

Exploring the Impact Project Definition Readiness Index on Capital Projects for Coal-Fired Power Station Projects

Yolisa Andi Motsepe, Bheki Makhanya and Prof. J.H.C Pretorius

Post-Graduate School of Engineering Management,

Faculty of Engineering and the Built Environment,

University of Johannesburg

Auckland Park, South Africa

olethu@gmail.com, Bheki.Makhanya@transnet.net, jhcpretorius@uj.ac.za

Abstract

Eskom is constantly responsible for the management of capital construction projects in order to sustain their assets and increase their generation capacity. Front end planning (FEP) is an important phase before the execution of the project, as it determines the scope of the project to be executed. Failure to have well defined scope leads, to scope deviations during execution that results in escalated cost and delays in the schedule. Eskom adopted PDRI as part of FEP in order to improve the scope definition level. PDRI is a tool designed by CII in order to quantify the level of scope definition through the FEP. This research is conducted to evaluate the impact of integrating PDRI on FEP for capital coal projects.

Keywords

Front End Planning, Scope definition, Project Definition Readiness Index

1. Introduction

Eskom (South African state-owned power utility), is Africa's largest power utility that supplies approximately 95 % of South Africa's electricity (Govendor, 2013). Eskom constantly has to manage Capital Projects to sustain their assets (e.g. Power Stations, Transmission lines, Building etc.) and to increase their life extension (Sandelandas, 2009). The project scope definition of a project determines the success or failure of the delivery of a project (Gibson, Dumont, and Fish, 1997). Poor scope definition of projects, lead to an escalation in the cost of the projects and it leads to time delays due inevitable changes to the scope (Syed, Zaheer and Fallows, 2011). Poor scope definition may also lead to poor quality of project outputs, as the client's requirements were not set out clearly and understood (Moncrief, 2004). To address the problem of poor scope definition during the Front End Planning (FEP), Eskom adopted the Project Definition Readiness Index (PDRI) tool that was designed by Construction Industry Institute (CII) of America (Murray, 2011). The PDRI is used to measure project scope definition completeness.

The Project Definition Rating Index (PDRI) is used to measure the completeness of the scope definition in projects (CII, 2015) (Sandelandas, 2009). It identifies important elements that should be considered during the process of defining scope in a project and weights the element in accordance with their significance towards the completeness of the scope (Cho and Gibson, 2001). The PDRI is used in the Front End Planning (FEP) of the project phase, as an additional tool to enhance the phase, it ensures that the risks are identified earlier on in the FEP and addressed immediately or during the next phases of FEP before execution phase of the project. It also serves as a checklist for the project team to be aware of the issues they must attend too, identify interfaces that may affect the scope and lead to potential escalations in cost or delays if not adequately address in the FEP (Staats, 2014). PDRI encourages communication and alignment between the user requirements, designers of the solution and the construction contractors by highlighting areas that are not defined in the works information (Department of Energy, 2017). It has been verified through several studies done by the CII, that a good PDRI score leads to greater chances of project success, it has also been noted that in the cases where PDRI is poor, the PDRI gives guidance to participates on the

actions to be take in order to improve the score (Muller, 2016) (Cha and Shin, 2011). This research will investigate if the impact of PDRI on coal capital projects implemented at Eskom, it will also evaluate the direct and indirect outputs on PDRI during the FEP of projects and on completed project success.

2. Literature Review

2.1 Front End planning

Front-end planning (FEP) is conducted at the beginning of the project to the beginning of the execution phase as indicated in Figure 1, during the FEP the Project Manager (PM) assess client's request to determine the resources required to form the project development team of the project, which will be responsible for developing the preferred solution (Ali, Hassan, and Rahmat, 2008). When the solution has been determined the project scope, cost and time for executing the project must be determined as accurately as possible, because this determines if the project gets executed (Mantel and Meredith, 2012). Empirical research was done by the renowned Construction Industry Institute (CII) and other researchers support the notion that, when more effort is put into FEP of the project its leads to project success, in term of project success factors such as time, cost and scope (Lotz, 2015).

