Development of processes to improve sustainability of industrial IDM projects

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ABSTRACT

Title: Development of processes to improve sustainability of industrial IDM projects

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Eskom, the primary supplier of electricity in South Africa, is struggling to keep up with the country's demand. This led to the creation of the Integrated Demand Management (IDM) Division which funds projects implemented by Energy Services Companies (ESCos). The IDM projects, also referred to as Demand Side Management (DSM) projects, are implemented by ESCos to reduce and manage the electricity usage on the demand side of the grid. In 2015, Eskom decided to change the DSM model to be more performance-orientated. This introduced a new funding model as well as an obligated maintenance phase.

The new DSM model shifted all the risk involved with the DSM projects to the ESCos. A result of this shift in risk forces ESCos to manage these risks and adapt to the new problems arising under the updated DSM model. Unfortunately, ESCos have limited experience in sustaining projects for extended periods.

This study will focus on developing processes which can be used as a guideline to assist the ESCo in solving issues as efficiently as possible. When the processes are implemented it can reduce the risk within the new DSM model. The first group of DSM projects under the new DSM model is nearly completed. This means that knowledge gained from these projects will be used within this study to assist in developing processes to sustain project performance.

The developed processes are verified with a verification survey. The survey is given to multiple project engineers responsible for industrial DSM projects. Six project engineers with varied knowledge in the field of DSM research were requested to complete this survey. The results indicate that the processes score an average of 84%. The survey results verify that the processes meet the requirements of each objective in this study.

The processes are validated by applying them to authentic industrial DSM projects. The DSM projects will be represented as case studies. Each process contains multiple steps which are applied by the ESCo to solve the sustainability issues encountered within each case study. Case study A consisted of a load shift project implemented on a pump station. The ESCo was able to increase the project performance from 0.2 MW to 3.28 MW with the applied processes, resulting in the project achieving 162% of the project target. Case study B consisted of a load shift project implemented on a mines' refrigeration system. The ESCo was able to achieve 164% of the project target, increasing the project performance with 2.99 MW. The results obtained from the case studies show clear improvements. In some cases it was found that the DSM projects over-performed, thus increasing the profitability for ESCos to implement DSM projects.

By applying the developed processes, the ESCo was able to increase the project performance of both case studies, resulting in an increased project sustainability. The results indicate that the processes can be used as a guideline to solve sustainability issues efficiently, thus proving that the processes meet the requirements of the study's objectives.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

NOMENCLATURE

Power	The unit for power is in kilowatt. It is the consumption of energy per second. 1 kilowatt is a 1000 J/s.
Energy	The unit of energy is in kilowatt per hour. It is the amount of energy consumption within a specified hour.
Tonnes	Unit of mass (Note: 1 ton is equivalent to 1000 kg).

UNITS OF MEASURE

kW	Kilowatt
kWh	Kilowatt hour
MW	Megawatt
R	Rand

LIST OF ABBREVIATIONS

BAC	Bulk Air Cooler
CLM	Conservation and Load Management
DSM	Demand Side Management
ELI	Efficient Lighting Initiative
ESCo	Energy Services Company
HMI	Human Machine Interface
IDM	Integrated Demand Management
LS	Load Shift
M&V	Measurement and Verification
MAD	Measurement and Acceptance Date
PA	Performance Assessment
PCM	Performance Centered Maintenance
PLC	Programmable Logic Controller
PT	Performance Tracking
RFQ	Request for Quotation
SANEDI	South African National Energy Development Institute
SANS	South African National Standard
SCADA	Supervisory Control and Data Acquisition
STE	Social, Technical and Economic
TOU	Time of Use

CHAPTER 1 - INTRODUCTION

1.1 Background

Due to economic weakness in South Africa and the rising electricity costs, there has been an overall decrease in electricity production of more than 4% between 2007 and 2016 [1]. Regardless of this, Eskom remains the primary supplier of electricity in South Africa [2]. Eskom generates approximately 90% of the country's consumed electricity [3]. Although there is a visible increase in renewable energy generation in South Africa, the country is still generating approximately 91% of their electricity from thermal power stations, with coal being the main contributor[1].

Due to a substantial increase in electricity demand, Eskom aims to increase their nominal capacity by 17 384 MW between the period of 2005 and 2019. Since Eskom achieved approximately 62% of the projected target by 2017/2018, the deadline was extended to 2022/2023 [4].

With the demand requirements and the slow grid expansion, Eskom decided to implement a short-term solution, namely load shedding [5]. This initiative was introduced between the period of 2007 and 2008. Load shedding is the reduction of the load/demand on the grid. It is described by Eskom as a controlled initiative to react to unintentional events that could cause damage to the national grid [5]. Unfortunately, this initiative resulted in [6]:

- Mining operations to shut down
- Negative effects on households
- Disruption of small businesses

The industrial and mining sectors are some of South Africa's largest electricity consumers. In 2017/2018 Eskom sold 221 936GWh of electricity to consumers, with approximately 37% sold to the industrial and mining sectors [3].

The continued electricity demand in South Africa led Eskom to implement initiatives to decrease demand. This is referred to as Demand Side Management (DSM) program [7]. This program funds projects that are found by Energy Services Companies (ESCo). DSM is the process where ESCos work with the consumers to manage the demand side of the electricity

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1 Ashley King. "Power Africa in South Africa | Power Africa | U.S. Agency for International Development." Internet: https://www.usaid.gov/powerafrica/south-africa, [May. 30, 2019].

distribution [8]. The DSM projects will contribute to the reduction and management of Eskom's main consumers' electricity usage. Some examples of the DSM projects include, but are not limited to, load shifting/management, peak clipping, and energy efficiency projects [9].

Even though the DSM program was finalised in 2003 and approved in 2004, Eskom was already busy with numerous DSM strategies. These strategies include an Efficient Lighting Initiative (ELI) and Time of Use tariffs (TOU). Figure 1 illustrates Eskom's initial DSM activities before and during the start of the DSM program [9].

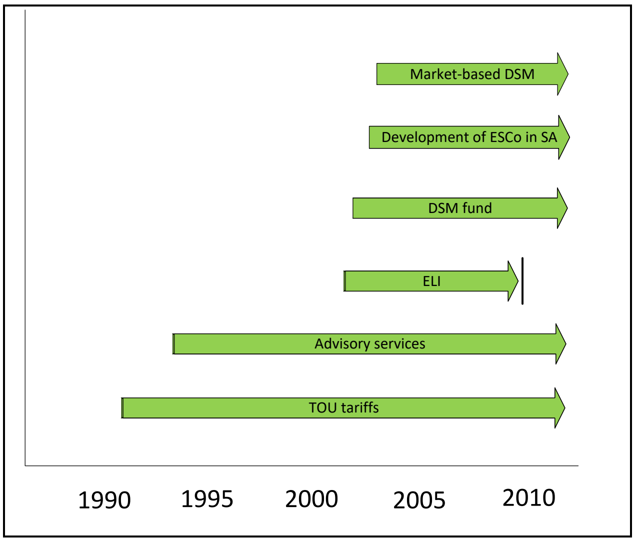

Figure 1: DSM initiatives [9]

As illustrated in Figure 1, TOU tariffs and ELI were implemented before the DSM program was commenced in 2003 by South Africa. Although Eskom deemed efficiency initiatives to be important, the main focus was assigned to how and when electricity will be used during the day [9]. This was performed due to Eskom struggling to generate the necessary electricity demanded from the consumers during peak hours [10]. ESCos worked with Eskom and their consumers to manage their electricity demand by means of:

- Load shifting measures
- Peak clipping
- TOU tariffs

The TOU tariff initiative enabled ESCos and the consumers to implement both peak clipping and load shift projects [11]. The TOU tariff initiative presents different electricity costs depending on the following factors [11]:

- Weekday

- High demand or low demand (seasonal)
- Time of the day

Figure 2 displays Eskom's Two-time period TOU tariff schedule. This schedule consists of high demand (winter) and low demand (summer) periods. During a 24-hour time period, the TOU tariff works as follows. The 24-hour day is divided into three time periods, namely a peak period, standard period, and an off-peak period which is indicated in Figure 2 using red, green, and yellow.

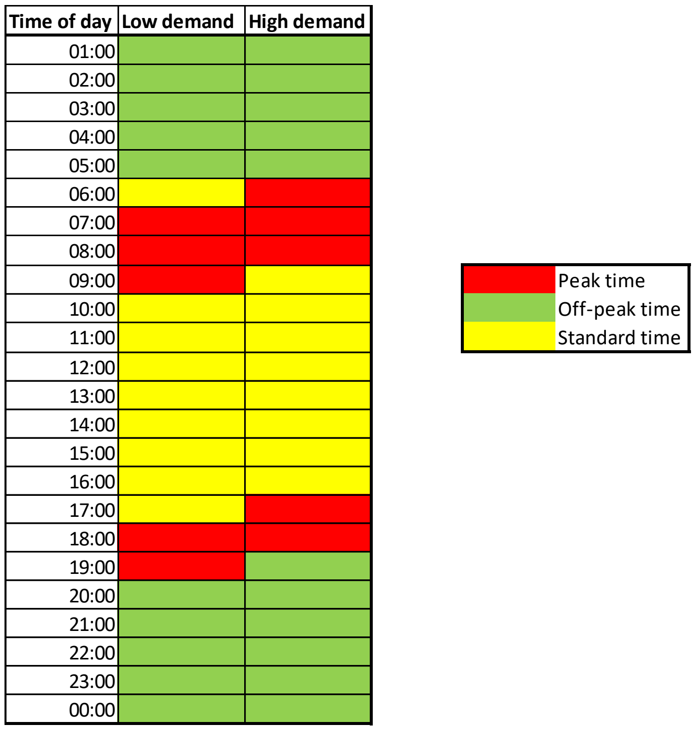

Figure 2: TOU tariff (Two-time period) [11]

The TOU tariff structure shown in Figure 2 is used to encourage industrial and mining consumers to reduce their electricity demand during Eskom peak periods. This made load shifting and peak clipping projects realistic for the industrial and mining sectors [12]. According to Eskom's 2019/2020 Megaflex tariffs, during low demand, the peak period tariff is more than double that of the off-peak period. In high demand, the peak period is more than three times the off-peak rates. The peak period increased from R 1.07 (low demand) to R 3.28 (high demand) per kWh with the present TOU tariffs [13].

Load shifting is the process of shifting the electricity consumption of the consumer from Eskom's peak period to less expensive time periods. The demand charges of the consumer will be reduced while the total energy consumption will remain constant. This can be achieved by rescheduling the operating time of equipment [14], [15].

Peak clipping is done by means of reducing the consumers' consumption during Eskom peak periods [16]. This will result in a reduction not only in the Eskom peak periods, but in the total energy consumption of the consumer as well [9], [17].

