing or procurement. During the process of completing a project, all incurred costs are indicated and analyzed to ensure that costs are constrained in line with initial expectations, to the degree possible and accepted to prevent overspending in existing and future projects.

The Electricity sector no doubt represents a pivotal sector of any nation's economy. Therefore, any nation that desires meaningful socio-economic growth cannot ill-afford the negative implications of an inefficient power supply chain. Several reasons have accounted for the shortfall or supply gap in the generation of power in Nigeria. According to a report presented by the Electric power sector team of the Bureau for Public Enterprises (BPE) Nigeria, the basis could be the underutilization of existing power plants, inadequate funding, high technical losses, vandalism, insufficient transmission and distribution facilities, careless use of electricity by consumers, inappropriate industry and market structure and ineffectual power sector governance.

Despite consistent perceived cash investment by the Federal Government of Nigeria, the impact of the National Integrated Power Projects (NIPP) is yet to be felt as the process of projects' completion has indeed been slower than projected and the gap between investment and extra megawatts achieved is very wide. The major case study considered in this work is a gas power station in Abia State, Nigeria, under the National Integrated Power Projects. It is the design, procure, construct and commissioning of a 505MW gas-fired power plant with its associated 330kV Switchyard that will, in its first phase, generate capacity 504MW of electric power with 459MW net output to the National Grid through an existing transmission Substation.

It is an industry norm that if completion and commissioning does not take place within 36 - 60 months, construction expenses would increase by about 25% of initial costs particularly those with capacity of not more than l50 MW. By 2007, at the time of the suspension, US$2.8 billion was already invested in NIPP, including US$1.78 billion in funded letters of credits which allowed some of the projects to continue despite the funding interruption. Contracted commitments totalled US$7.385 billion. In view of these, 8 - 10 years down the line, the reference NIPP has not been completely delivered to the nation as envisaged with a total $8billion so far been sunk into the NIPP.

According to a government report (NDPHC, 2013), the initial contract sum for the reference power project was US$l64,485,525.54 (PHCN Contract, simple cycle), but by May, 2015, ten years later, the simple cycle phase of the project had gulped a total sum of US$744,000, 000 leading to a unit cost of US$1,377,777.8 per MW which is above a worldwide threshold of $1,000,000.00 per MW.

The focus of this work is the identification of the risk factors that affect cost or promote cost escalation by way of evaluating the project and to develop mitigating measures to keep cost within range. In view of the current wave of privatization

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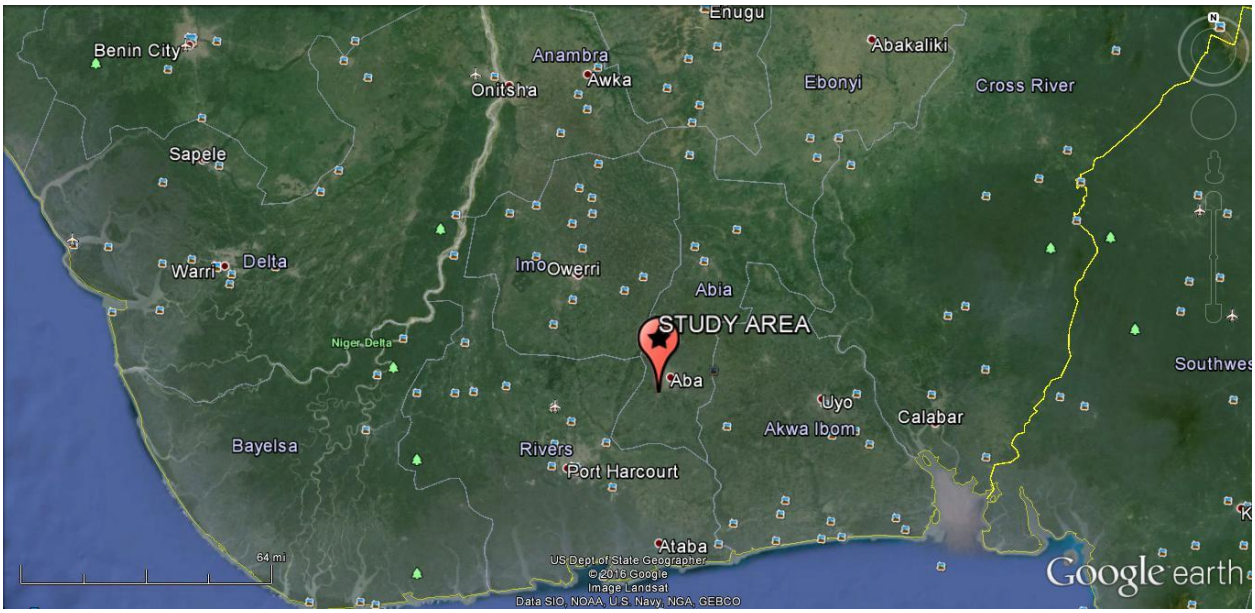
in the sector, enlighten potential and existing project developers on the main factors to look out for in planning and executing power projects in Nigeria, to enhance revenue payback period, Internal Rate of Return, and Net Present Value.