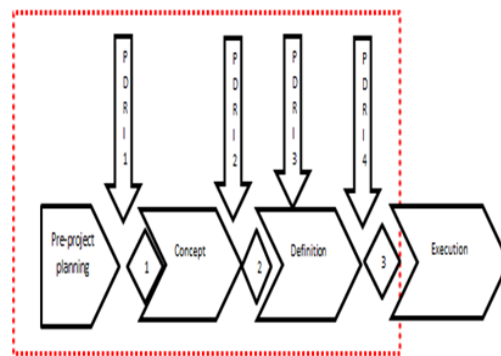


Figure 1: Front-end planning in the dotted area

During the FEP the scope of the project is defined (DoE, 2017), the risk is identified that can affect the objectives of the project and mitigation strategy are formulated to treat or eliminate the risks, in some instances in can be transferred (Gibson and Hamilton, 1994). The purpose of the FEP is to eliminate potential risks early in the project lifecycle that could lead to delay, scope creep and cost escalations (Malunga, 2012). The FEP also enhances alignment of the expectations of client and project team, as the client's requirements may not be well reflected initially (Moncrief, 2004). Therefore monitoring of alignment should be integrated throughout the entire project.

2.2 Project Scope Management through Project Definition Rating Index Methodology

The PDRI is a tool used for determining the degree of scope definition completeness and it is integrated as part of the front-end planning (CII, 2015). The PDRI aims to evaluate the scope definition completeness before the execution phase of a project, during the FEP PDRI assessment is performed to lower the risk of project delay and having the wrong output. The PDRI tool can be used for tradition construction projects in the power utilities/electricity generating projects and the PDRI tool can also be tailored for development of more specialized projects (DoE, 2017).

Originally the PDRI tool was intended to determine if the project can proceed with project execution after gate 3 as indicated in Figure 1, but experience has shown that it should be repeated more often to deal with the risks earlier in the pre-planning phase (CII, 2015). Currently, it is used to determine if the project is ready to move to the next phase during FEP and it is repeated till the execution release gate as indicated in Figure 1. This is done by scoring each

phase of the PLCM to get the PDRI score. The 70 elements are evaluated for completeness using the PDRI definition scales as indicated are score as below in Table 1.

Table 1: Scoring table for the PDRI

Value	Meaning
0	Not applicable
1	Complete Definition
2	Minor Deficiencies
3	Some Deficiencies
4	Major Deficiencies
5	Incomplete or poor Definition

The elements have been assigned a pre-determined weight by the CII and organisations using this tool are also encouraged to customize the weight to suit their application (CII, 2013). The elements score then contribute to three sections score of the PDRI as weighted below in Table 2.

Table 2: Weighting of the different sections in the Industrial PDRI (CII, 2015)

Section	Weight	Definition
Basis of project decision	499	49.9%
BASIS OF DESIGN	423	42.3%
Execution approach	78	7.8%
Total Max score	1000	100%

According to research done by CII, it has been indicated that when the PDRI score is less than 200, the cost is expected to 4% below budget and 4% behind schedule. However, when the PDRI score is over 200, the cost is expected to 4% over the budget and 10% behind schedule (CII, 2015). There is a direct correlation between high PDRI score and poor project performance, however, a PDRI score alone does not guarantee successful projects. When it is combined with good project governance, planning and project execution it improves the probability of good performance (Cho and Gibson, 2001) (Wang, 2006).

2.3 The structure of the Industrial PDRI

There are different types of the PDRI versions developed by CII (Gibson, Dumont, and Fish, 1997), for different applications. The PDRI version is customized for the industrial, Infrastructure, building projects and the Shutdown Turnaround Alignment Readiness (STAR) type for the projects that include a shutdown/turnaround/outage activity (CII, 2015). All these versions consider the specific risk factors unique to the type of PDRI and those that are common in all the PDRI types. For the purpose of this research, the focus is on the Industrial PDRI. The Industrial PDRI has 3 main section as illustrated in Figure 2, the 3 sections are divided into 15 categories and the categories are divided into 70 scope definition elements as its indicated, each of the elements is weighted according to its significance comparative to other elements (CII, 2015).