1.2 Demand side management

Demand side management is the adjustment of the energy usage pattern on the demand side [8], [18]. This is done to improve the efficiency as well as the operation of electrical systems [18], [19]. The DSM model was announced in the 1980s where numerous actions were applied to alter the energy usage pattern. In the United States, electricity services spent around 14.7 billion dollars on the development of demand side management between 1989 and 1999. The aim was to inspire consumers to invest in the DSM program [20].

As explained by Ferreidoon, the DSM program is currently in its second stage in the United States [21]. The first stage of DSM was identified as Conservation and Load Management (CLM) [21]. Due to the increase in oil costs in late 1979, there was an enormous rise in electricity costs in the USA. This led to the creation of the CLM program. The CLM program consisted of relatively small projects, for example switching off unnecessary lights. The implementation of CLM projects had little to no costs while producing noticeable benefits [21].

In the early 1980s the oil price reduced by more than 50% which led to a decrease in electricity costs [21]. Unfortunately, this resulted in a substantial decrease in interests in CLM projects. In order to solve this issue, incentives were introduced to utilities pursuing DSM projects. This was done in an effort to convince more utilities to pursue DSM projects [21].

Various countries started pursuing energy efficiency in an effort to bring their actual energy use close to their optimum energy use. One method in achieving this is for countries to use the services of ESCos to improve energy efficiency across various markets [22]. ESCos contain crucial knowledge to provide energy services to clients in order to reduce their energy costs [22]. Figure 3 provides a list of all the energy services provided to the market [22]:

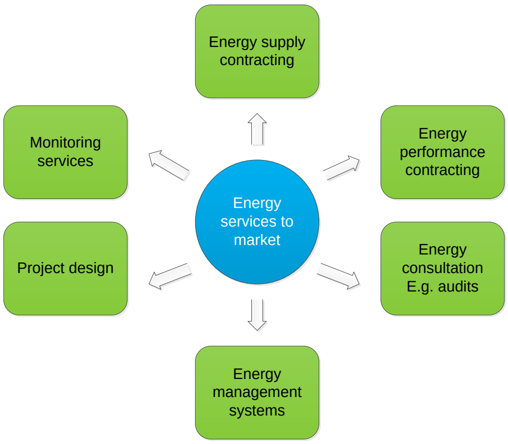

Figure 3: Energy services [22]

As mentioned, ESCos provide energy services to the market (demand side) in order to improve energy efficiency. There are various energy services contracts, namely [22]:

- Energy performance contracting
- Energy supply contracting
- Build-own-operate-transfer

The following sub-sections contain information on the various energy service contracts provided by ESCos.

1.2.1 Energy performance contract

This contract entails that the ESCo implement energy efficiency projects on clients' sites. The ESCo uses revenue received from the cost saving achieved to reimburse additional project expenses [22], [23]. The ESCo guarantees a specific quantity energy saving by using the technical equipment of the client. The energy cost saving post-contract end date remains

the client's [22]. Energy performance contracts consist of four phases, namely [22], [24]:

- Preliminary analysis
- Detailed analysis
- Project implementation
- Operation and follow-up

Preliminary analysis consists of tasks such as site visits, preliminary targets, and a project viability analysis. Detailed analyses follow the completion of preliminary analysis tasks, such as audits, financial implications, project design, baselines, and a guaranteed energy saving target.

The project implementation phase consists of contract specifications as well as construction details. The fourth phase consists of an evaluation phase by means of M&V reporting, project maintenance, and any project modifications if required. The energy supply contract is discussed in the following sub-section.

1.2.2 Energy supply contract

As the contract name implies, energy supply contracts entail that the ESCo supplies the client with energy. The energy supplied by the ESCo is usually heat. The ESCo is responsible for installing and implementing the necessary equipment as well as procedures to supply the client with energy. Energy supply contracts span over longer periods than those of energy performance contracts. These contracts can reach lengths of up to 30 years. The financial implication falls to the ESCo for all the necessary equipment bought. The ESCo receives payments depending on the difference in energy costs. The following sub-section contains information concerning the Build-own-operate-transfer contract [22].

1.2.3 Build-own-operate-transfer contract

In this contract, the ESCo is responsible for the design, financial implications, and the implementation of the energy efficiency project. Fortunately, the ESCo owns the project for a predetermined period until it is transferred to the client [22].

Figure 4 shows a flow diagram indicating the growing risk level of each contract [22]. As shown in Figure 4, the energy performance contract carries the greatest risk. This is due to the ESCo using the client's equipment as well as their resources to achieve energy savings.

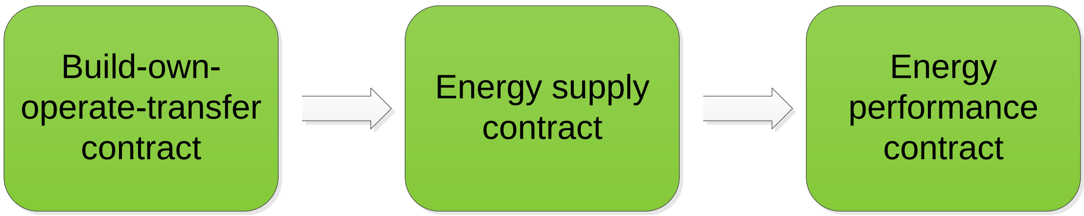

Figure 4: Growing risk level of each contract [22]

The following section contains information on ESCos as well as the DSM model used in South Africa.

1.3 ESCos and IDM in South Africa

Due to an increased electricity demand accompanied by excessive challenges faced to maintain energy generation in South Africa, Eskom created the Integrated Demand

Management (IDM) division. This division's primary focus is managing energy supplied to the grid and the demand from the consumers. IDM awards ESCos with DSM projects aimed at reducing energy consumption [25]. IDM will be accountable for assessing and funding the implemented DSM projects [25], [26].

Before ESCos will be allowed to work with Eskom IDM, they need to register at the South African National Energy Development Institute (SANEDI)[2]. It is possible for ESCos to operate in both the public and private sectors if they are registered. After the registration process, ESCos will be categorised either as a Tier 1 or Tier 2 depending on the following criteria[3]:

- Number of years' experience of the company
- Number of clients
- Number of completed projects
- Number of verified references
- Provision of quality
- Number of technical professionals
- Number of professional degrees
- Overall experience of technical professionals

Figure 5 illustrates the overall focus of South African ESCos during 2018. As illustrated, South African ESCos focused around 60% of their time on the industrial sector. The remaining 40% comprise the residential, non-residential (includes municipal), and the transport sectors[3].

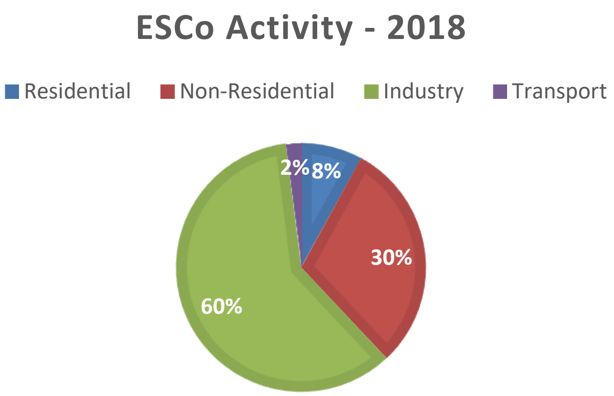

Figure 5: South African ESCo activity per sector[3]

2 SANEDI. "Purpose of register. " Internet:http://www.sanediesco.org.za/purpose-register, 2016 [June. 16, 2019].

3 IEA. "Energy Services Companies." Internet: https://www.iea.org/topics-energyefficiency/escos/Southafrica/, 2019 [June. 16, 2019].

Industrial clients mainly consist of mines, process plants, and water services. These clients use inefficient equipment that was installed when electricity tariffs were cheaper. Industrial clients use outdated control methods to operate their equipment. With production as the main focus, this led to the client neglecting energy management. This leaves scope for ESCos to implement energy efficiency projects as well as creating energy awareness [25].

Post-project implementation, a quantity of savings will be demanded from Eskom. In order for a project to be successful, the impact of that project must be determined in a measure of accuracy and trust that is acceptable to all the involved parties. The impact of the project will be measured and verified by the Measurement and Verification (M&V) team. The goal of M&V is to give an unbiased, trustworthy, and accurate measure of calculating the impact of the implemented DSM project. This can be achieved by means of site visits, measuring equipment, engineering calculations, and reporting [27].

In the case where ESCos require a specific skill, knowledge, or assistance with installing specific hardware that is crucial for energy savings, they can make use of third-party contractors. ESCos will initiate a new contract with the third-party contractors that will exclude the influence of Eskom's IDM division or the M&V team.

The amount of energy savings can be calculated using various methods. Typically, it is achieved by examining the electricity usage after the project was executed. The next step is to compare the electricity usage to the data collected during the investigation. Equation 1 is used by M&V teams to calculate the energy savings achieved by a DSM project [27]. Table 1 provides an explanation of the variables used in Equation 1.

Equation 1: Energy savings

$$Energy\ Savings = (Baseline - Actual) \pm Adjustments$$

Table 1: Equation 1 explanation

	Description:
Baseline	The *baseline* is a set of data gathered for a pre-agreed duration (usually a minimum of a month) which is compared to the data after the project implementation.

Actual	*Actual* is the energy data gathered during the assessment period of the project. This represents the project performance after the implementation is done.
Adjustments	If any adjustments occur to the baseline conditions during the project duration, M&V will make suitable amendments to the energy savings calculation [27]. For example, more equipment leads to an increasing energy usage.
Energy savings	*Energy savings* are the results which represent the reduction in energy consumption. In short, if the *actual* is less than the *baseline* it results in energy savings.

Eskom IDM made use of a DSM model that was continuously updated. The old DSM model was used between the period of 2004 and 2015. The new DSM model is used from 2015 onward. In this study the old and the new DSM models will be compared. For this reason, the old model will be discussed in the next section.

1.3.1 Old DSM model – South African ESCo

As previously mentioned, the first DSM model was finalised in 2003 and approved for implementation in 2004 In South Africa. This model was used between the period of 2004 and 2015. ESCos were responsible for inspecting and implementing projects that were funded through Eskom's IDM division [26], [24]. The client was responsible for maintaining the project performance after the project handover between the ESCo and the client was concluded.

It was found that the old DSM model was project-orientated due to the specific model phases, namely [25], [28]:

- Investigation;
- Proposal;
- Implementation, and
- Performance Tracking (PT).

The listed model phases will be discussed in more detail in the following sub-sections.