II. MATERIALS AND METHODS

2.1 STUDY AREA

The study area with co-ordinates as 5°04′00″N 7°19′24″E is located at Alaoji along the Aba-Owerri express way close to a major transmission substation.Aba is a major urban centre and a commercial hub of the south-eastern Nigeria, boasting of above 1.5 million houses, Abia State Government, ASG (2015), with the population comprising of artisans, traders, and business persons. It is the home of Ariaria international market, projected to be the biggest market in West Africa, Aba textile mills and a glass industry, brewery, and distillery (See Figure 1).



Source: Google Earth (2016)

Figure 1: Map of Study area, within Aba, Abia State, Nigeria

2.2 DATA COLLECTION

In order to determine factors that could impede the progress of a gas plant project, contributing to costs, the SWOT analysis was carried out. Some possible factors imagined to impede the progress were put up as a questionnaire of 20 top risk factors (Ijioma, 2015). Theses questionnaires were presented to engineers, construction experts, consultants, stakeholders and academicians related to the power sector as to gather data needed to certify the level of agreement amongst them on the degree of impact, each factor or group of factors have on the total cost of the project.

The risk factors presented in the questionnaire were categorised into four groups for the purpose of ranking them. These groups are as listed:

i). Estimator cost factor which comprises of Poor feasibility studies; Change in scope (Logistics/ access route); and Change in Scope (new facility);

ii). Contract and Construction specific, which comprises of Non-harmonization of contract to EPC Contractor; Lump Sum contract by EPC contractor; Non-timely payment of contractor; and Schedule Variance;

iii). Economic environment specific, which comprises of No firm gas agreement and pricing between Government and IOCs; Inadequate gas supply infrastructure; Demurrage incurred at Port/Loss of warranty; Degradation of equipment during demurrage; Improper pricing of electricity; Inadequate skilled local workforce; Exchange Rate; and Inflation; and

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iv). Political Environment that comprises of Nigerian problem of managing money; Labour Action; Political Force majeure; Political influence and beaureucracy; and Insecurity.

III. RESULTS AND DISCUSSION

3.1 RESULTS

The feedback given in the questionnaires were rounded up to give a total number of respondent views on each risk factor (See Table 1). The summarized data (See Table 2) were then subjected to the following methods of statistical analysis, viz:

i). Kendall's W- Statistic to evaluate the level of agreement among the respondents; and

ii). Principal component analysis (Excel Add-in)

All these were done to evaluate the level of agreement amongst respondents.