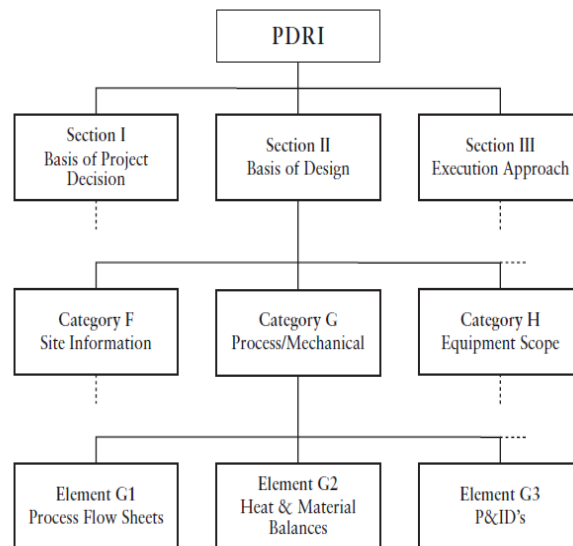


Figure 2: The 3 Sections of the PDRI tool (CII, 2015).

Section 1: Basis of the project decision this section determines how clear and complete is the objective of the project. It covers the project scope as well as the process scope. The project scope is the work that needs to be done in order to deliver the required operational capabilities which improve the process (CII, 2013).

Section 2: Basis of design this section is concerned with the technical information that must be evaluated and used as the basis for the designs. This section evaluates how the design parameters and specification have been defined. In the refurbishment project, some of this element can be completely defined early in the project those that are contained in F (Site Information), as most refurbishments improve the existing processes or it's about replacing equipment. This section is mainly done by the engineering team on the capital projects. The experience and knowledge of the engineering team also play a critical role in improving the basis of design. If there is a lack of experience this poses a risk in the quality of scope definition (Schaub and Franfenberger, 1999). Design Engineers are often required to creatively solve the problems and propose sound solutions, although this is a good principle, it does become challenging on an environment where time and resource are limited, this problem gets worse when some engineering members lack experience (Ali and Yong, 2013). Poor designs lead to poor scope definition and it may cause a lot of scope creep during execution, resulting in escalation of the cost of implementing projects.

Section 3: Execution approach of the PDRI, the procurement strategy of the projects is evaluated for its completeness. At the beginning of FEP this may not be defined, but as the solution of the projects becomes clearer or more defined, after the concept phase during the definition phase plans for execution can be enhanced, such as identification of long lead and critical equipment. For procurement strategy, it's also important to detail the procurement procedures and special requirement, such as social corporate policies. This section also focuses on the definition of expected deliverables of the project, the hardware's and software's, as well as the associated documentation for the design base, detailing the specifications, quality assurances, control and operation philosophy (Lock, 1988).

3. Methodology

A methodology similar to that was used previously to validate the effectiveness of the PDRI after it was developed; it was also used for this research (Cho and Gibson, 2001). The method used for evaluation is by case study. A case study is an empirical inquiry that examines a phenomenon within the real-life application environment (Schaub and Franfenberger, 1999). The case studies evaluation included interviews, archival records, documents and participant-observations. This multiple sources of evidence were done to authenticate the findings (Yin, 2014).

A mixed approach to quantitative and qualitative research methodology form part of this research. The objective of the qualitative research is to describe the perception of a certain phenomenon within a group or organisation (Bouma, 1996). The quantitative research was used to evaluate the performance of the projects and well as quantify some response of the candidates involved in the interviews (Bouma, 1996).

3.1 Data Collection

The data was collected by means of case study comparison reviews of outcomes of a project that used the PDRI tool as part of the FEP and a project that did not use PDRI in the FEP. This is done in order to evaluate the impact of implementing PDRI on a project and the impact of the PDRI score.

The interviews were conducted on Eskom personnel who have been involved in the FEP of project development of capital projects and had participated on the PDRI assessment session. The interviews conducted were guided by the questioner that contained a mixture of open-ended and closed questions (Vinten, 1988). Open-ended questions were asked to learn about the responder's experience with the use of the tool (Bouma, 1996). Using open-end questions will allow the interviewer the opportunity to get genuine feedback about the attitudes and views from the users who have implemented the Industrial PDRI tool in ESKOM (Vinten, 1988). Close question where ask to determine if they had used the tool and to determine their role within the project team (Bouma, 1996) (Vinten, 1988).

3.2 Data Analysis

The information received from the open-end questioner was summarized and categorized according to the themes that link to the objectives of this research. For qualitative research, the records of interviews can be systematically read and key issues, concepts and opinions identified through the categorization of themes (Bouma, 1996). Once the information has been codified, then data will be grouped and compared.

