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Multiproject Scheduling By Prioritizing Projects of Domestic Piped Natural Gas Using Analytic Hierarchy Process

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Abstract:
This paper focuses on Multiproject scheduling problem in a Piped Natural Gas distribution company. To solve this problemAnalytic Hierarchy Process (AHP) Methodology is proposed. The project manager aims to gasify buildings as soon as possible to reduce the tardiness, so that revenue generation starts at the earliest. Due to resource constraint, proper scheduling and sequencing of projects (buildings) are essentialto achieve maximum output using limited resources and time. Specifically our project uses AHP methodology in order to rank the projects and deduce the sequence in which they are needed to be completed. The AHP deliverablehelps the project managers to divert their resources to such projects which can be easily completed so that numbers of pending projects are reduced and the company starts getting returns on their investmentwithin short span of time..

Key words:
Oil and Gas, multi-project scheduling, multi-criteria decision making, project management, AHP

1.Introduction:
Today there is increasing impact of good project management on organization goals. Project management is used to derive some innovative and optimized results within resource and time constraints. Project scheduling is a tool for supervising and controlling project activities and is a major tool for project management. Sequencing and scheduling of multiprojects is different and difficult than scheduling of single project. In the current business scenario when demand for the service is high and work has to be completed within stipulated amount of time and also within the constraints of limited resources multi-project scheduling becomes crucial. There is a considerable increase in time limits for calculations in scheduling of multi projects. The managers of project based organizations always face a project portfolio selection and scheduling problem.

One of the project selection policies is the selection process based on the evaluation and ranking of each project, for this there are several evaluation methods, however the economic analysis is most common, these projects are ranked based on the net present value (NPV). In order to overcome the weakness of focusing on single criteria several ranking models are proposed based on various criteria to evaluate the project (Klein 2000). The present model that we will discuss in this paper is mostly based on the shortest processing time addressing various other factors. These factors are given different weightages. And the priority of the project portfolio is decided by the AHP method and ranking is given based on the criteria befitting the real project scenario in the company X. The company X is engaged in distribution of Natural gas comprising of domestic, commercial, industrial connections as well as CNG gas stations. The entire business in company X has been integrated through ERP-SAP system. It has got a track record of almost 100% reliability in its gas supply. The Project execution department of company X deals with laying of Medium Pressure (MP), Low Pressure (LP), Galvanized pipelines and with steel pipelines from main station to the District Regulation Station (DRS).

From there it is travelled from MP till the boundary of society building and inside boundary LP lines. Under the scope of Project execution department laying works of steel pipelines, Poly-Ethylene (PE),Galvanised Iron (GI) pipes, meter regulator and meter control valve (MCV) are there. The local distribution network (MP and LP) is constructed of Poly-Ethylene (PE) pipes. GI pipes are installed on the external walls of the building with entry into registered customer's kitchen in the building . The meter is installed to measure the gas consumption for each customer.A Meter Control Valve (MCV) is fitted upstream of the meter immediately where gas enters the Property, it regulates the gas supply inside the specific kitchen/property. Following figure depicts the flow of pipelines of varying pressure across the city.

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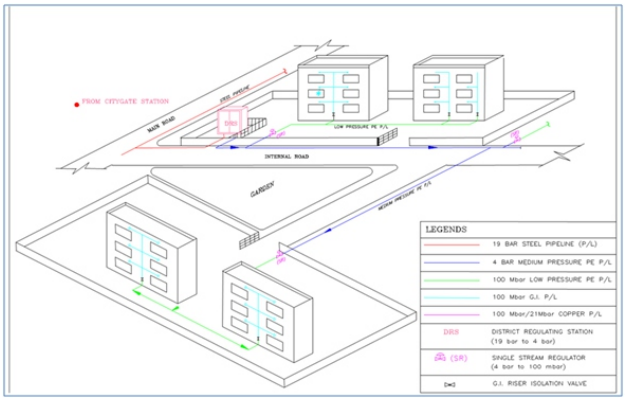