Table 1: Respondent's frequency tableau on various risk factors

S/N	Questionnaire Parameter		Answer options ±			
		SA	A	NI	DA	SD
1	Poor feasibility studies	8	4	6	4	-
2	Insecurity	4	15	1	2	-
3	Schedule variance	7	14	1	-	-
4	Political influence and beaureucracy	8	12	2	-	-
5	Lump sum contract by EPC contractor	4	3	13	1	1
6	Demurrage incurred at port	3	13	3	1	2
7	Inadequate gas supply infrastructure	8	13	1	0	-
8	No firm gas agreement between Government and IOCs	4	12	6	-	-
9	Non-timely payment of contractor	6	8	4	3	1
10	Exchange rate	3	7	6	5	1
11	Inflation	3	15	2	1	1
12	Inadequate skilled local workforce	3	10	3	5	1
13	Political force majeure	4	5	9	3	1
14	Labor action	2	-	9	9	2
15	Degradation of equipment during demurrage	-	9	9	3	1
16	Change in scope (4^{th} turbine addition)	-	10	11	1	-
17	Change in scope (logistics/access)	9	13	-	-	-
18	Improper pricing of electricity	3	4	10	1	4
19	Nigerian problem of managing money	-	8	4	4	6
20	Non-harmonization of contract to EPC contractor	-	2	12	4	4

±SA = strongly agree; A = Agree; NI=No idea, DA =Disagree; SD = strongly disagree

Table 2: Summary for Questionnaire Responses (questions and individual responses)

± RDT	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
R1	4	4	3	4	5	4	4	4	4	3	4	4	3	3	3	3	5	3	4	2
R2	2	2	4	4	4	4	4	4	5	4	4	2	2	2	3	4	5	1	3	2
R3	5	4	4	4	3	4	4	4	4	2	4	3	4	3	3	4	5	3	4	2
R4	4	4	4	4	3	4	4	4	3	3	4	4	3	3	4	3	4	4	4	4
R5	3	4	4	4	3	4	4	4	4	3	4	3	3	3	4	3	4	4	4	3
R6	3	4	4	4	3	3	4	4	3	4	4	4	2	2	4	3	5	3	4	3
R7	5	4	4	4	4	2	4	4	4	2	4	2	2	2	4	4	4	4	1	1
R8	2	5	4	5	2	4	4	4	5	4	4	2	4	2	4	2	5	1	1	2
R9	3	4	4	4	3	3	5	4	4	4	3	3	4	3	3	4	5	3	2	1
R10	5	4	4	3	3	4	5	3	4	3	4	4	3	3	3	3	4	3	4	3
R11	3	4	5	5	3	4	5	4	5	2	4	4	3	2	4	4	5	3	3	4
R12	4	4	5	4	3	4	5	5	5	4	4	4	4	3	3	3	4	3	4	3
R13	3	4	4	4	3	3	4	4	4	4	4	4	3	3	3	3	4	3	3	3
R14	2	5	5	5	5	1	5	5	2	5	5	5	5	2	2	3	5	5	1	3
R15	5	4	5	5	5	5	4	3	5	4	4	2	5	5	3	4	4	3	2	3

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R16	3	4	4	4	1	4	4	3	3	2	2	2	3	1	4	3	4	1	2	1
R17	5	2	5	5	3	5	3	3	1	1	1	1	1	1	1	4	4	1	1	1
R18	4	3	4	5	3	4	4	5	3	2	3	4	3	2	4	4	4	2	3	3
R19	5	5	4	4	4	5	4	4	5	3	4	5	5	2	4	4	4	4	1	3
R20	5	4	5	5	3	4	5	3	2	5	5	4	4	5	2	4	4	5	2	3
R21	2	5	5	5	5	1	5	5	2	5	5	5	5	2	2	3	5	5	1	3
R22	5	4	4	3	3	4	5	3	4	3	4	4	3	3	3	3	4	3	4	3

± **RDT** – Respondent 1; Q1 – Question 1.

Kendall w - Statistic

Estimating Kendall statistics (W) to evaluate the level of agreement among respondents on the different risk factors impacting on costs or bringing about cost variation of construction of reference power plants give: involves the evaluation of Equations (1-2)

$$W = \frac{12\sum(R_i-\bar{R})^2}{m^2n(n^2-1)} \quad (1)$$

$$R_i = \sum_{j=1}^{m} r_i \times j \quad (2)$$

$$\bar{R} = \frac{1}{2}m(n+1) \quad (3)$$

Where: R_i=total rank of rating given by respondents; m = total number of respondents; n = total number of questions; and $\bar{R}$ = mean value of total ranking

Weighting response options, we have Strongly agree = 5; Agree = 4; No Idea = 3; Disagree = 2; strongly disagree = 1.

