

# IDENTIFYING CRITICAL FAILURE FACTORS FOR HVAC PROJECTS IN SAUDI ARABIA

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## ABSTRACT

*This study aims to understand the critical success factors of HVAC projects in Saudi Arabia. In particular, this study focuses on the factors that lead to the failure of HVAC projects in Saudi Arabia. The study is exploratory and utilizes a questionnaire to collect data from 100 respondents that include engineers, HVAC project managers, HVAC manufacturing workers, HVAC supply chain professionals, HVAC quality controllers, HVAC technicians, and HVAC on-site implementers in major Saudi cities. The sample was selected using the purposive sampling method. Results show that the most critical failure factors of HVAC projects are quality control and assurance of HVAC parts, weak decision and delayed decision making, and extreme geographical conditions affecting HVAC. The implications of these results were discussed, and suggestions for future studies were given at the study's end.*

**Keywords:** Heating, Ventilating and Air Conditioning, Project Failure, Critical Success Factors, Saudi Arabia.

## INTRODUCTION

Saudi Arabia is considered a semi-developed nation or can also be grouped with the countries known to be developing economies in this region in terms of numerous factors. According to United Nations Secretariat, Saudi Arabia and many neighboring countries such as Bahrain, Kuwait, and Jordan are developing economies in the Western Asian region. However, Saudi Arabia has a better edge over the other countries because it is also known to be the world's largest producer and exporter of fuel to the world because of which the economy of the country is strong and has been stable till 2015. According to the World Bank, the GDP is expected to rise from flat 2.2% to 3.7% in the upcoming year of 2016-2017 (Economic, 2016; Al-Kodmany & Ali, 2013; Bearg, 2019), which is slowing down from an expansion of 5.46 percent in the June quarter because of the continuously falling prices of oil.

Saudi Arabia is a monarchy that has had its pros and cons on the state whereby it is witnessed that there is a lack of equality amongst the population whereby projects and contracts are approved based on ties and relationships amongst the royal family, e.g., The Bin Laden family had been running its business in earlier years as they had a powerful bond and tied with the late King Abdullah. Such special privileges and inequality have made the country notorious

for its failures of projects in the industry due to lack of competency. Many hiring have also been done based on reliable sources and bonds, resulting in failures of projects in the market. Saudi Arabian market also lacks in the internal technological advancement of their educational system, which has taken a toll on its youth; this not only causes a high rate of unemployment amongst the Saudi population but has also caused appointments of people who lack industrial knowledge and end up causing significant damages to the country's economy and projects. Foreign investors, therefore, avoid spending massive sums of money in the country, especially in the HVAC sector (Ashrae, 2015; Hemming, 2013; Hardy-Vallee, 2012; Holladay, 2012; ArabNews, 2015; Goatham, 2015; Joseph, 2010) (Table 1).

<b>Table 1</b> <b>FAILURE FACTORS OF HVAC PROJECTS</b>	
Factors	References
Incompetent HVAC project management	Jackson (2013)
Weak decision making/delayed decisions	Lock (2013)
Extensive outsourcing of jobs	Trigg (2015)
The hiring of unskilled HVAC professionals	Collin (2011)
Extreme geographical conditions affecting HVAC	Vanessa (2020)
Lack of risk management towards projects	Mosaad et al. (2018)
Quality control and Assurance of HVAC parts	Ping (2013), Singh (2013)
Mismatch of financial requirements	Gavin (2021); Gbbons & Javed (2022)
Poor information management during manufacturing and installation	Maine (2012)
The vast gap between executors and management	McGregor (2015)
Wrong calculation of BTU in HVAC	Grey (2015)