Figure 1: Schematic of Flow of pipelines of varying pressure across the city

2.Literature Review

Project management is a system of managing nine knowledge areas pertaining to projects' time, cost, scope, quality, risk, procurement, human resource, communication, and integration. Amol (2013)[1] explains this as Integration of these nine knowledge areas makes the project management a complex decision making process. In this paper the author aims to minimize the make span time as well as the project cost if in case the project delay cause any penalty. In this paper researcher solves the problem by integrating the project priority by activity priority and generates the project schedule using hybrid algorithm based on priority rules and AHP (Analytic Hierarchy process). The proposed method was validated with a case study under various scenarios. Experimental results were compared with existing priority dispatching rules. Jun Gang et.al(2013) discusses a a multiproject resource allocation problem in a bi-level organization where the upper level, the company manager aims to allocate the company's resources to multiple projects to achieve the lowest cost, which include resource costs and a tardiness penalty. On the lower level, each project manager attempts to schedule their resource-constrained project, with minimization of project duration as the main objective[2]. Whereas Ali Namazian et. Al [3] explained the new formulation of the project portfolio selection problem based on the project schedules in uncertain circumstances have been proposed. According to Jeeno Mathew et.al(2016) [4] Activities that repeat from one project unit to other project unit create a very important need for a project schedule that ensures the uninterrupted flow of crew from one unit to the next. This study will help to develop a method for scheduling repetitive projects with objectives of minimizing project duration, project cost and both of them with constraints of precedence relationships between activities, constraints of precedence relationships between units and constraints of the due date in which work should be completed, our project also has fixed set of activities but not necessarily has the same durations in addition the set of factors in which project is being carried out may vary. A blog on A new Consensus Indicator in Group Decision Making with the Analytic Hierarchy Process by Klaus &Lita [5] explains that for using AHP in a scenario where group decisions are often made because decision problems can become very complex by nature; they could require special expertise and complementing skills, as they cannot be provided by a single person. One of the methods in arriving at the consensus or a majority vote or a single leader's final decision, based on his position and power. When using AHP with its questionnaire, these problems can be avoided. Each member of the group has to make judgment by doing a pairwise comparison of criteria in the categories and subcategories of the hierarchical structured decision problem Aggregation of individual judgments in AHP can be done using the geometric mean. The outcome i.e. consolidated weights or priorities for different criteria are final priority list obtained. The weighted-sum method (WSM), or the decision matrix approach, is perhaps the earliest method employed. This evaluates each alternative with respect to each criterion and then multiples that evaluation by the importance of the criterion. This product is summed over all the criteria for the particular alternative to generate the rank of the alternative. (Bhushan,2004)[6].

3.Present Scenario

In this paper we will investigate a problem based on of project portfolio selection so that revenue generation can be started within shortest period of time as well as consumer satisfaction can be gained by providing them connection on time. Various problems we have identified in our projects are late connections (tardy projects); problem of statutory permissions, i.e. Municipal corporation (MCGM), Traffic police permissions & Fire No objection certificate (NOC); Society issues; customer availability.
As per the Governments assurance the time window to provide gas pipeline to household is within 90 days from the date of registration,else the deposit has to be refunded, but in the analysis of customer complaints we came to know that there is a stretch of up to 15 years till date. Adding to worse on this case theconcernedcustomer have already paid the deposits for the connection for so long time.

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The Pie chart (shownin fig.2. the proportion of pending connections across the time. Hence we decide to take it as an important consideration as customer satisfaction is important for sustainability of an organization. The reputation of an organization is at stake if care is not taken at time when a company is dealing directly with the consumer.

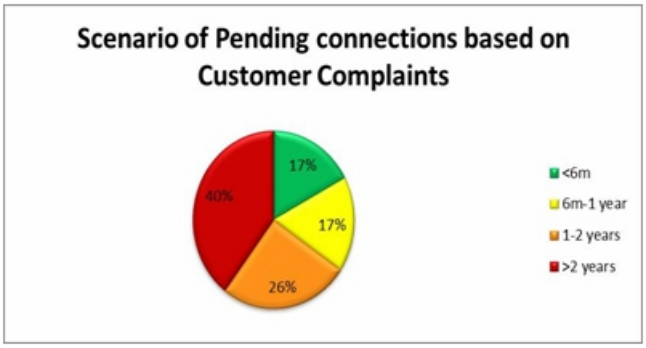

Figure 2: Distribution Of Consumer Complaints According To Elapsed Time From Registration Date

The current scenario shows following project alternatives and the respective factors that form the basis of selection of the projects are tabulated as below. Out of current sample of 80 buildings with pending connection requests 37% of the buildings are lagging behind because of permission unavailability from various sources. For illustration of our model application we are currently dealing with only 4 buildings out of the total queued buildings.