Therefore, inputting these in the equations for questionnaire parameter number one (Q1), we have:

$$\boldsymbol{R_{i=}(5\times 8)+(4\times 4)+(3\times 6)+(2\times 4)} = 82$$

$$\bar{R} = \frac{1}{2}\times 22(20+1) = 231$$

The summary of estimating R_i and $\bar{R}$ for all the questionnaire parameters is as presented in Table 2.

Table2. Evaluation Response Using Kendall's Statistics

S/No	Parameter	R	$\bar{R}$	$(R_i-\bar{R})^2$
1	Q1	82	231	22201
2	Q2	85	231	21316
3	Q3	94	231	18769
4	Q4	94	231	18769
5	Q5	74	231	24649
6	Q6	80	231	22801
7	Q7	95	231	18496
8	Q8	86	231	21025
9	Q9	81	231	22500
10	Q10	72	231	25281
11	Q11	84	231	21609
12	Q12	75	231	24336
13	Q13	74	231	24649
14	Q14	57	231	30276
15	Q15	70	231	25921
16	Q16	75	231	24336
17	Q17	97	231	17956
18	Q18	67	231	26896
19	Q19	58	231	29929
20	Q20	56	231	30625
TOTAL				472340

$$\boldsymbol{W = \frac{12\times 472340}{22^2 20(20^2-1)} = \frac{5668080}{9680\ X\ 399}} = 1.467\ (146.7\%)$$

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Principal Component Analysis (PCA)

From Table 2, the PCA of Microsoft Excel is used to analyse the level of agreement between respondents and between grouped factors perceived to cause cost overrun. Figures 2 to 6 show results outputted from the software.