Globally, much research has been conducted on various HVAC projects, phenomena, and advancements. However, it is noted that very few studies have been carried out in this region. The weather conditions in Saudi Arabia have been seen to be drastic, from cities such as Tabuk and Abha, where people witness heavy snowfall during the winters and very cool temperatures even in the summers, to densely populated regions of Makkah and Madinah, where temperatures have been recorded up to 60 degrees centigrade during the summers. Such weather conditions require special HVAC projects with much more high endurance and research projects that need to identify the gaps and lacks because these projects fail or are not successful. After skimming through literature is noted that there is a gap in the literature that discusses HVAC project failure in Saudi Arabia; therefore, this research study will help us identify, differentiate and analyze the facts and figures that lead to a not successful or instead failed HVAC project in Saudi Arabia. Accordingly, this paper investigates problems HVAC projects and companies face, primarily working on Saudi Arabian projects. Specifically, the paper investigates the effect of the following factors on the failure of HVAC projects in Saudi Arabia (Krugen, 2009; Offermann, 2015; Ping, 2013; Ristinen, 2006).

## METHODOLOGY

Purposive sampling has been performed to ensure that the questionnaire is widely spread amongst the sample space and a significant chunk of views are acquired (Patton, 2009). The sample space for the questionnaire includes engineers, HVAC project managers, HVAC

manufacturing workers, HVAC supply chain professionals, HVAC quality controllers, HVAC technicians, and HVAC on-site implementers. The major cities of Saudi Arabia, Jeddah, Riyadh, Dammam, Madinah, and Makkah that comprise nearly 85% of major HVAC giants and HVAC projects are targeted for data collection. The major HVAC giants will include Carrier, York, and Trane. At the same time, the HVAC projects will include the most significant government projects, which are KAAIA, also known as King Abdulaziz International Airport, Taif Hospital, Makkah Expansion project, Haram railways, Kingdom tower, Madinah Prophet mosque expansion, Al Kharj Marai plant, Nada Dairy, Cleveland project Abu Dhabi. These different projects are chosen to ensure that the response is from a vast sample space, and the response is from all the parts of this sector. The total sample size includes 250 targeted respondents. Details of the sample selection and size are given below. All of the samples are from HVAC organizations and projects in Saudi Arabia (Table 2) (Robert, 2010; Smith, 2011; Swenson, 1995).

<b>Table 2</b>	
<b>RESEARCH PARTICIPANTS</b>	
<b>Major/Specialization</b>	<b>Number of participants</b>
HVAC / Mechanical Engineer	40
HVAC Project Mgmt. team	10
HVAC Manufacturing team	30
HVAC Installation team	10
HVAC QC and SC team	10

The questionnaire is developed with the help of a literature review and closely observed factors that affect the HVAC project failures in Saudi Arabia. After the development of the questionnaire, it has been tested as a pilot test in order to make sure that the questions are not vague and lengthy and questionnaire form of research is an easy and quick form of getting responses and does not take a long time because of which the success rate of responses is better than other methods and techniques. Out of the 250 individuals targeted with the questionnaire, 100 completed questionnaires were returned and used for the data analysis making a response rate of 40%. A standard questionnaire has been used to acquire exact data information that will support the research theory. These responses and views are then compared in order to conclude (King, 2010). The data available is analyzed and examined to identify themes and then are coded in order to extract data into patterns that are meaningful for the research objective (Boyatzis, 1999). After the extraction, the data were analyzed through SPSS to have a better result upon which the results are based and formed.

## **DATA ANALYSIS**

### **Validity and Reliability of the Variables**

The reliability of the measurement scales was ensured through Cronbach alpha. All the variables showed a value greater than the threshold value of 0.5 and ranged between 0.527 and 0.873, reflecting higher reliability of the variables' measurement scales. A confirmatory factor analysis (CFA) was performed to address the validity of the variables. To ensure that the measurement scale of each variable is valid, CFA was performed by setting a higher threshold

value of 0.70. All the items successfully loaded to respective variables above the threshold value ranging between 0.701 and 0.937 (Vincent, 2008; Yousef, 2014; Yin, 2013; WorldBank, 2010).

### Assessment of Critical HVAC Failure Factors

As explained in the literature review, the failure factors for HVAC projects were classified into 11 broader categories or factors. The factors were analyzed for significance assessment as indicated by the frequency of occurrence of failures in HVAC projects using a five-point scale; rarely, low, medium, high, and very high. Each of these points was given a number ranging from 1, for rarely, to 5 for very high. The weighted score for each factor was calculated by multiplying the value of the scale category by the frequency of occurrence of the value, as shown in Table 3.