Table 2.1. Alternative and Criteria mapping

S.No	Building Name	Criterion	Status
1	GurusevakKutir	Economical	GI pending
		Potential	x < 30
		Time elapsed	2 to 3 years ago
		Permission issues	society issue
2	Navi Asha	Economical Feasibility	GI pending
		Potential	30 > x > 60
		Time elapsed	6m to 1 year ago
		Permission issues	no fire NOC
3	Police Quarters	Economical Feasibility	LP to be laid
		Potential	80 > x >100
		Time elapsed	2 to 3 years ago
		Permission issues	no issues
4	Shikhar Apartments	Economical Feasibility	GI pending
		Potential	60 > x > 80
		Time elapsed	More than 3 yrs
		Permission issues	no issues

4.Methodology

For determining the selection of projects (say buildings in this case) the priorities are obtained by using AHP process to simplify the decision making and moreover following a standard process of rating and sequencing of the projects throughout the department and trying to make it more quantitative rather than existing subjective judgments. The responsibility of making priority judgment is on lower management.

4.1.AHP Theory

Saaty[12] describes the seven pillars of AHP as follows: Ratio scales, proportionality and normalised ratio scales.

- Reciprocal paired comparisons.
- The sensitivity of the principal right eigenvector.
- Clustering and using pivots to extend the scale.
- Synthesis to create a one-dimensional ratio scale for representing the overall outcome.
- Rank preservation and reversal.
- Integrating group judgments

AHP is analytic and strength of this method is its mathematical and logical reasoning for arriving at the decision.

Following are the avenue for any AHP problem.
Step 1:It follows a top down approach to solve MCDM (Multi criteria decision making) problems.Evidence from psychological studies suggests that human beings can compare 7 ±2 things at a time. Hence to deal with a large and complex decision makingproblem it is essential to break it down as a hierarchy.

Figure 3: Analytic Hierarchy process Model

Step 2: The decision-maker makes paired comparisons Aij of two alternatives i and j corresponding to a criterion on a ratio scale which is reciprocal, i.e.$A_{ji} = 1/A_{ij}$.The criteria are compared pairwise according to their levels of influence.

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Which is judged on the grounds of expertise and experience.In the first matrix Values of m performance measures for n projects after quantifying expertise into numbers. Whereas the other shows Pairwise comparison matrix or normalization matrix.

Table 4.1. Values of m performance measures for n projects after quantifying expertise into numbers

Project	Criteria		
	C_1	C_2	C_m
P1	A_{11}	A_{12}	A_{1m}
P2	A_{21}	A_{22}	A_{2m}
P_n	A_{n1}	A_{n2}	A_{nm}

Table 4.2. Pairwise comparison matrix or normalization matrix.

Project	P_1	P_2	P_n
P1	A_{11}/A_{11}	A_{12}/A_{22}	A_{1n}/A_{nn}
P2	A_{21}/A_{11}	A_{22}/A_{22}	A_{2n}/A_{nn}
P_n	A_{n1}/A_{11}	A_{n2}/A_{22}	A_{nn}/A_{nn}

The decision-maker never judges one alternative to be infinitely better than another corresponding to a criterion, i.e. $A_{ij} \neq \infty$.

Step 3: Calculate the weightage decision matrix. The column sum of Table 2 is computed and each value of the column is divided by its column sum then the row wise average is computed of the weightage decision matrix. These values denote the weights of the 'N' number of projects with respect to the considered criteria.

Step 4: The principal eigenvalue and the corresponding normalized right eigenvectorof the comparison matrix give the relative importance of the various criteriabeing compared. The elements of the normalized eigenvector are termed weightswith respect to the criteria or sub-criteria and ratings with respect to the alternatives.