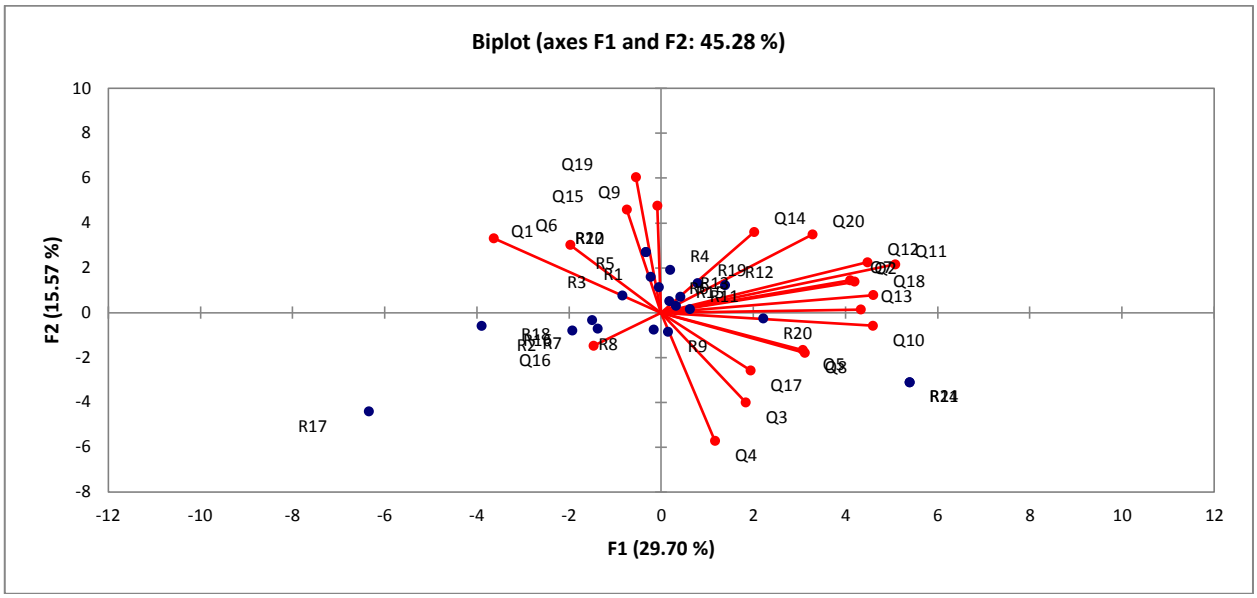

Figure 2: PCA result for all factors

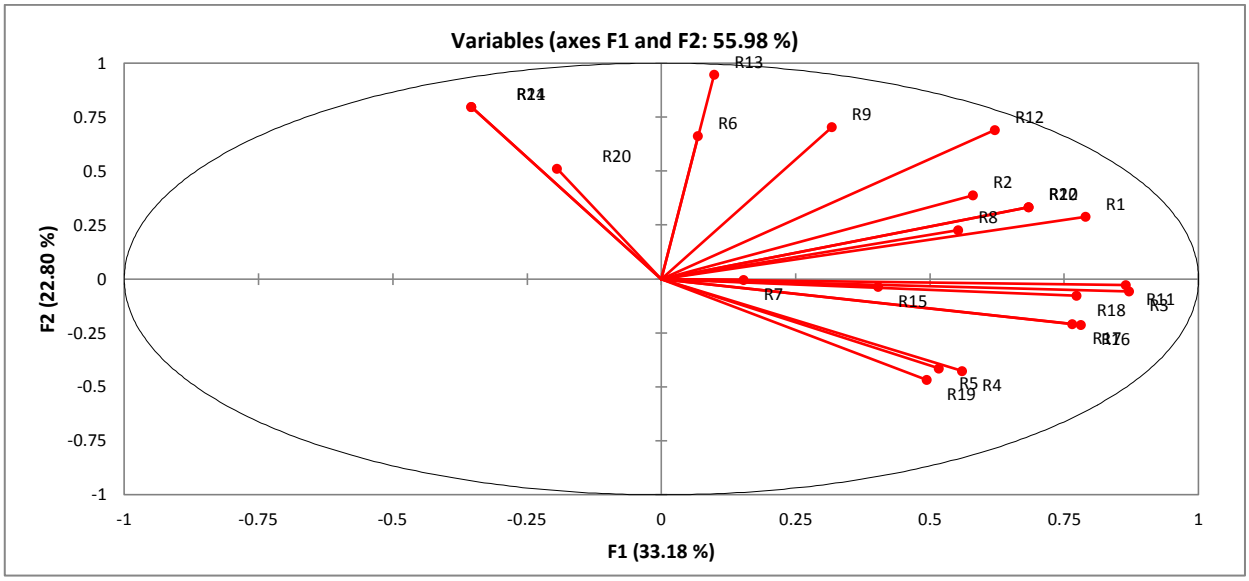

Figure 3: PCA result for the Economic specific factors

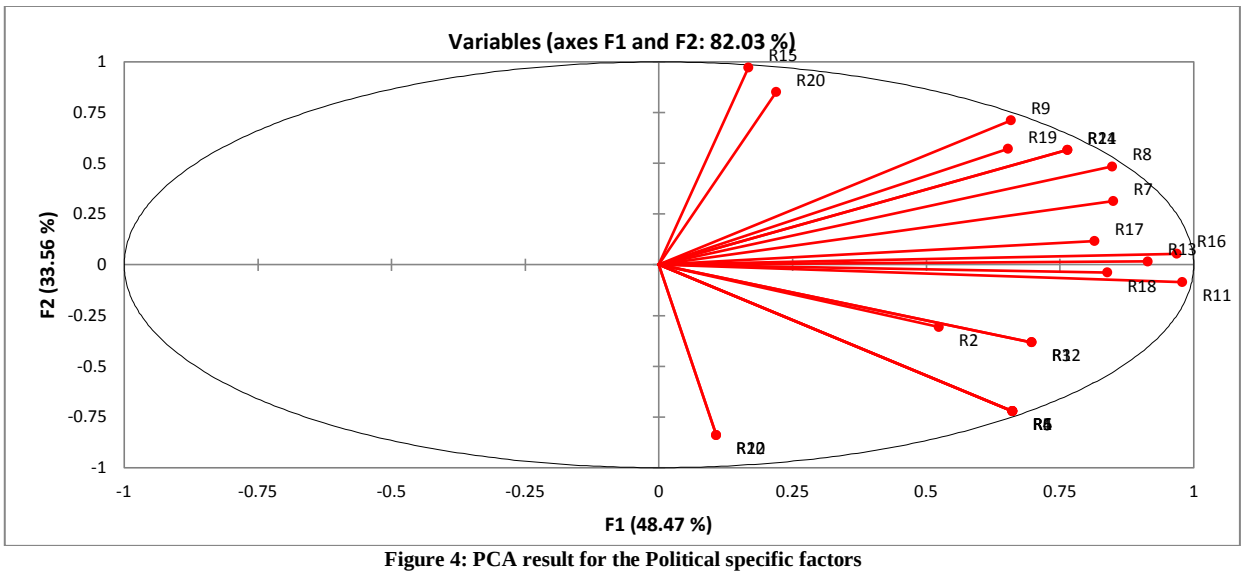

Figure 4: PCA result for the Political specific factors

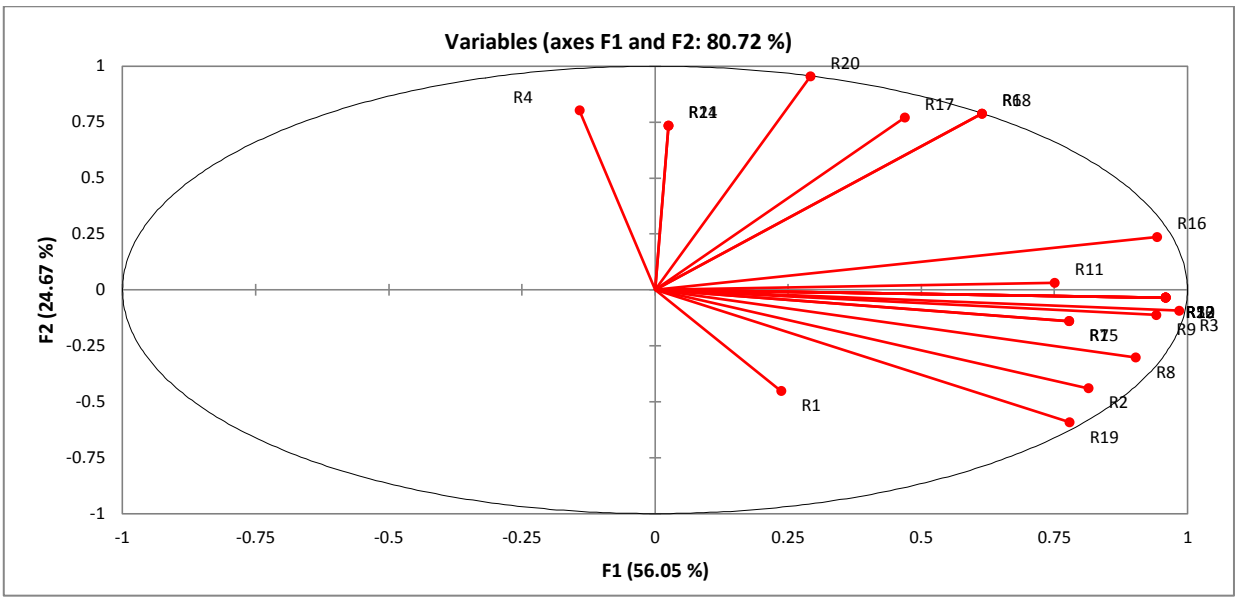

Figure 5: PCA result for the construction and contract specific factors

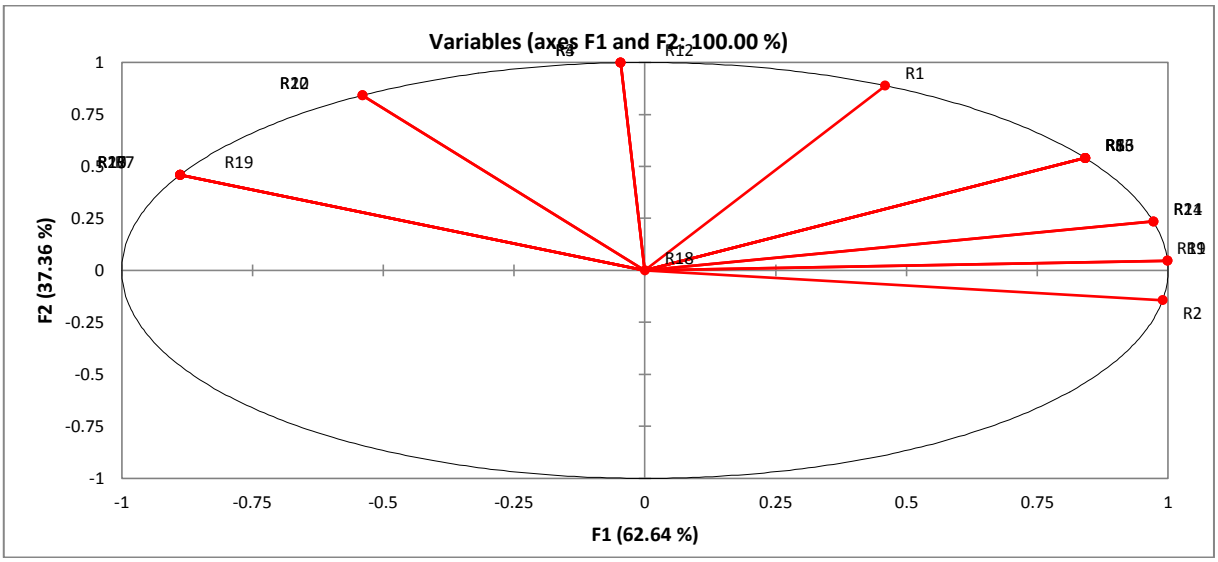

Figure 6: PCA result for the Estimator specific factors

3.2 DISCUSSION

The main factors that are responsible for over run cost of completion of major gas plants has been analysed using the Agoji gas plant as a case study. This analysis was carried out with judgement from respondents based on their practice, experiences and knowledge. The Kendall's method which is a statistical tool for checking the level of agreement between respondents was adopted and the level of agreement was estimated as 146%. This is unrealistic and has been noticed in house as one of the major faults of the kandell's statistic. When opinions from respondents are widely spread the kandell's *w* tends to be greater than 100%. For this reason