Old DSM model – Investigation

Figure 6 illustrates the Investigation phase process typically followed by ESCos. It is the ESCo's responsibility to acquire potential new clients with the possibility to implement new DSM projects. ESCos use knowledge they acquire from previously implemented projects to assist with marketing purposes. ESCos meet with the clients in order to obtain site-specific information and to familiarise the client with the DSM model [25].

Documentation is a vital factor in the investigation process. It provides both the client and the M&V team with perspective of the type of work ESCos are planning. Poor documentation can lead to clients using an ESCo's ideas and executing the projects without compensating the ESCo.

After the project is approved from the clients' side, ESCos schedule a site investigation. This entails getting the necessary data and information regarding the available equipment significant to the project. For example, site layouts, layouts of all the equipment, and power data. Unfortunately, this can be a time-intensive process. Equipment can be non-operational, or the lack of data can be problematic. Time and opportunity is lost due to preliminary site investigations that are done improperly. This leads to unnecessary work and the entire process to be held up [25]. In extreme cases, it can lead to ESCos initiating poorly developed projects which can result in ESCos losing possible clients and projects.

It was noticed that poor investigations either led to DSM projects over-performing or under-performing, or projects fail to be initiated for various reasons. Eskom does not compensate for over-performance. Thus ESCos lose out on income due to poorly estimated targets. Failed projects can lead to ESCos as well as the clients having to pay penalties. In either case, it affects the ESCos in a negative manner.

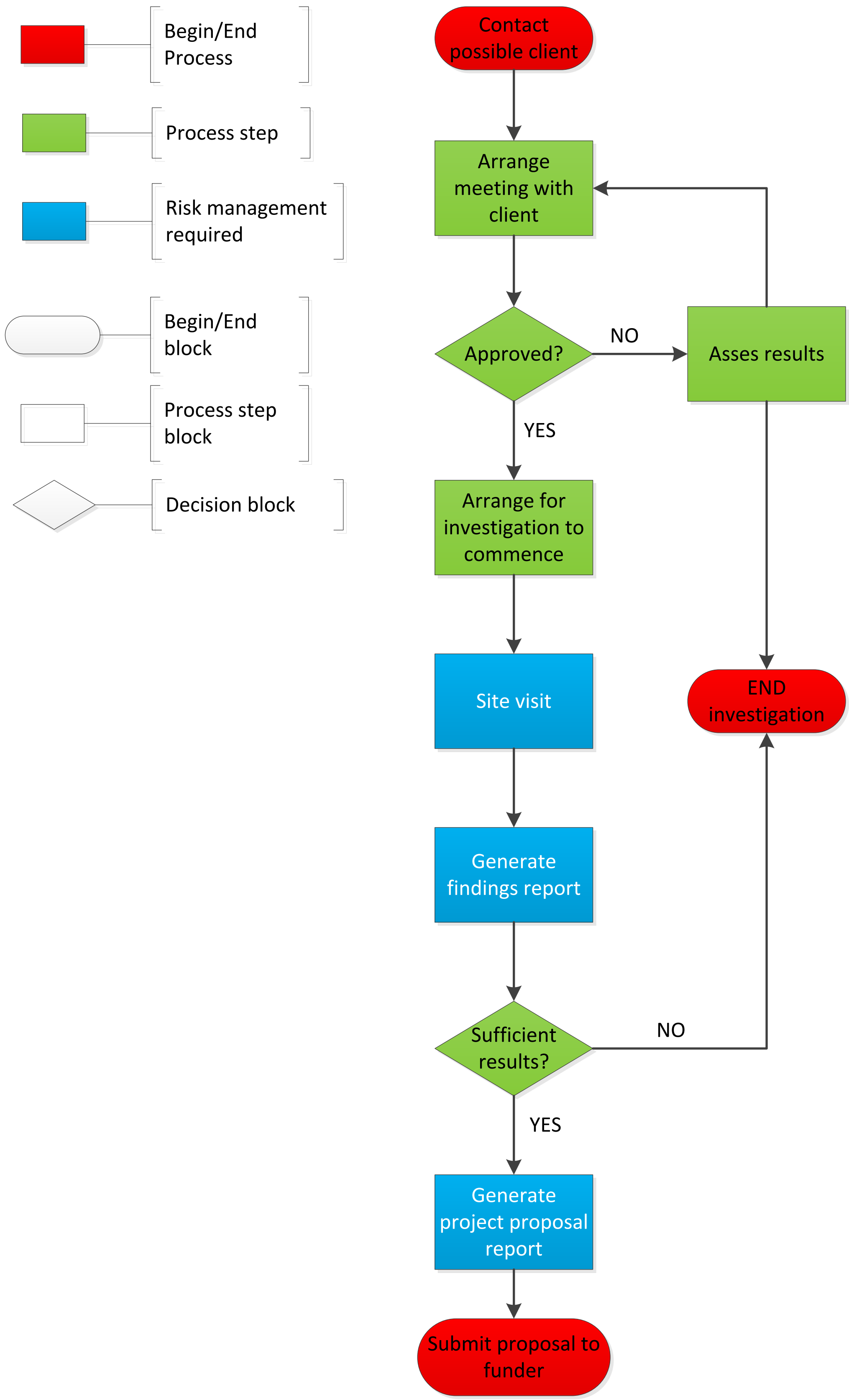

Figure 6: Investigation phase process [25]

Old DSM model – Proposal

Once the investigation phase is completed, ESCos will submit the project proposal to the client and Eskom's IDM division for funding approval. An ESCo will need to submit a project with a minimum target saving of 500 kW from a single site through the Eskom evening peak period [29]. The target saving may be between 250 kW-1250 kW if it is spread across five sites [29].

After the ESCo has submitted the proposal, they have limited involvement in this phase. Eskom IDM (funder) investigates the proposal to determine if the proposed project is feasible. In the case where the proposal is denied, ESCos will attain an additional opportunity. However, ESCos will have to correct the problem and resubmit the proposal [25], [29].

Unfortunately, by resubmitting a project, it leads to a time-consuming process. Various ESCos submit proposals to Eskom IDM as they are the largest funder of DSM projects in South Africa [25]. This results in resubmitted projects to be reprocessed, leaving a gap for rival ESCos to propose a similar project at the same location [25].

Figure 7 illustrates the proposal phase. It is important to submit a thorough investigated proposal to justify the time spent on approving a project. The blue blocks in Figure 7 illustrate where risk management will be required, as well as illustrating the time-consuming section of the process.

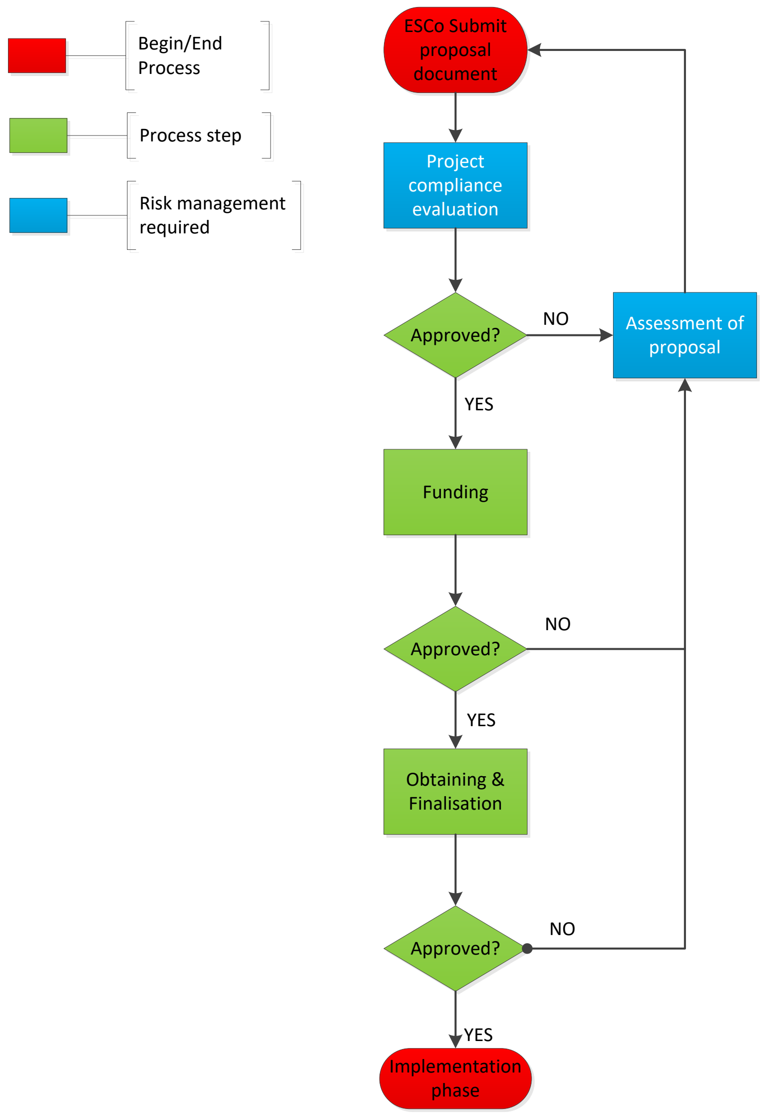

Figure 7: Proposal phase process [25]

Old DSM model – Implementation

The implementation phase commences as soon as the proposal phase is completed and the final contract is signed between the client, the funder (Eskom IDM), and the ESCo. ESCos are obligated to implement the project and achieve the agreed upon savings. The ESCo's income is dependent on the project performance. Figure 8 illustrates the implementation phase process, as well as indicating areas where risk management is required. [25], [29]

During the implementation phase, ESCos are obligated to create a scope document, clearly stating the nature of work to be completed. ESCos will be responsible for any additional equipment required to implement the project [25].

As previously mentioned, in the case where the ESCo lacks the skill or knowledge to implement equipment, they will make use of a third-party contractor. The third-party contractor will have nothing to do with the original contract as the ESCo hired them. It is the ESCo's responsibility to implement a quality check on all the work done by the contractors. If the quality check is acceptable, ESCos can commence with the control philosophy optimisation which can also be outsourced to a sub-contractor.

The project completion certificate must be signed upon completion of the implementation phase by the involved parties. The completion certificate is required for the following PT phase to commence.