<b>Table 3</b> <b>CRITERIA FOR SIGNIFICANCE ASSESSMENT</b>		
Weighted Score	Significance Index	Significance Level
250 - 290	1	Highly Insignificant
>290 - 330	2	Moderately Insignificant
>330 - 370	3	Neither significant nor insignificant
>370- 410	4	Moderately Significant
>410- 450	5	Highly Significant

Based on the calculated weighted scores, a significance index was created from 1 to 5, where one represents highly insignificant, and five represents highly significant, as shown in Table 4. Based on the analysis, out of 11 factors, three factors were found highly significant, five moderately significant, one neither significant nor insignificant, one moderately insignificant, and one factor highly insignificant.

<b>Table 4</b> <b>SIGNIFICANT PROJECT SUCCESS FACTORS WITH CATEGORY</b>								
Factors Affecting Failure of HVAC Projects	Frequency of Failures (Occurrence)					Weighted Score	Significance Index	Category
	Rarely (1)	Low (2)	Medium (3)	High (4)	Very High (5)			
Quality control and Assurance of HVAC parts	0	0	13	47	40	427	5	Highly Significant
Weak decision making/ delayed decisions	4	7	9	21	59	424	5	Highly Significant
Extreme geographical conditions affecting HVAC	0	0	24	36	40	416	5	Highly Significant
Vast gap between executors and management	0	7	28	26	39	397	4	Moderately Significant
Extensive outsourcing of jobs	0	15	12	40	33	391	4	Moderately Significant
Poor information management during manufacturing and installation	0	10	25	29	36	391	4	Moderately Significant
Lack of risk management towards projects	0	10	25	30	35	390	4	Moderately Significant
Incompetent HVAC project	0	12	16	72	0	360	4	Moderately

<b>management</b>								<b>Significant</b>
<b>The hiring of unskilled HVAC professionals</b>	5	37	15	4	39	335	3	Neither significant nor insignificant
<b>Mismatch of financial requirements</b>	0	31	40	29	0	298	2	Moderately Insignificant
<b>Wrong calculation of BTU in HVAC</b>	16	20	34	21	9	287	1	Highly Insignificant

The analysis revealed that quality control and assurance of HVAC parts, weak decision making, delayed decisions, and extreme geographical conditions affecting HVAC are the topmost critical failure factors of HVAC projects in Saudi Arabia (Table 4). These three factors are interrelated and correspond to factors or conditions out of the control of the engineers or team members who are the targeted respondents in this study. Assurance of quality of HVAC parts lies mainly on the suppliers of these parts; weakness and delay in decisions are mainly the responsibility of top management. Also, extreme geographic conditions are the responsibility of top management. Therefore, the respondents are trying to blame project failures on these factors out of their control.

The moderately significant failure factors at the second level include the vast gap between executors and management, extensive outsourcing of jobs, poor information management during manufacturing and installation, lack of risk management towards projects, and incompetent HVAC project management. These factors are related to the management's competency and skill in doing their jobs. Undoubtedly, the ability of the firm to; execute the project in terms of its experience, provide human and material resources, and clearly define the scope and objectives of the project as per the client's requirement plays a crucial role in the project success or failure.

At the third level, the failure factors with neither significant nor insignificant, moderately and highly insignificant levels include the hiring of unskilled HVAC professionals, mismatch of financial requirements, and wrong calculation of BTU in HVAC. Based on respondents' opinions, these factors that are less likely to occur are mainly related to factors that show the respondents doing something wrong that leads to the failure of HVAC projects. Of course, the respondents are not expected to show a bad image of themselves or are careless about their job given that most of them are highly educated and have long years of experience. Therefore, mistakes or wrong calculations are not likely to occur and be a reason for the failure of HVAC projects.