The data collected from the case studies based on the Final Release Approval's (FRA), that were presented to the investment committee to give feedback at the close of the project. The project performance was analysed considering the cost variance (CV), duration variance (DV) and the variance deviation (VD). The performance variables are indicated by the equations below:

$$CV = \text{Actual Cost} - \text{Planned Cost}$$

$$DV = \text{Actual duration} - \text{Planned duration}$$

$$VD(\%) = \frac{(\text{Cost or Duration}) \text{Variance}}{\text{Planned (Cost or Duration)}}$$

The equations can be either positive, negative or zero. When the duration or cost variance is positive it means the planned duration or cost was exceeded, indicating the degree of poor performance. When the duration or cost variance is negative it means the planned duration or cost was more than the actual, indicating the degree of good performance, and when it's zero it means there was deviation from the planned and the actual duration or cost.

4. Case Studies Analysis and Interpretation of Data

4.1 Case study 1: Completed Project with PDRI Vs Completed Projects without PDRI

Case study 1 consists of two Capital Projects that have been completed and handover to their clients, which are Power Stations. One project had done industrial PDRI assessment and received a score of 230. For the other project there was no PDRI assessment done prior to its execution. A comparison is done to evaluate the performance of the two projects and evaluate the impact of including PDRI assessment on the capital project for a power station.

4.1.1 Completed Project with PDRI - Conveyor System Project

An incident occurred where silo collapsed due to structural failure. As a result, no coal could be supplied to any of the three silos. An Interim Solution project was undertaken to restore the full generating capacity of all six units while the Permanent Solution was investigated and developed.

The Interim Solution project scope involved the construction of a temporary conveyor system that by-passes the coal silos and provides a reliable coal supply to the generating Units over the medium term.

Table 3: The performance of the completed project with a PDRI score of 230

	Planned	Actual	Variance	% of Deviation from planned
Cost (R Mil)	203.59	160.72	-42.87	- 21%
Duration (Months)	11	10	-1	- 9%

The amount of money spent was 21% less than the planned amount, and the project execution duration was 9% less than the planned duration. This project exceeded its performance targets.

Project Performance Analysis

- The scope of this project was well defined and the activities planned well in advance during the FEP.
- The saving is primarily associated with construction as a result of successful negotiations with successful tenderer, and the saving of a small contingency cost incurred as the minimal unexpected events.
- The project was implemented as an emergencies project, so a result more resources assigned to the project.
- The good supervision of this project was good as this was a high priority project resulting in cost savings.
- Two tenders were awarded, one for the Design, Construction, Commissioning contract and the second one for Operating and Maintenance contract of the Interim Conveyor System
- Local content 100%, there was no need for imported services as the conveyor belt industry in South Africa has matured enough to possess almost all the skills required. Hence contributing to a further cut down in lead times.

4.1.2 Completed Project without PDRI – Return to service project

Due to increase in the demand for electricity, the Eskom Board of Directors took a decision in 2004 for the Return to Service (RTS) the power station, that was mothballed in the late 1980's and early 1990's as the demand for electricity was low and the utility had excessive reserves. This project was executed prior to Eskom integrating the PDRI tool to the FEP. The scope of work for this project included:

- Return to Service of six units
- Upgrading of the High Voltage yard and associated electrical reticulation system.
- Installation of a new control system on all units, and common plant.
- Installation of new MV and LV switchgear.
- Refurbishment of the ash system, ash water returns system, and cooling water system.

Table 4: The performance of the completed project without using PDRI

	Planned	Actual	Variance	% of Deviation from planned
Cost (R mil)	4 347	8 331	3984	91.6%
Duration(Months)	74	112	38	51.4%

The variance indicates that there was a 91.6% increase in cost over the amount that was budgeted for the project and the schedule was 51% percent over the expected time of completion.

Project Performance Analysis

- The User Requirement Specification (URS) was completed, five months after execution has been approved and had commenced. There was uncertainty about project scope.
- The delays in completing the URS of units were due to scope increase due to unknown conditions of units in the Power Station. Conditions of the plant were assessed to determine the scope of work by detailed inspections; hence the delays sufficient work was not done for FEP.
- This also resultant in 5 cost revisions, requesting more funds to complete the project from the investment committee in order to complete the project.
- Unit 5 also suffered multiple tube failures during commissioning, which meant super-heaters had to be replacement prior to full load operation; this caused a 21-month delay to procure and install. The MW output was also affected; Unit 5 produced 160 MW instead of 200 MW. The contract was placed with the OEM to replace the damage superheaters and an outage had to be scheduled for the replacement. Once replaced full load operation could be achieved.
- Hand over documentation was not in the correct format, in accordance with Eskom project document management system. Documentation system was not defined by the client prior to the commencement of Project.
- Access to commercial units was difficult to arrange in order to conduct final optimization of the plant on some systems.