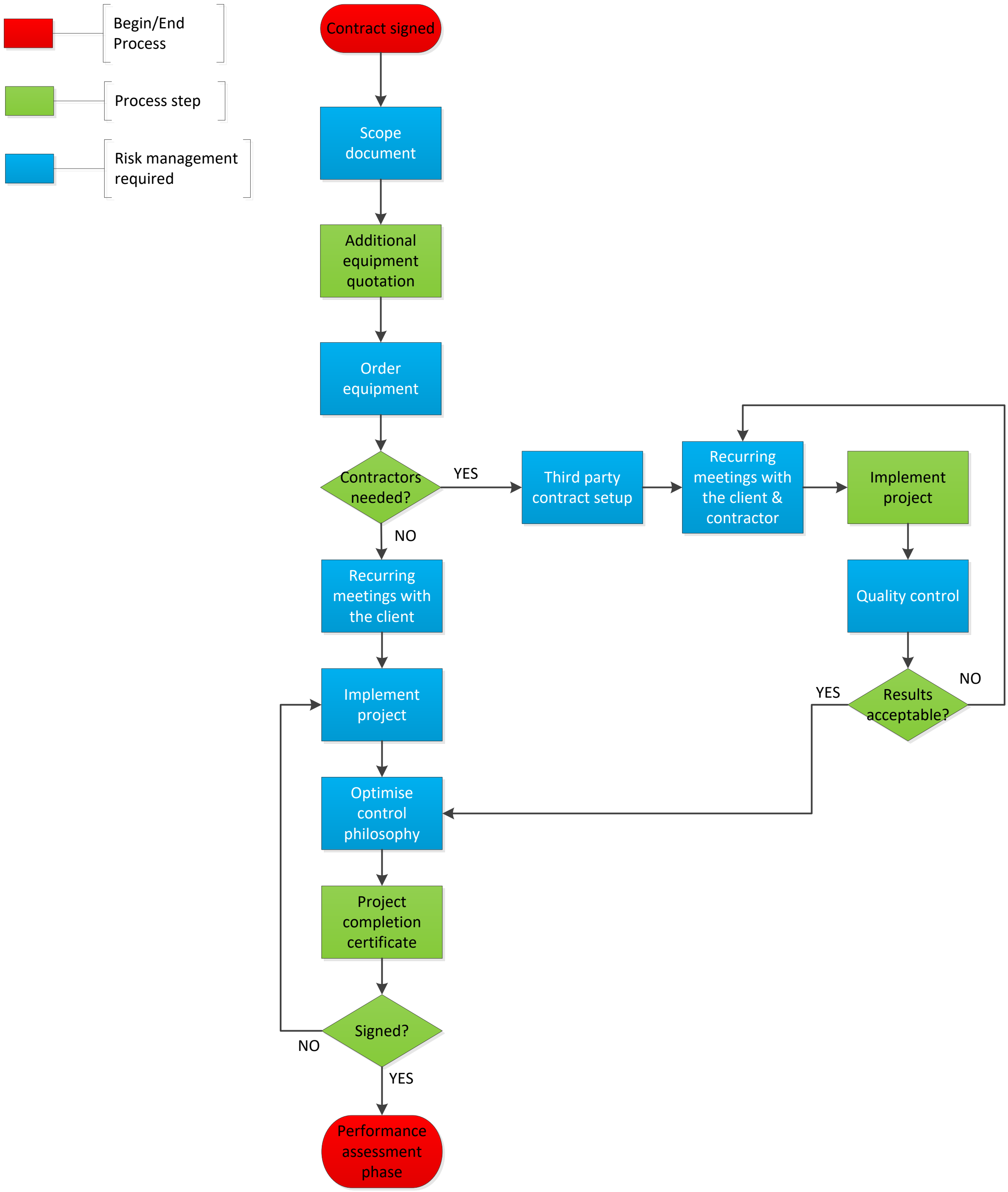

Figure 8: Implementation phase process [25]

Old DSM model – PT

Once the Implementation phase is completed, the Performance Tracking (PT) phase will be used to verify the electricity cost savings. This phase consists of a three-month period, where the ESCo should maintain the project for three months. The M&V team will verify all the electricity cost savings; thus they will form an important part of this process. If the ESCo is unable to achieve and sustain at least 90% of the target savings, they would be held liable for paying penalties [25], [29].

The M&V team will create a performance certificate stating the amount of energy savings achieved by the ESCo. The achieved savings will be reported in a handover document in the form of a Measurement and Acceptance Date (MAD) certificate. The project will be handed over to the client once the MAD certificate is singed. Thereafter, the client will be responsible for maintaining project savings for at least five years after the handover was completed. This is called the PT period. Figure 9 shows the PT process.

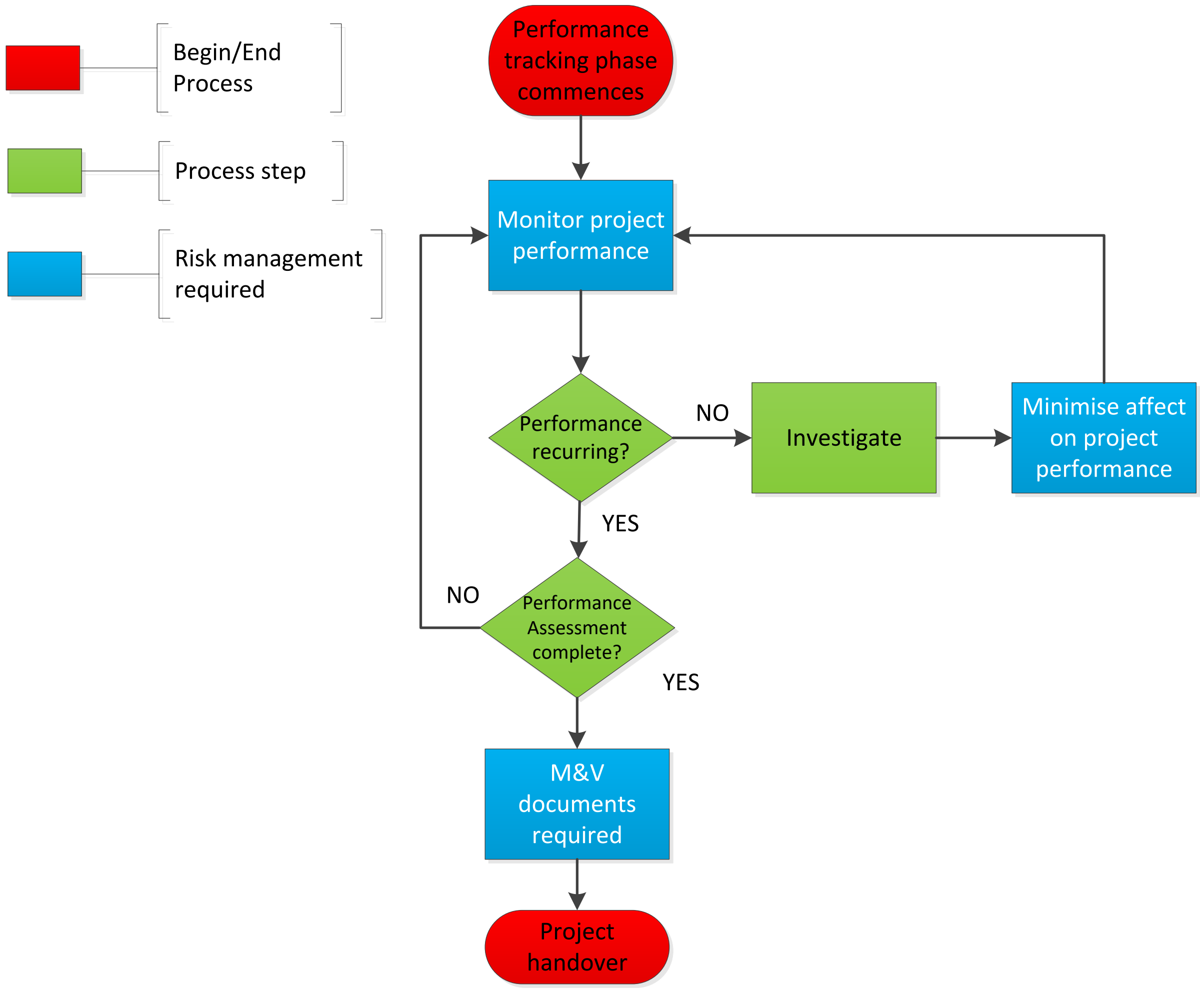

Figure 9: PT phase process [25]

The project orientated phases discussed above are integrated into the old DSM model. Eskom found that the old model is not sufficient due to various reasons. Eskom decided to drastically update the model to the new DSM model in order to manage issues on their side. The new DSM model is discussed in the next subsection.

1.3.2 New DSM model – South African ESCo

Due to the financial problems Eskom experienced, it was decided to change the entire DSM model. This change occurred in 2015 and is still applicable today. Eskom states that the new DSM model is changed to a performance-based model although the new model still contains project-based components. The noteworthy change between the models are that Eskom introduced a maintenance period which is compulsory for all ESCos. Eskom changed the model to focus on project performance. This results in all the risk shifting towards the ESCo since they are not only responsible for the performance of the project but for the maintenance period as well [25], [30].

In the old DSM model, ESCos involvement ended after the project handover was signed. The old DSM model stated that the client would be responsible for maintaining the project after the handover from the ESCo was completed. Numerous reasons caused project performance to deteriorate under the clients' maintenance. In some cases, ESCos offered a maintenance contract to revive and maintain DSM projects on the clients' behalf [25], [30].

The new DSM model accommodates the client due to the mandatory maintenance period. The clients will no longer be responsible for maintaining the project performance. The maintenance period consists out of a three-year period with 12 performance assessments consisting of three months each. To accompany the performance-based model, Eskom restructured the funding process. This means that ESCos will no longer receive funding upfront, significantly reducing the total funding of the project. ESCos will receive income on a PA basis. This means that ESCos will be able to invoice Eskom every three months, depending on the project performance [25], [30].

Figure 10 illustrates the process of the new DSM funding model. After the project implementation is completed, the first PA will start for a period of three months. As shown in Figure 10, a maximum of 30% of the total funding is available to the ESCo, depending on whether the target savings were achieved. The remaining 70% of the ESCo's payment will be available for invoicing after each PA. Thus a maximum of 6.36% of the total funding can be achieved by the ESCo per PA from the start of the second PA [25], [30].

The ESCo will not be able to achieve a payment value of more than 6.36% of the total funding. This means that over-performing on a project will not result in additional funding. Under-performing on a project will result in a deduction of the maximum achievable payment. A M&V team will verify the claimed electricity cost saving and as soon as the MAD certificate is signed, the payments can be made. The value of the payment received by the ESCo can be calculated using Equation 2 [28].

Equation 2: ESCo revenue per PA

$$PPA = P_{Max} \times \frac{AT}{CT} \times PA_{Max}$$

Table 2: Equation 2 explanation

Parameter	Description:
PPA	Payment per Performance Assessment – The invoice amount for a PA.
P_{Max}	Total funding specified by the contract.
AT	The actual saving that was achieved by the ESCo in MW.
CT	Contract target in MW.
PA_{Max}	Maximum amount that the ESCo can achieve in the specific PA (Percentage).

To simplify this concept, an example will be discussed. The example's parameters can be found in Table 3.