Step 5: The consistency of the matrix of order n is evaluated. Comparisons madeby this method are subjective and the AHP tolerates inconsistency through theamount of redundancy in the approach. If this consistency index fails to reach arequired level then answers to comparisons may be re-examined. The consistencyindex, CI, is calculated as

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

whereλ_{max} is the maximum eigenvalue of the judgment matrix. This CI can be compared with that of a random matrix, RI.

The ratio
$$\frac{CI}{RI} = CR,$$

that is Consistency Ratio, Saaty suggests the value of CR ≤ 0.10

Step 6: The rating of each alternative is multiplied by the weights of the sub-criteria and aggregated to get ratings with respect to each criterion. These ratings are then multiplied by the weights of the criteria and aggregated to get overall ratings.

5.Case Study

Based on observations in the company we have set criteria for prioritizing the project. These criteria have been derived out based on the pending gas connections and analysis of their possible reasons. We have come up with certain factors which can be a cornerstone of deciding the priority of project and ranking them.The Goal is Prioritization of buildings for providing gas connection. The following are the criteria based on which decisions are made-

1) Economic Feasibility:

Economic feasibility of a project suggests that if it is possible to achieve the project objectives utilizing the given resources and within the stipulated budget and time, at the same time not undermining the scope of the project. : Economic feasibility can be categorized as:

i.MP line very far
ii.MP tap-off available
iii.MP done, LP pending
iv.MP charge done
v.Only GI pending

2) Potential:

According to the thumb rule followed by the project department- Potential = 70% of total number of kitchens in the building. However the actual number of connections may vary a little, but it gives an estimate to calculate the priority.

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Higher the potential, larger is the conversion, with lesser per unit of LP/MP work. The potentials scale may vary depending on the project site is a building or a building complex.

3) Time Elapsed:

Time elapsed from the date of registration i.e. request for new connection. It has been observed that number of pending connection gets increasing at a high rate and usually more than the rate at which company X can cater it. Hence a systematic approach needs to be followed in order to reduce tardy project.

4) Ease ofobtaining statutory permissions:

Permissions from Municipal corporation office, Traffic Police department and Fire No objection Certificate.

5) Ease of obtaining permissions at point of connection (POC)

, i.e. issues related to society or customer. The easier it is to obtain the permissions the faster the work can be finished.

To get the exact picture of the importance of different criteria, questionnaire was prepared and floated for opinions of different officers in the project department, the Area In charge (AIC), District In charge (DIC), and Zonal In charge (ZIC) who come under lower management and their task is project portfolio selection.

5.1.Assumptions

While making a decision in multiproject scenario following assumptions are to be made. These assumptions are-

•There is no new project during the scheduled resource allocation periods or no withdrawal of request of connection

•Material and equipment rent and costs are constant

•Resources (manpower, material and equipments) assigned to all projects do not exceed the limited quantities in any time period neither is there any reduction in these.

The present multi-criteria decision problem is firstly decomposed into a hierarchy of an interrelated decision alternatives (we say here buildings) The criteria and alternatives are arranged in a hierarchical structure similar to a decision tree with decision alternatives at the bottom and criteria above that. As shown-

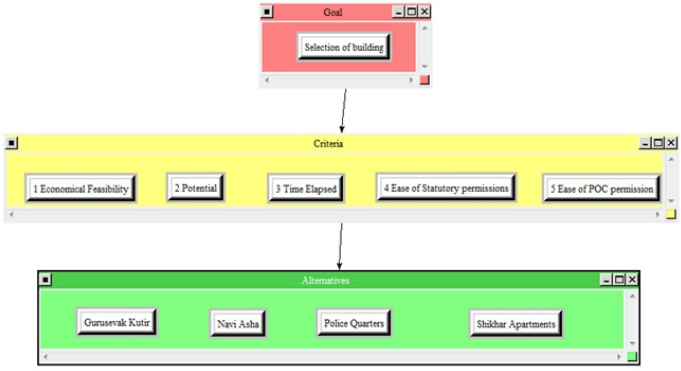

Figure 4.criteria and alternatives are arranged in a hierarchical structure

After the analysis of questionnaires based on Superdecisions software version 2.6.0- RC1 for AHP problems, the final input is filled as-