4.1.3 Conclusion

The project that had PDRI assessment performed better than the other project that had not done the assessment. Its scope was more defined upfront, eliminating addition funds to complete the project and resulting in a saving because there were less unexpected events leading compensation claims of the project. Generally, the governance of the project was good because the roles and expectation were clear for every stakeholder. Each stakeholder knew their role and what they had to produce and the duration.

While on the other project without the PDRI assessment, the scope was not clear hence the planned funds and duration were not accurate. Insufficient FEP lead to poor designs and incidents. The quality of output was affected in unit 5, it underperformed; more cost and time had to be allocated to fix unit5 so it can perform as expected.

5. Analysing Interview Data

The purpose of the interviews was to understand the impact of the project team on the PDRI score and their satisfaction with the tool. The interview question schedules consistent with 9 questions, the first 3 questions were used to identify the role and profile of the candidates in the FEP of the capital project and their technical experience in the power production field. Question 4 was asking if the candidate had attended PDRI assessment. All the candidates that were interviewed, have attended the PDRI assessment, those who have not attended it were not asked further questions. The remainder of the 5 questions were relating to candidate's experience and view of the PDRI assessment. Table 5 is the response rate of people who were interviewed.

Table 5: The response rates to the interviews

Anticipated number of interviewees to be interviewed.	An actual number of interviewees interviewed.	Response percentage
20	18	90%

5.1 The Result of Question 1-4

The profile of responded is tabulated below in Table 6, is the list of the candidates that responded to the interview, most of the candidate to who responded had between 7 years' and 15 years' experience working in the power generation utility.

Table 6: The project role of candidates that responded

Project Role	No. of candidates
PDRI facilitators	3
Project Managers	12
Engineers	3
Total	18

The project managers interviewed they were further asked to indicate their years as project managers. All project managers interviewed before their current roles, they were practising in the engineering field specialising in coal power generation as senior engineers and others were lectures. Below in Table 7, are the years of experience of the project managers. This was important to determine the years of experience and the level of exposures to PDRI assessments.

Table 7: The years of experience as Project Managers

Role	0-6 years	7-12 years
Project Manager (PM)	4	8
Total of PM	12	

5.2 Response to questions 5-9

Question 5: How many PDRI assessment have you attended as Eskom?

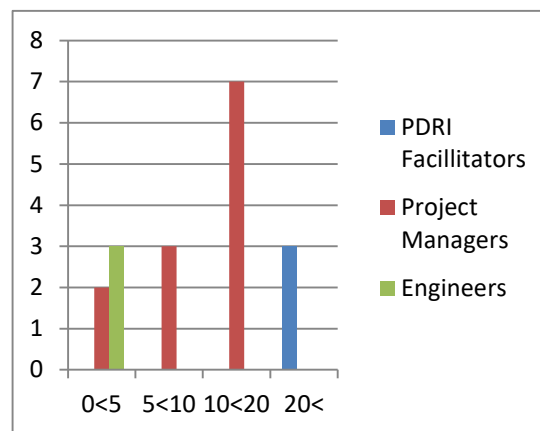


Figure 3: Project participates and the number of PDRI assessment they have attended.

Response to question 5 in Figure 3, it clear that 100% of PDRI facilitators have had the opportunity to attend more of the PDRI assessments, as they are the facilitators. 58% percent of the project manages have attended between 10-20 PDRI, this indicates that project managers with experience of 7-12 years have more experience.

Question 6: Was it clear what was required by the PDRI elements?

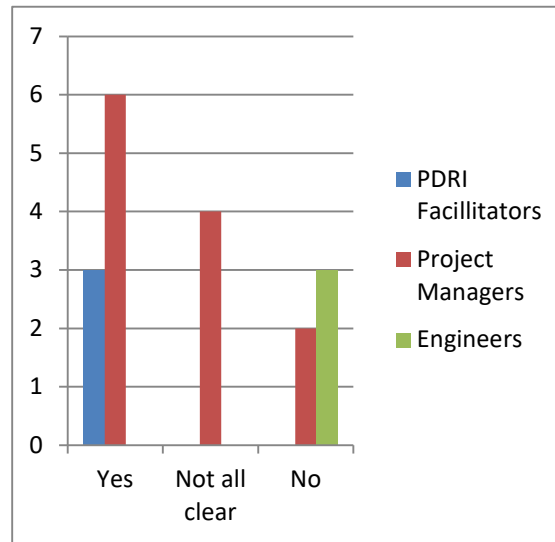


Figure 4: PDRI assessments participants response to question 6 about the clarity of PDRI elements