Table 3: ESCo funding parameters - example

Parameters	Value
Total contract funding (P_{Max})	R 1000 000
PA 2 (PA_{Max})	6.36%
Contracted target saving (CT)	3 MW
Saving achieved (AT)	1.5 MW

With the parameters in Table 3 and using Equation 2, the amount of funding received by the ESCo can be calculated as follows.

$$PPA = 1\ 000\ 000 \times \frac{1.5}{3} \times 0.063$$

$$PPA = R\ 31\ 500$$

As calculated, the ESCo will receive $R\ 31\ 500$ for PA 2 with the given parameters.

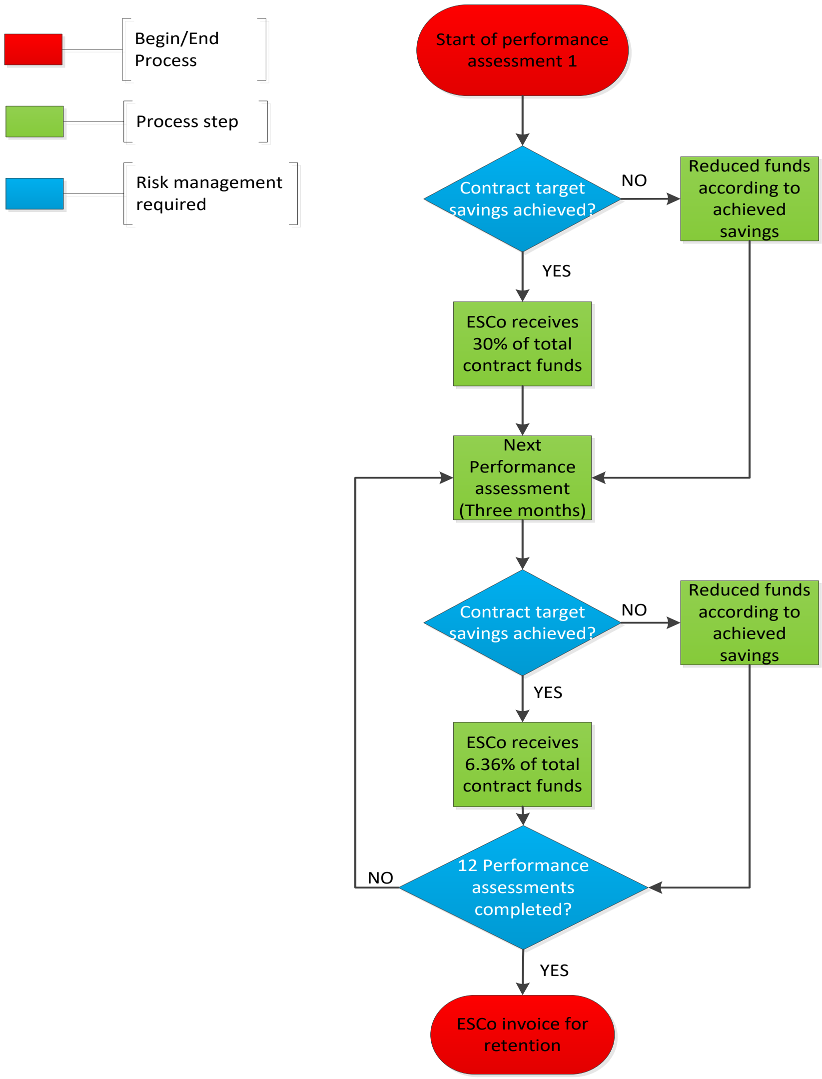

Figure 10: New DSM model funding process [25], [30]

The new funding model shifts the risk towards the ESCo. The maintenance of DSM projects is important, since ESCos are dependent on the income from Eskom IDM. This income can be used to implement future projects and to maintain current projects. This study will not focus on the lessons learned from the old model as they are outdated. It will investigate issues faced during the new DSM model to develop processes which will assist ESCos with future maintenance issues. Proper risk management will be required since ESCos have little experience with the new maintenance phase.

1.3.3 Variations between DSM models

There are quite a few differences that ESCos had to adjust to in order to thrive after the implementation of the new DSM model in 2015. The differences are within the implementation, performance assessment, maintenance, funding, and the risk involved.

- **Implementation** – The old DSM model offered a longer implementation time for projects. The period has been shortened from 6 – 18 months to 0 – 6 months. The reduced implementation period gave ESCos less time for proper project implementations. Improper investigations can lead to unrealistic project targets.
- **Performance assessment** – The old DSM model has one performance assessment of a three-month period. The new DSM model is stretched over three years with 12 PAs of three months each. This adds risk for the ESCo within the following obligatory maintenance phase.
- **Maintenance** – An obligatory maintenance period was introduced by Eskom in the new DSM model. Since the new model consists of 12 PAs over three years, it forces ESCos to be responsible for maintaining the project performance. ESCos will need to maintain the project performance for the duration of the three years. In the old model the client was responsible for the maintenance of the project. ESCos can offer assistance in maintaining the project if a maintenance agreement is established.
- **Funding received** – In the new model ESCos receive funds after each performance assessment. The amount will vary depending on whether the ESCo reached the contract target savings. The new model denies the ESCo additional funding for projects over-performed. The old model ensured that ESCos received their funds upfront. This means ESCos obtained funds for proper project implementations.
- **Risk** – The risk was divided between all the involved parties in the old model. Eskom was responsible for funding while ESCos were responsible for implementing the project. The maintenance was the clients' responsibility. The new model entails that all the risk is shifted towards the ESCo, since the ESCo is responsible for implementing and maintaining the project on a limited budget.

Risk involved for the ESCo:

- No initial funding upfront
- Reduced overall budget
- ESCo responsible for project maintenance
- Limited funding available after each performance assessment
- No compensation for over-performance

Table 4 gives a summary of the significant differences between the old and the new DSM models.

Table 4: Summary of variations between the old and the new DSM model

Project components:	Previous DSM model	New DSM model
Implementation	6 - 18 Months	0 – 6 months
Performance assessment (three-month period)	×1	×12
Maintenance	Client	ESCo
Funding received	Received as invoiced	After first PA (Performance dependant)

The similarities between the models allow ESCos to use knowledge gained from the previous model when implementing projects through the new model. It was noticed that ESCos cannot fully rely on the knowledge gained from the old model to maintain and solve problems faced during the new model.

1.4 Sustainability of energy savings

An increasing amount of industries are focussing more on sustainability. Sustainability is the process to maintain a curtain state for a determined period, while sustainable development is the development of a product that satisfies the present user's need [31], [32]. This product must not affect the ability of upcoming generations to fulfil their needs [31]. Industries aim to become more sustainable whilst remaining profitable during times when natural resources decrease drastically [33], [32].

Processes to solve sustainability issues differ from industry to industry due to every industry facing different issues [34]. Companies focusing on energy management are affected by climate change and involved parties' sustainability [32], [35]. According to the Loughborough University, by managing resources, financial and social sectors will assist corporate companies to achieve sustainability values [36], [37]. Corporate companies should connect sustainability to the environment of the specific company; thus focussing on solving issues consisting of production processes, resources responsible for production, and the investors (social) [36].

The Loughborough University states that the government usually has a large impact on various sustainability sectors, especially on environmental sustainability [31]. Unfortunately, governments are struggling to keep up with the increasing focus on environmental sustainability. Thus industrial companies are required to assist with sustainability. This puts pressure on multiple sections within an industrial company due to the pressure to comply with environmental regulations as well internal pressure to manage resources (human) [31].

The United States' environmental protection agency has developed an indicator model to assist with measuring the sustainability factor of chemical reactions [38]. The chemical reactions are evaluated on multiple categories, namely [38]:

- Energy;
- Efficiency;
- Economics, and
- Environment.

This allows companies to compare different chemistry reactions and determine which reaction is the most sustainable. Additional principles, namely monitor and reporting, were deemed important to achieve green chemistry [38]. Thus these principles were incorporated within this study.

DSM plays an important role in attaining sustainability objectives, as their main goal is to decrease excessive resource wastage [39]. It has been identified that numerous processes are developed to assist companies with increasing their sustainability throughout multiple internal sectors. The following subsection provides information on sustainability within the South African DSM field.

1.4.1 Sustainability within the South African DSM environment

The South African mining industry is one of the largest producers of gold in the world. In 2018, South Africa managed to produce 120 tonnes of gold. This resulted in South Africa becoming the eighth largest producer of gold in the world [40].

South Africa is highly dependent on the mining sector due to the large contribution it (the mining sector) makes to the economic and labour sectors of the country [32]. The high taxation of the mining sector substantially increases the country's revenue [32]. Unfortunately, the financial impact of the mining industry has decreased over the years [32]. This is due to:

- Lower-grade ore;
- Decreased amount of ore;
- Retrenchments;
- Increased living costs, and
- Above-inflation electricity tariff increases.

The recurring process of increasing mining costs and high accident rates caused an increase in the retrenchment rates. Drastic decreases in the gold price caused gold mines to downsize. Between 1996 and 2010, an estimated 70 000 employees lost their jobs in the gold mining industry [41]. By September 2018 an average of 6876 employees lost their jobs in the gold mining industry, correlating to 38.7% within the mining sector[4]. By downsizing the mine, it negatively effects the country due to [41]:

- Decreasing housing markets;
- The bank redlining specific areas;
- Change in ownership of the mine;
- Increased number of closed businesses;
- Decreased number of job opportunities, and
- Increase in illegal mining.

This reflects poorly on the South African mining industry, which results in other countries hesitating to invest in South Africa [41].

The mining industry in South Africa is one of the largest electricity consumers in the country. Large coal supplies are needed to meet the increased need for electricity in South Africa. Coal is generally cheaper than the other ore mined in South Africa [42]. The fossil fuels used to generate electricity are harmful for the environment; power stations require large quantities of water for cooling, nuclear power plants generate radioactive waste [42], [43], and electricity generation is such a large contributor to greenhouse gases. Thus it is unquestionably clear that electricity consumption should be reduced in South Africa, particularly in the mining and

4 SOUTH AFRICAN MARKET INSIGHTS. "Employment in South Africa's gold mining industry over time." Internet:https://www.southafricanmi.com/employment-gold-mining-10jan2019, 2019 [June. 25,2019].

industrial sectors since these sectors are the largest energy consumers. A method to reduce electricity consumption in energy-intensive industries is by implementing DSM initiatives.

DSM projects are required to reduce electricity expenses in the mining industry. Project sustainability/maintenance became significant with the new DSM model. ESCos receive financial income from DSM projects if the target saving is achieved. As previously mentioned, ESCos need to implement projects with a limited budget and ensure that the electricity cost savings are sustained. Unfortunately, ESCos have little experience in sustaining DSM projects over longer periods. This is due to ESCos not being responsible for maintaining projects for longer than three months in the old DSM model. This leads to ESCos using knowledge gained from the previous model to solve problems faced during the new model. Various projects struggle to sustain energy saving, and some of the reasons include [32]:

- Limited resources;
- Limited experience and training;
- Projects not being monitored, and
- Operational changes after the implementation process.