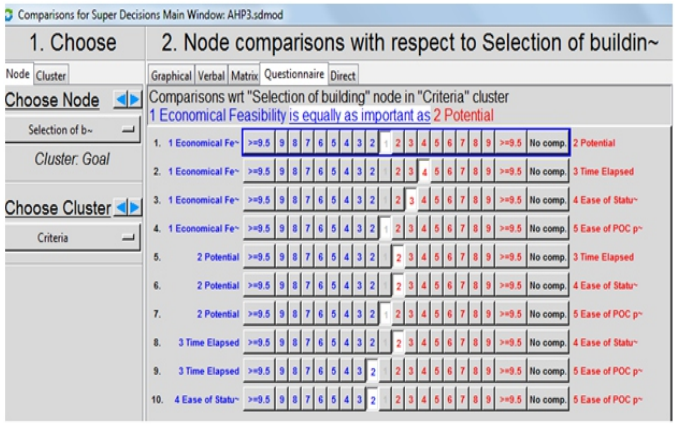

Figure 5. The Questionnaire comparison screen of AHP

The analysis of opinions of 26 project managers of company X across all branches are calculated on MS Excel using geometric mean.

6.Results

The results are shown in fig.6. The priority has been computed through the AHP software based on the questionnaire filled by the project engineers and manager, It has been found that Ease of obtaining permissions is more crucial than any other factors as it is the major bottleneck in completing the task. Time elapsed is the second most crucial factor as it leads to customer dissatisfaction which creates pressure on the project department.

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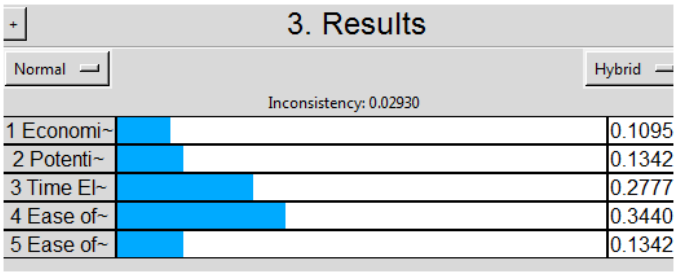

Figure 6.The results of Pairwise comparison

Regarding the prioritizing the projects an inconsistency or CR is 2.93% which is much less than 10% as suggested by saaty[12].The ranking of proposed buildings are obtained after synthesizing the model. The final result of ranking projects is shown in fig.7. The overall synthesized priorities of the alternatives that is buildings in our case are obtained which suggests the sequence for selection of projects for a set of queued projects.

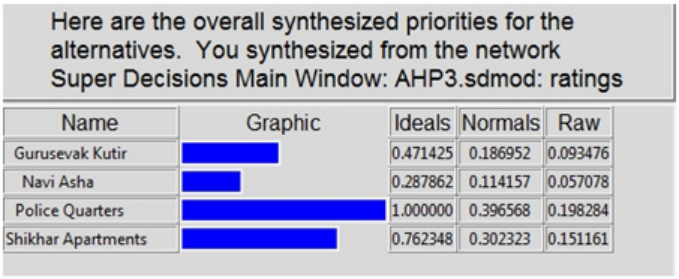

Figure 7. The Final result showing ranking of projects

Thus, the final sequence of project selection should be as shown in fig.8.

Figure 8: Desired Sequencing of queued Projects

7.Conclusion and Future research directions

As we know each project and its related activities is unique. In the current paper we have dealt with broad criteria that form the basis of selection of any project like Time elapsed, economic feasibility, issues related to get permissions for carrying out work. To get the insights we have conducted surveys by floating questionnaires to managers of different offices, the responses were then fed into model prepared on AHP software to derive out what should be the sequence of working on projects while considering different criteria. The inconsistency of 2.93% is obtained as a result which is acceptable as maximum acceptable inconsistency in no more than 10%. In future we can include sub criteria as well to approach to more precise solutions. More over the activities involved in different projects can be sequenced and a holistic project model can be made by clubbing activities of all available projects in a multiproject environment.

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