The PDRI facilitators felt that the requirements of the PDRI elements are easy to understand and indicated that they have been adjusted to be understandable terms in Eskom's context. Approximately 50% of the project managers agreed that the PDRI elements were easy to understand and they also admitted that the PDRI elements became easy through repetition; the more they attended the assessments the more they became familiar with the requirements. The other 50% of project managers indicated that some of the PDRI elements requirements were not easy to understand. They depended on the facilitator to explain the element requirements to them. During the interviews some project managers felt that "some of the PDRI elements are subjective", they say the evidence required to fulfil the element is different. They can receive different score on different PDRI assessments, while using the same evidence. Few project managers and engineer interviewed felt that the PDRI elements requirements were not clear, but the facilitator helped clarify them.

Question 7: What impacted the score of the PDRI?

Response to question 7

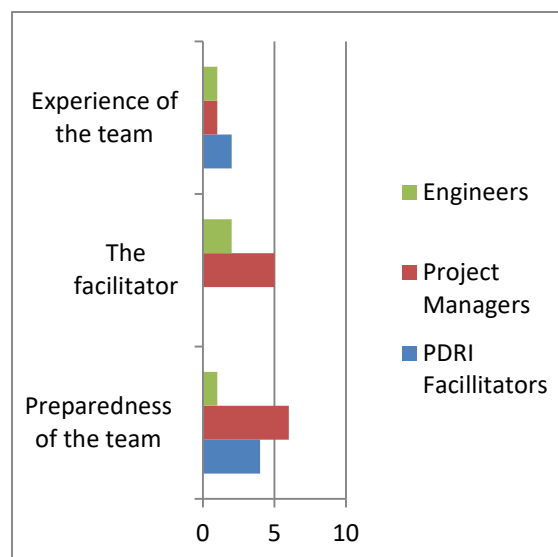


Figure 5: The themes that arise in response of Question 7

Preparedness of the team - 64% of the candidates interviewed, indicated that the preparedness of the team influences the score of the PDRI. The more the project team is aligned with the requirements of the project that improved the score. Instances where there was a change in the project team, it made the team alignment weaker as

the new members requires some time to gain knowledge about the project and this reflects negatively in the PDRI score. The candidate's response also indicated that the quality of engineering deliverables has a big influence on the score; contents of the engineering document must address the elements in order to improve the score.

The facilitator: 41% of the candidate responded that the facilitator had a big influence in helping them understand the requirements of the PDRI. Candidates also reflected that the scoring of the PDRI can be subjective according to the facilitator's view, scoring differently for the same project on the same phase while producing same evidence, the only variable being the facilitator. Responded also believe that the technical experience of the facilitator, influences the quality of the facilitation. When the facilitator has experience or understanding of the topic, the score becomes more reflective of the true quality of the project scope definition readiness.

Experience of the team: When the team knows what is required to be presented as a body of evidence, this implies the more experience in attending the PDRI assessments the better the performance of the project because the candidates know what needs to be presented and the format it should be presented in.

Question 8: How was your experience of been involved in a PDRI assessment?

Response to question 8

The candidates reply to this question by reflecting on the benefits and difficulties of using PDRI.

Benefits:

- It highlights what needs to be done to have a well-defined project scope.
- It gives an accurate reflection of the readiness of the project to proceed to the next phase
- It helps focus the effort on things that need to be done.
- It helps if it's done earlier on in the project. When less effort is put into the concept design phase that sometimes leads to poor basic design.
- PDRI provides a structured way to define project maturity.
- It's a good monitoring tool for project deliverables
- It helps identify risk not foreseen by Project managers and mitigation strategies in place
- It is good for record keeping and to documents the decision that were made and the reasons
- It gives foreign investors the confidence invest, in the projects that have undergone the PDRI assessment

Difficulties:

- PDRI must be guided by Eskom process, there are minor misalignments.
- It can be manipulated to get bare minimum through the system
- At times its purpose is not understood, because the designs are not developed in line with the PDRI.
- Initial it was difficult when it was facilitated by external facilitators who had no understanding of Eskom processes.