Due to the significant change between the old and the new DSM model, knowledge gained from the old DSM model has not been successful in solving sustainability issues. For this study, some of the main issues encountered for the initial projects under the new DSM model will be used and characterised into three categories. The categories are:

- M&V
- Technical and systems
- Resource management

Figure 11 and Figure 12 illustrate an example of project performance deteriorating due to project performance sustainability issues. The example consists of the performance of a refrigeration project in the mining sector. The results were gathered in July 2017 and August 2017. As shown in Figure 11, the project performance deteriorates in a time frame of a month due to poor project sustainability. The project's performance decreased from 2,26 MW to -0,71 MW.

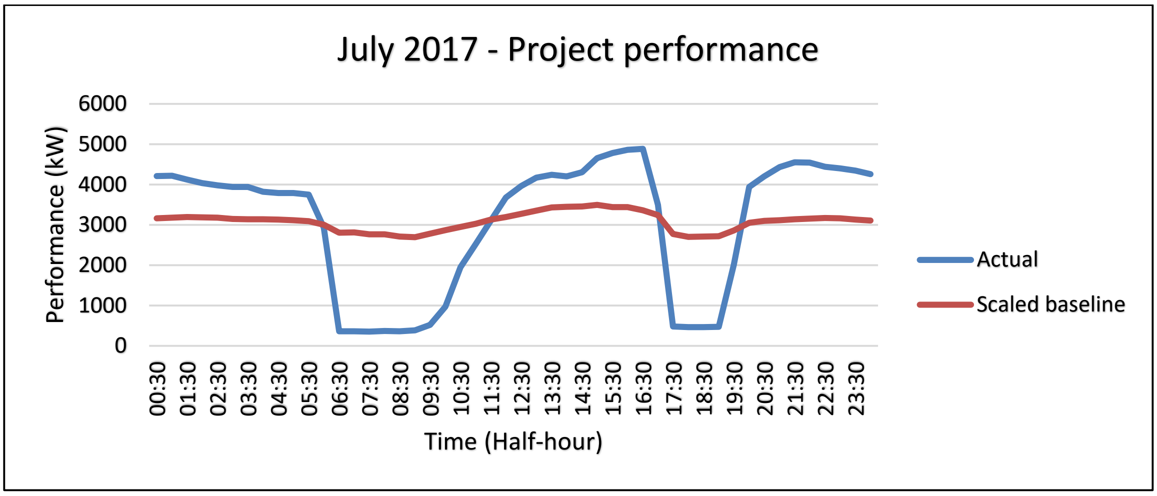

Figure 11: Project performance July 2017

Figure 12 illustrates the results of the sustainability issue. As can be seen, the project performance deteriorated by a significant amount.

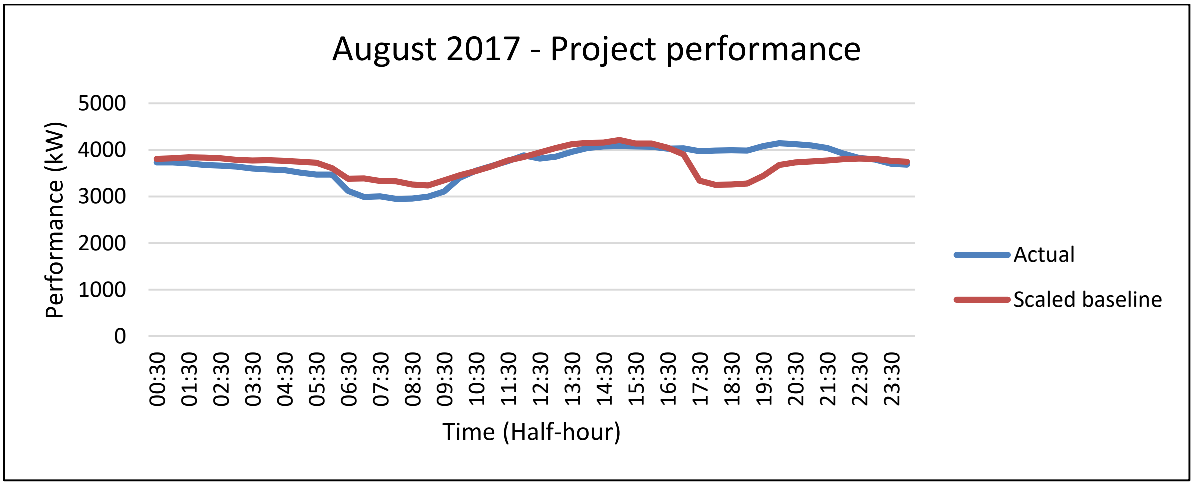

Figure 12: Project performance August 2017

Unfortunately, the time period falls during the high demand period of Eskom's Megaflex tariff structure. As previously mentioned regarding this high demand period, Eskom's tariffs can be between two and three times more expensive than in the low demand period. Thus it is very important to sustain project performance, especially in the high demand periods.

It is important for ESCos to identify and solve sustainability issues as quickly as possible. This will reduce the effect issues have on the project performance and maximise the ESCos' revenue from the total contract finances.

As previously mentioned, ESCos experience various sustainability issues over a three-year duration of the DSM projects. The following sub-chapters provide information on various sustainability issues encountered within the three identified categories as well as various solutions developed.

1.4.2 M&V issues

As previously mentioned, the measurement and verification team is responsible for giving an unbiased method of calculating and verifying the ESCo's claimed savings. Certain challenges associated with the M&V team faced by the ESCo affects project sustainability in a negative manner. Challenges experienced by the ESCo in this category are listed below. The challenges listed will be beneficial for this study and will be used throughout.

Additional M&V issues experienced by ESCos are:

- Lack of measuring equipment - After the proposal phase, M&V will generate a baseline report of the specific DSM project. This report includes all the characteristics of the project and the measured data the project savings will be compared to. In order for M&V to complete this report, they require a substantial amount of data. Various water schemes were built and never modernised. These water schemes do not have access to a fully functional Supervisory Control and Data Acquisition (SCADA) system and as such record data manually. This makes it difficult to obtain historian data and delays the project by a substantial amount.
- Incomplete data sets - For the new DSM model, data must be available at least every three months for M&V to process and for ESCos to invoice Eskom IDM after each PA. Unfortunately, natural factors can cause electricity outages which can affect measuring equipment. This may result in incomplete data sets and M&V not being able to calculate accurate results.
- Force majeure – A force majeure event is a circumstance which none of the involved parties have control over. This allows a party to suspend or terminate their performance for a predetermined period. A list of specific events will be determined in the initial project contract. It is impossible to determine what could happen in the three-year maintenance period. Thus it is a difficult process to condone specific events [44], [25].
- M&V report issues – As mentioned, M&V is responsible for generating reports to recognise savings within energy projects [45]. It was found that various M&V reports contain errors and some instances where the savings were calculated incorrectly.
- Alternative scaling methods – M&V uses scaling methods to calculate the savings achieved by the ESCo. Scaling methods ensure that the savings claimed are reasonable for all the involved parties. It is rarely found that equipment or control

philosophies get upgraded to become more efficient in the mining industry over the three-year period. In the cases where such an event happens, it can affect the results of the project and decrease the amount of achievable savings.

1.4.3 People issues

People issues are probably the most common type of issue experienced by the ESCo. ESCos work with a lot of personnel including the Eskom IDM team, M&V team, and the client. Conflicts are bound to occur and if they are not handled properly, can be the downfall of a project [46]. It is found in Dr H.P.R. Joubert's study that communication is a crucial factor in any DSM project [25]. He developed a communication process to assist ESCos with communication disputes.

Terblanche [47], [48] states that multiple levels of conflict can be identified. A low level consisting of small disagreements which can easily be solved, and a high level. The high level contains detail analysation to present a proper solution to the client in order to resolve the identified conflict.

ESCos communicate on a daily basis with various clients. Unfortunately, it can be challenging for ESCos to communicate with busy clients. Dr H.P.R. Joubert developed a communication process to assist ESCos in solving communication issues between involved parties [25]. This process is developed to focus on achieving a communication link between the ESCo and the client.

Additional people issues experienced by the ESCos include:

- Mining personnel are used to doing their work in a certain manner and rarely deviate from what they are taught. This can become an issue as soon as ESCos start with their projects. ESCos rely on mining personnel in order to fully implement their projects as quickly as possible. It is sometimes necessary to go higher in the hierarchy if certain personnel do not cooperate [25]. If not managed correctly, the ESCo will never receive cooperation from certain personnel again.
- Project handover – It is to be expected that there might be a possibility that engineers working for ESCos get transferred to new projects within the company, or, worst-case scenario, get a new employer. All of the project details and knowledge will need to be transferred to a new engineer of the ESCo. It is crucial that the previous engineer working on the project provides as much information regarding the project as possible.

- Contractor management – It is mentioned that ESCos use sub-contractors to assist them with knowledge and installations when required. Poor contract management can lead to improper installations and decreased project savings.

1.4.4 Technical issues

ESCos rely on the clients' infrastructure to be maintained and to be as reliable as possible. DSM projects get implemented on the clients' equipment. Failures can have drastic effects on project performance if not managed correctly.

Equipment failure – ESCos rely on the clients' equipment to function in the same manner it did during the baseline period. The effect equipment failures have on the project savings can be absorbed by the three-month average if the project overperforms and the downtime is limited. This requires that ESCos manage equipment fails to minimise downtime as quick and efficiently as possible.

Mr. B.G.G. Terblanche developed a Social, Technical, and Economic (STE) model containing various processes to assist ESCos with technical issues such as [47]:

- Requirement management
- Risk management

The following subsection explains the need for the study by considering shortcomings within relative studies.

1.5 Need for the study

Various studies focused on increasing DSM project performance as well as improving project sustainability. Multiple shortcomings were identified from these studies.

Study A – Dr H.P.R. Joubert [25]

- The shortcoming identified in this study is that most of the knowledge used to develop the new funding model was gained from the previous DSM model. Although this model was perceived to have a 69% success rating, it will not be able to solve all the issues faced with the new DSM model.
- Due to the new DSM model and the added maintenance phase, ESCos will be required to manage DSM projects for longer periods. The DSM projects are open to additional risks, such as outdated baselines, scaling method adjustments, and contractor management. Processes are required to address these issues.

Study B – Mr. H.L. Grobbelaar [32]

- The shortcoming identified in this study is that most of the knowledge used to develop this maintenance procedure was from issues and knowledge from the old DSM model.
- This maintenance procedure is mostly applicable to dewatering systems as this was the main focus point of this study.