## DISCUSSION

From the collected data, we noticed that many respondents had reservations regarding the laid-back attitude portrayed by the management and people responsible for handling the tasks by themselves. We have noticed that many organizational processes and decisions that are extremely important and can make considerable differences in the project outcome are also delayed until the actual problems arise to the masses. Many of these respondents have mentioned clearly that project managers play a critical role in the failure of HVAC projects. According to them, these managers fail to identify the exact requirements and thus create insufficient plans that eventually cause the projects to collapse. Project engineers then backed up these insufficient plans, which follow the given commands and plans regardless of putting in their judgments and

theoretical knowledge. This lack of interest and laid-back mode of work has undoubtedly affected the HVAC projects negatively.

The reviews and professional response also suggest that the professional interface and professionalism have a few insufficient corners and gaps that need to be filled in as soon as possible to avoid further failing issues in the HVAC units of the Saudi Arabian projects. A majority of the respondents claim that the current Saudi labor market has a dire shortage of skillful men who can be recognized as certified professionals. Saudi Arabian market has been facing this shortage for quite a long time after the government decided to put up new labor laws and organizational policies to support the local economy. Such harsh steps have caused the market to move at a languid pace and forced people from other countries to move back, leaving their current jobs. Many of these workforce shortages are also blamed on the project management teams that have not performed accordingly during the difficult times. People have been hired based on links and contacts while leaving behind those with experience and degrees to perform the jobs. This business method has also caused much damage to the HVAC projects and thus pushed them downhill.

During the progress of the questions and their responses, we came across an uncontrollable factor of geographical limitations faced by the project and have also been seen to cause large amounts of damage and failure to HVAC units. Undoubtedly the harsh climate and geographical situation of Saudi Arabia is a big hurdle in the success of the endeavor, but it is something that cannot be neglected or looked upon from the start to the end. Organizations are well aware of this negative aspect of the region but tend to cover them by performing extra efforts. According to the respondents, the organizations need to train every individual according to his job task to minimize the losses. It is all about how the work and working hours are planned. A good project plan shall include this climate phenomenon into its mode and planning process, which is currently not always done. Many professionals believe that organizations should plan their work at night during the colder times of the day and teach their employees the concept of preventive maintenance. This phenomenon of preventive maintenance, if followed accordingly, can save a lot of person-hours, money, and precious human lives as well that are often seen to be put at stake in order to meet the time of the project. Respondents also believed that training the people to perform tasks safely should also be a must throughout the projects, and they should also be taught how to take care of the units beforehand. These beforehand checks and maintenance can help reduce many damages and rework to the project, thus moving it further to success rather than pushing it towards failure.

## CONCLUSION

The focus of this study was to analyze the processes and procedures of the heating, ventilating, and air condition projects in Saudi Arabia and to identify as to what are the challenges and problems that are faced by these projects that lead it to the stage of failure. Failure is not only regarding the complete stoppage of the projects but also includes projects that have faced delays in timely deliveries, have faced problems due to lack and shortage of material; HVAC units malfunction due to lack of quality check and approvals, incurring extra cost. The research has been conducted through stages over 12 months, and much in-depth information has been gathered from all possible sources. The questionnaire was formed based on the literature available to the study, and thus it was passed on only to a pool of specific HVAC professionals who can figure out and advise about the problems and issues they have faced in their careers.

Thus all the given information is collected by people working in the HVAC industry of Saudi Arabia. This direct approach and selective pool of samples have helped the study cross leaps and bounds by acquiring accurate to-the-point information. This information collection method has been a good one but has taken a lot of time, effort, and repeated reminders as the HVAC professionals have been busy and generally do not respond on time. However, regardless of all the hardships, the study has managed to gather the responses of 100 respondents who belong to the mass HVAC professional industry. The study's preliminary results show that uncontrollable factors by the study respondents are the main factors that lead to the failure of HVAC projects.

## RESEARCH LIMITATIONS

Although the research has a larger sample of professional engineers, there are still a few limitations, such as a representation of remote locations and other smaller regions that could not be accessed. Alongside this, due to financial limitations, issues have not been researched in depth. Further research can be conducted by keeping this aspect in mind and researching the financial aspect or cost of the failed HVAC projects.

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