the PCA was employed for further analysis. The PCA tool is usually used for data reduction by the method of developing factors and also it is used for pattern recognition. In this study, it is used for recognition where the correlations between the respondents and the assumed factors are estimated. The level of relationship between the factors and the variables and that between variables themselves are analyzed. The PCA when used to check the Respondent level of agreement showed an agreement level of 70% with factor 1.

When, the risk factors were classified, and run with the Principal Component Analysis (PCA), to determine which class of risks had more impact on cost, the results are as presented in Table 4.

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Table 4. Ranking of Cost Impacting Factors

S/N	Risk factor	F1	Level of agreement	Rank	Level
1	Economic environment specific	33.18%	66.82%	1	Highest cost impacting factor (uncontrollable)
2	Political environment	48.47%	51.53%	2	Second most cost impacting factor (uncontrollable)
3	Contract and construction specific	56.05%	43.95	3	Third cost impacting factor (controllable)
4	Estimator-cost factor	62.64%	37.36%	4	Lowest cost impacting factor (controllable)

The economic factors are the highest cost impacting risks. This may be due to the economic risks that are largely uncontrollable and external to the project company and therefore have huge impact on costs if not factored in properly during planning. For instance, inflation is bound to escalate the costs of materials, so also is the strength of the local currency in comparison with foreign ones.

Gas fired power plants run on gas, therefore the gas market dynamics is important when building a plant. As at the time of completion, the gas infrastructure in the proximity of the reference power plant was inadequate. Proper feasibility studies on pre-construction and analysis on gas infrastructure availability in the region of power plant should have been carried out before commencing power plant construction. Alternatively, striking partnerships with the government to build gas infrastructure on Public Private Partnership basis with specific contract agreements transferring risks to the appropriate party would have also reduced the impact of late arrangements for gas.