Study C – Dr H.J. Groenewald [49]

- The shortcoming of this study is that most of the knowledge used to develop this maintenance procedure was from issues and knowledge gained from the old DSM model.
- The Performance Centered Maintenance (PCM) strategy was developed before the new DSM funding model was applied.
- The PCM model does not contain processes focussed on specific sustainability issues.

Study D – Mr. B.G.G. Terblanche [47], [48]

- The shortcoming of this study is that the processes were developed in the beginning of the new DSM model. The processes are developed from knowledge gained from the previous DSM model combined with knowledge from the initial phase of the new model. This means that there are various sustainability issues that were not included in the design of these processes.
- Due to the new DSM model and the added maintenance phase, ESCos will be required to manage DSM projects for longer periods. The DSM projects are open to additional risks, such as outdated baselines, scaling method adjustments, and contractor management. Thus the STE model developed in this study is limited. Processes are required to address additional sustainability issues.

Study E – Mr. C.J.R. Kriel [30]

- The shortcoming of this study is that most of the knowledge used to develop this maintenance procedure was collected from issues and knowledge from the old DSM model. This study was completed in 2014 with the old DSM model still in use.
- This maintenance procedure is only applicable to compressed air systems as this was the main focus point of this study.

Study F – Mr. N.D. Slambert [50]

- The shortcoming of this study is that the web application was developed in the period of the old DSM model.
- This study focused on information gathering to enhance the observation of DSM projects.
- This study does not contain processes that will assist ESCos in solving people or M&V issues that causes project performance to deteriorate.

Table 5 provides a summary of the studies contributing to address the deterioration in project sustainability. The table is divided into four sections, namely:

- Old DSM model
- New DSM model
- Risk management
- Field specific processes

The studies completed using knowledge from the old model will be categorised as such even though they will be applied to new projects. Studies focusing on the risk involved with the new and the old model will be categorised under risk management. Studies developing processes focused on a specific field will be characterised as either M&V, Technical, or People.

Table 5: Summary of previous contributions.

				Field specific processes		
	Old DSM model	**New DSM model**	**Risk management**	**M&V**	**People**	**Technical**
Study A	×		×			
Study B	×		×			×
Study C	×		×			

Study D	×	×*	×	×	×	
Study E	×		×			×
Study F	×					×

*Study is limited to initial phase of the new DSM model.

1.6 Study objective

The objective of this study is to develop processes that will assist ESCos in solving sustainability issues. ESCos need funding to implement future projects. Due to the funding decrease from Eskom IDM, ESCos are forced to shift their focus to sustaining projects in order to maximise financial income.

With ESCos having little to no experience with maintaining projects, assistance is required to manage issues to increase project performance. These processes can be used by ESCos, especially new ESCos, to manage risk and resources efficiently, thus increasing the profitability of implementing DSM projects under the new DSM model.

All the previous studies contributing to assist ESCos with maintaining DSM projects were developed from knowledge gained from the previous DSM model. This means that ESCos lack processes that were developed from knowledge gained from the new model. Figure 13 is a timeline indicating the range from implementation of the old DSM model through to the ending of the first DSM projects implemented with the new DSM model.

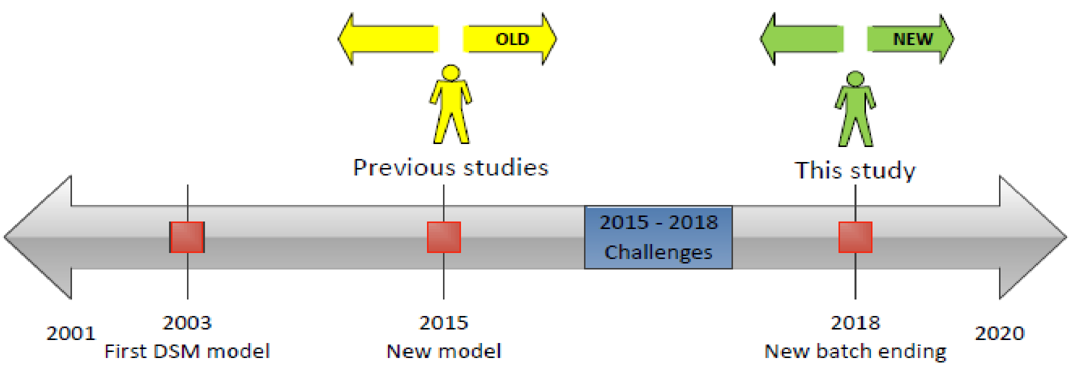

Figure 13: Study timeline

As illustrated in Figure 13, the processes developed from previous studies to assist ESCos in maintaining DSM projects are from the old DSM model. These studies contain knowledge gained from issues confronted during the old model. The obligated maintenance phase and the lack of experience ESCos contain within this phase resulted in ESCos using processes developed from outdated knowledge.

ESCos use outdated processes to solve sustainability issues faced with the new DSM model. Unfortunately, ESCos were unable to solve the sustainability issues. Thus there is a need for processes developed specifically for the new DSM model. This study will focus on the DSM projects implemented from the start of the new DSM model, and will use the knowledge gained from the sustainability issues faced during the new DSM model. The processes will be developed to solve specific issues ESCos have experienced under the new DSM model. The objective of this study is to:

- Develop processes that will assist ESCos;
- Solve issues as efficiently as possible while reducing the effect on project performance;
- Supply ESCos with a guideline to manage sustainability issues, and
- Reduce risk involved with the new DSM model.

The developed processes need to satisfy the objectives and increase project performance. An increase of 80% was chosen as a measurement of success. The following subsection provides an overview of the following chapters.

1.7 Chapter overview

1.7.1 Chapter 2

Chapter 2 will provide the development of a solution to each of the identified sustainability issues faced during the new DSM model. The chapter is divided into three categories and each category will have developed processes to solve issues involved within the specific category.

1.7.2 Chapter 3

Chapter 3 will provide the results of the applied processes. This chapter should prove that the developed processes will assist in significantly decreasing sustainability issues and the time/resources spent in solving these issues.

1.7.3 Chapter 4

Chapter 4 will present the conclusion of this study, stating the problem as well as the reason for the identified issue. The study objectives will be discussed with the results obtained from the applied processes. In addition, recommendations will be provided for further research.

1.8 Conclusion

Eskom being unable to generate the required electricity demand is significant which led to Eskom developing a DSM model in 2003. In 2015 Eskom decided to change the model to the new DSM model. This introduced a compulsory maintenance period for three years with ESCos' income influenced by the performance of the implemented projects. ESCos have a limited amount of experience in the maintenance phase of a project, as they were responsible for maintaining DSM projects for a three-month period with the old model. Due to this, ESCos were unable to use the knowledge gained from the old DSM model to implement on the new DSM model.

Due to the new model incorporating the additional project phases, ESCos will be able to benefit from the lessons learned. ESCos are in need of a guideline to assist them in sustaining project savings during the maintenance phase. The study objectives determined from the literature are to:

- Develop processes that will assist ESCos;
- Solve issues as efficiently as possible while reducing the effect on project performance;
- Supply ESCos with a guideline to manage sustainability issues, and
- Reduce risk involved with the new DSM model.

CHAPTER 2 – DEVELOPMENT OF PROCESSES

2.1 Introduction

As mentioned in Chapter 1, Eskom is under enormous pressure, particularly during the Eskom peak periods. As such, they are battling to provide electricity for South African consumers. Eskom being the largest supplier of electricity in South Africa increases the risk towards Eskom to provide for the country. Eskom implemented various methods to assist them in managing electricity production as well as the consumers.

One of the methods implemented was to develop the first DSM model in South Africa. This is done to mitigate the risk by reducing the electricity demand during the Eskom peak periods. The DSM model was used until Eskom decided to update the model in 2015. Unfortunately for ESCos, they lacked experience with the updates added to the new DSM model. Thus the new model increased the risk for ESCos to continue implementing DSM projects. Various ESCos implemented processes developed for the old DSM model to assist them in sustaining DSM projects under the new model. This study will focus on developing processes to solve sustainability issues found in the new DSM model.

The processes will be developed from information and personal experiences collected from the first set of DSM projects under the new DSM model. The majority of these projects came to a conclusion at the beginning of 2019. Thus the entire project duration will be taken into consideration when developing these processes. This chapter consists of the processes developed to assist ESCos with sustainability issues. As mentioned in Chapter 1, the sustainability issues identified within the new DSM model projects are categorised according to:

- Measurement & Verification
- Technical
- Resource (People)

An integrated process is developed that identifies an appropriate solution (process) for a specific sustainability issue. ESCos can use these processes to assist and guide them in sustaining project performance of new DSM model projects. The Integrated process will be discussed in the next section.

2.2 Integrated process (Master)

Figure 14 illustrates the integrated process, named the Master process. This process can be used to develop a solution process that can be applied to a specific sustainability issue found in the new DSM model. The steps in this process are as follows:

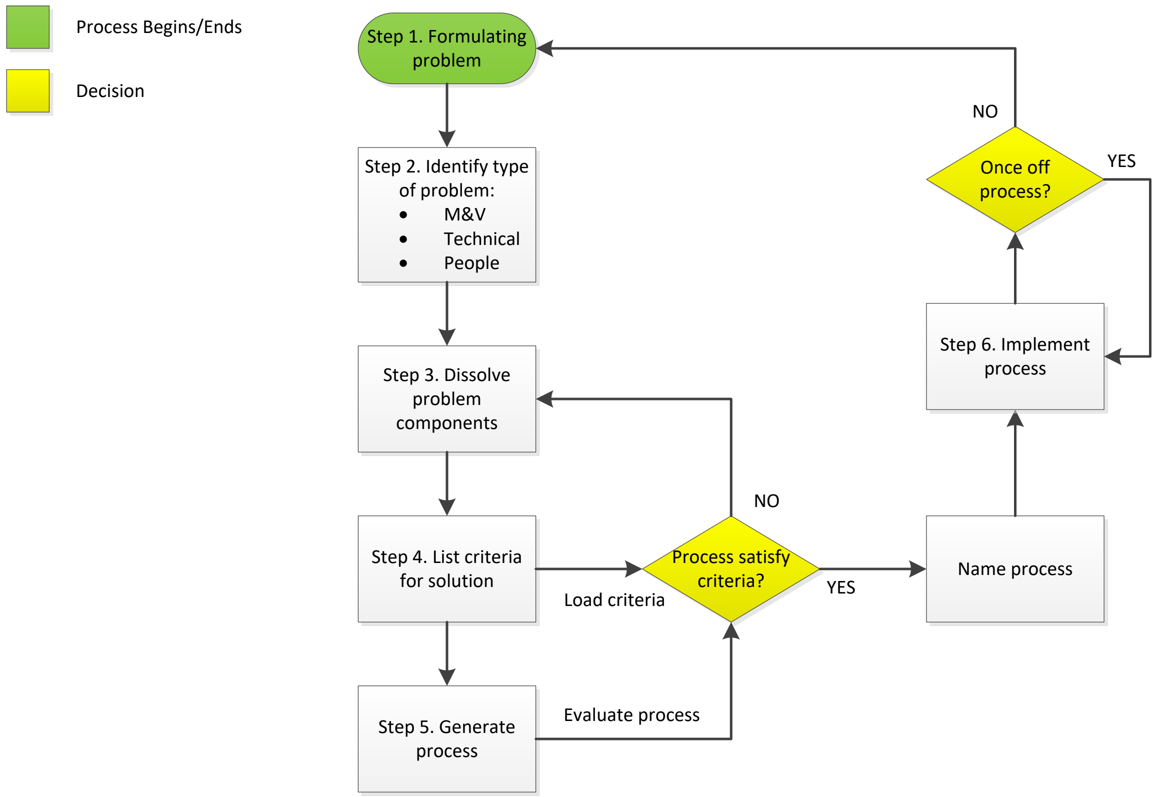

Figure 14: Integrated process (Master)

Step 1: Formulating problem – The obligatory maintenance phase introduced in the new DSM model resulted in ESCos experiencing an increasing amount of sustainability issues within DSM projects. The initial step in this process is to recognise the problem causing a decline in project performance.