Question 9: Do you think the PDRI is a necessary tool for Front End Planning (FEP)?

All candidates interviewed candidates agreed, that the PDRI is a necessary tool for FEP. They definitely recommend the use of it on every project.

5.3 Conclusion

From the interviews conducted it does can be concluded that the PDRI tool, is a useful and effective tool for FEP of the project. It assists with the development of scope ensuring that it's well defined. It also assists in risk identification and risk can be resolved early or have mitigation strategies put in place when it's not possible to resolve them.

Over 50 % of the responded indicated that they depend on the facilitator to assist with the explanation of the requirements, and some have indicated that the interpretation of the elements it's not standard depends on the facilitator. The PDRI assessment needs to be standardized further, so that it becomes less subjective. The technical experience and project management experience place a positive role on the score. The more technical experience the better the quality of designs and the project manager's experience can help the team better prepare for the overall PDRI assessment.

6. Conclusion

The projects that had undergone PDRI assessment, performed better than those who did not have PDRI assessment. The direct outcome of the PDRI assessment on capital projects, it helped identify deficiencies in the scope definition and risks early. The identified risks were address in the subsequent phase during the FEP, those that could not be resolved were captured as risks and mitigation strategies put in place. During execution the projects that had done a PDRI assessment, they had savings in the actual budget used when compared to the planned budget for the project and the also finished early than scheduled.

The indirect outcome of the PDRI assessment on capital projects, it improves contracting strategies and contract negotiations, when the scope is clearly defined. Projects that had PDRI assessment done also improve the governance of the project during the execution phase, as the role and responsibilities are outlined clearly.

From the findings of the interview project team impacts the PDRI score, differently depending on their role in the project team. The facilitator's role is critical in assisting and guiding the project team through the PDRI. The project team relied on the facilitator to explain the interpretation of elements they did not understand. It was also noted that the Project managers who were familiar with the tool, who had more experience using the tool helped improve the PDRI score of their projects as they are able to better guide their teams in preparations for the PDRI assessment and for phases in the FEP.

Engineers with more technical experience help improve the score in terms of their technical preparation of the engineering design documents. Engineers who had more experience with PDRI assessments also contributed to the improvement of the project score because in their technical documents they also focused on additional information required for execution, such as site layouts, client requirements and equipment status etc. Those team members with less experience with the tool said at times they did not understand what the elements required and this led to poor PDRI scores. Training and awareness for project teams, in capital projects would help teams get more experience in the tool and help them with FEP.

The Capital Project teams are the clients that use the PDRI tool. All the candidates interviewed they expressed their satisfaction with the tool, even those who struggled to understand. The common themes that come out from the users are that it guides them in what they are required to do for the next phase of a project. The organization is also satisfied with the tool, PDRI assessment has been integrated into the FEP of all Capital projects. The PDRI is part of requirements of Investment Committee before the project can be allocated funds for FEP phases up to the execution phase. Eskom possesses the characteristic of organizations that implement the tool effectively (CII, 2015). It can be concluded that the impact of the PDRI on the capital projects for coal-fired power station has been positive , it improves the FEP , which helps improve the performance of the projects at execution.

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Biographies

Yolisa Motsepe is currently employed by Eskom as a Manager Complex Projects, in Group Capital Division. She earned a BEng Hons in Electronics Engineering from Multimedia University in Malaysia, MEng Engineering Management from the University of Johannesburg. Before her current position she spent 9 years working as a Senior Engineer in Control and Instrumentation at Eskom. She is a registered Professional Engineer with ECSA. Her research interests include project management and reliability.

Bheki Makhanya is currently a full time doctoral student at University of Johannesburg. He earned MPhil. in Engineering Management from the University of Johannesburg. He has about 10 years' experience working in rail industry and he is currently employed as senior maintenance manager for rolling stock (wagons and locomotives). His research interests include maintenance and reliability management.

Prof JHC Pretorius is currently a Professor and Head of Postgraduate School of Engineering Management. He has earned a BSc Hons (Electrotechnics), MEng and DEng degrees in Electrical and Electronic Engineering at the University of Johannesburg and an MSc (Pulse Power and Laser Physics) at the University of St Andrews in Scotland. He has over 30 years of lecturing and consulting experience with various utilizes on optimization of their electrical systems.