Demurrage/Loss of warranty and degradation of equipment during demurrage most times is a result of other factors like delay in payments, logistics and improper scheduling of project activities which are other risk factors identified in the course of this study. Improper pricing of electricity serves to reduce investment returns and deter funds while cost planning. This is due to the fact that if the price of the commodity is not known, the project would not be bankable. The tariff at the inception of this project was not economically viable.Inadequate skilled local workforce has resulted in companies paying so much to bring in expatriates. The case study had a minimum of about six expatriates working with them besides foreign consultants, leading to increase in labour costs and security. Exchange rate may not have been a big challenge at the beginning of this project because of availability of funds from the Excess Crude Oil Account (ECOA). However, due to the fact that it had lingered up to 2015, the depletion of the ECOA and exchange rate fluctuations would have resulted in some variations. Project companies can also enter into swaps to hedge foreign exchange risks.The political environment related risks are also largely uncontrollable.

Nigerian problem of managing money and corruption has been inherent in the system, therefore the building of this power plant would not have been an exception. Labour action can hinder a project significantly, though there were not major challenges with the workforce, however, low wages and late payment of salaries which were encountered by the workforce could have led to apathy and deliberate delays in executing work assignments. Political Force majeure is any occurrence within the country of project execution but outside the control of the contractor or client that affects the execution of the project. The reduction in the speed of execution and indeed halting of the project in 2007 and for two years due to government intervention, investigation proceedings, and legislation could be classified as a political force majeure.

Political influence and beaureucracy was the undoing of the reference project from the onset. Ranging from choice of location, interest groups, and so on.Insecurity in the form of restiveness, militancy, kidnapping and shootings led to a security budget that gulped a significant amount of the total budget.

The other two categories are controllable to a large extent, hence the low impact on the costs of the project. Construction and contract specific factors which include non-harmonization of contract to EPC Contractor, Lump Sum contract by EPC contractor, Non-timely payment of contractor, Schedule Variance are details that could be negotiated between the counterparties

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to the project with specific clauses detailing responsibilities of each party in the contract execution. A lump sum contract however transfers all price risks to the contractor. Schedule variance is as a result of poor project management, non-timely payment of contractor would have been accounted for with clauses addressing it in the contract to indemnify the contractor.

Indeed, the estimator risk factors are all offshoot of poor feasibility studies. The logistics challenge which refers to the integrity of the bridge connecting Aba with Port Harcourt would have been identified if feasibility studies were carried out. Also the scope variation which led to schedule variation.

Earned value measures, critical path method and activity based costing are proper measures that could mitigate the controllable risks. Activity based costing is borne out of feasibility studies, critical path method ensures schedules are carried out in timely fashion while earned value measures integrate cost variances, schedule variances and the use of a control account to manage projects. The EPC contractor may also seek vendor support packages from the OEM while the government would have to ensure and enforce local content development.

The uncontrollable risks, that is, the economic and politically related are managed or mitigated in several ways such as: using proper contract clauses to transfer risks connected with force majeure, carrying out SWOT, PESTLE and sensitivity analysis to determine thresholds of inflation, exchange rates, and other factors the project company can withstand. A private project company would try to get hold of sovereign guarantees like the World Bank or African Development Bank partial risk guarantees, letters of credit and performance bonds from the host government.

IV. Conclusion

The following conclusion can be drawn based on this research;

i). Any power plant project developer that intends to build in Nigeria should plan rigorously, having in mind that costs overrun beyond reasonable thresholds would arise due to various risk factors;

ii). The economic and political environment specific factors are largely uncontrollable and the number one risk factor to consider when constructing a gas plant;

iii). Demurrage incurred at Port/Loss of warranty, degradation of equipment during demurrage, improper pricing of electricity, inadequate skilled local workforce, exchange rate, inflation, and Nigerian problem of managing money, labour Action, Political Force majeure, Political influence and Insecurity should be factored in with efficient measures to curtail negative impact on final costs; and

iv). The other category of risks being construction and contract specific risks and the estimator cost risks are largely within the control of the project company, and can be properly accounted for using proper project management measures.

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