Step 2: Identify the problem – The following step in the Integrated process is to identify the problem. This is attained by categorising the problem as either an M&V, Technical, or Resource issue.

- M&V: Is the M&V team required for sustaining project performance?
- Technical: Is the client's system or physical equipment the direct cause for a decline in project performance?
- Resource: Is the sustainability issue caused or influenced by a human dynamic?

Step 3: Dissolve problem components – After the problem is categorised, the problem can be broken down into problem-specific components. This is needed for ESCos to understand the problem and to identify where the problem originated from. In this step, ESCos need to obtain as much information regarding the problem as possible. The obtained information will be required for the list of criteria in the next step.

Step 4: List of criteria for solution – In order to generate a process to solve the sustainability issue, a proper list of criteria is required. This is a list of actions required to counteract the identified problem components. For example:

- Problem components
    - Project performance
    - Time duration
    - Communication
- List of criteria:
    - Performance assessment recur daily
    - Steps to solve the problem quickly which will increase project savings
    - Communication with the client as required

In the end, the solution process must satisfy the list of criteria in order for the problem to be rectified. Improper investigations can lead to an incorrect list of criteria, which can result in the problem recurring.

Step 5: Generate process – The process (solution) is generated after the list of criteria is developed. The process can be named and implemented after it satisfies the criteria.

Step 6: Implement process – Apply the developed process to the specific sustainability issue to solve the specific sustainability issue. If the developed solution process is not once-off, the Integrated process can recur in order to generate an additional solution process.

The Integrated process can be implemented to select a process designed for specific sustainability issues found in the new DSM model projects. The following section consists of the Flag Management process.

2.3 Flag Management (FM)

The Flag Management (FM) process is developed to assist ESCos when an issue arises during a process. Time management is a crucial aspect with any project. Poor time management can have catastrophic results on project performance as well as project sustainability. Additional risk management is applied by implanting time limits in the processes developed in this study. If the time limit is exceeded, the FM process becomes active to address the risk of ESCos spending more time than required with certain steps. Figure 15 illustrates the FM process.

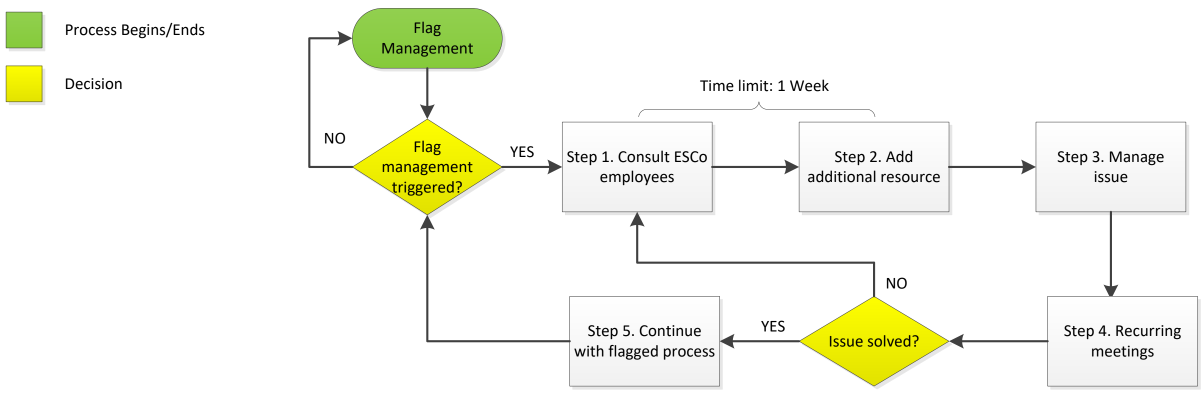

Figure 15: Flag Management (FM) process

Step 1: Consult ESCo employees – Immediately after the FM process is triggered, the first step entails that the project engineer meets with the ESCo supervisors. This step as well as Step 2 must be completed within the time limit as the processes which were flagged are dependent on the FM process.

Step 2: Add additional ESCo resource – If required, the ESCo may need to add additional resources to improve problem-solving techniques.

Step 3: Manage issue – The ESCo is required to manage the issue efficiently to resume the previous process. The ESCo will need to work through the issue as the project performance is dependent on the results.

Step 4: Recurring meetings – This step is added for additional risk management. It is advised that the project engineer schedule recurring meetings for additional assistance and feedback from the ESCo.

Step 5: Continue with flagged process – Immediately after the FM process is completed the project engineer can continue with the process that was flagged.

Thus the goal of the FM process is to assist ESCos to complete a focus action in a specific process. The following sections will consist of processes developed for Measurement & Verification, Technical, and Resource management, starting with the processes developed for Measurement & Verification sustainability issues.

2.4 Management of measurement and verification

As discussed in Chapter 1, the M&V team is responsible for delivering an unbiased third-party input on DSM projects. The M&V team will work alongside ESCos and Eskom IDM.

The M&V team is responsible for quantifying the project performance of each DSM project. ESCos are responsible for providing the M&V team with correct data. The M&V team delivers independent processes which can be used to report on the feasibility of the project, as well as report on the project savings achieved. The South African National Standard (SANS) are responsible for managing the M&V teams [51].

The M&V team will manage their responsibilities, although ESCos will benefit by understanding the process. There are risks that can affect ESCos and cause sustainability issues within:

- M&V reports;
- M&V calculations;
- Development of the baseline, and
- Development of scaling methods.

Proper management by ESCos can reduce risks as well as increasing sustainability. Figure 16 represents the M&V confirmation process. This process is a general process developed to manage time and risk involved in M&V. The steps in this process are as follows:

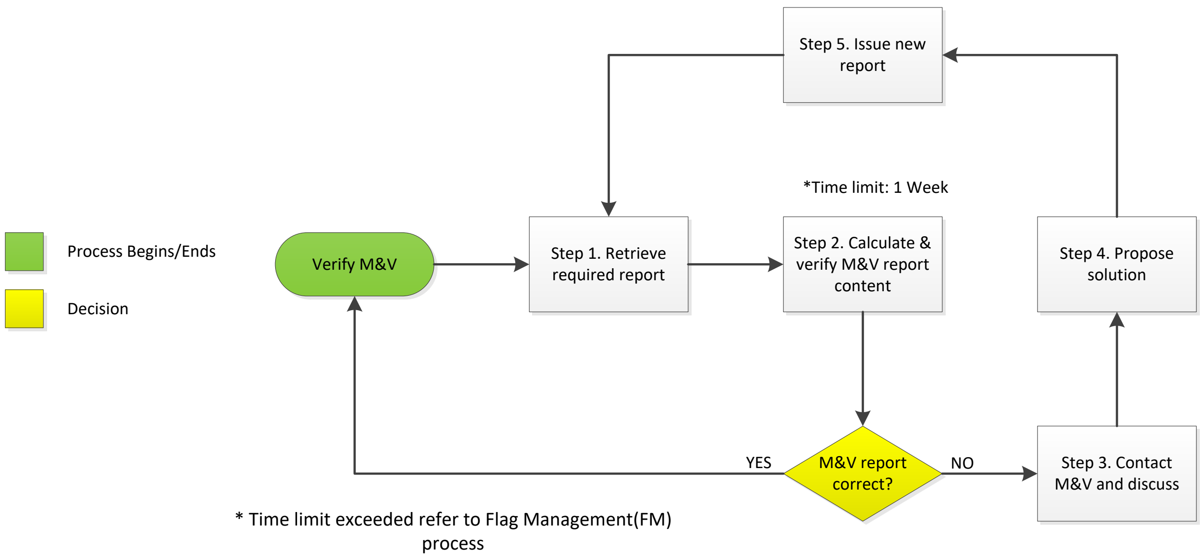

Figure 16: M&V confirmation process

Step 1: Retrieve required report – The M&V team is required to generate initial as well as performance-based reports for the DSM project. This includes:

- PA reports – PA reports are available every three months. This report caries high risks as the ESCo's income is dependent on the electricity cost saving stated in this report.
- Baseline report – The baseline reports are generated at the beginning of the project. This report contains information on the data the ESCo will be evaluated by as well as the scaling method used. If this report contains errors, it can result in an incorrect electricity cost-saving calculation.
- PT reports –PT reports are available every three months.

Step 2: Calculate and verify M&V calculations – ESCos are advised to calculate the electricity cost savings to verify the reports mentioned in Step 1. It is important that the reports are scrutinised regularly. This step contains a time limit and should not extend a one-week duration to complete. If Step 1 exceeds the time limit, it is flagged, and the Flag Management (FM) process is applied.

Step 3: Contact M&V – If an error is detected within the reports, the ESCo is responsible for contacting the M&V team dedicated to the DSM project to discuss the issue. If there is no error detected, the ESCo can continue the process with an additional report.

Step 4: Propose solution – The ESCo can provide a solution for the issue depending on the discussion in Step 3.

Step 5: Issue a new report – After the solution is applied, the M&V team is responsible for issuing a new report. The ESCo is required to follow up and manage this step to retrieve the new report as quickly as possible. The process can recur from Step 1 with the new report.

The following process is the Force Majeure Process (FMP). This process is developed for a specific issue. Thus this process is not included in the M&V confirmation process.

2.4.1 Force Majeure Process (FMP)

Force majeure is an unplanned event that prevents contracting parties from achieving their obligations [44], [52]. The force majeure event must be beyond the control of all the involved parties. This includes an act of God event [44], [52]. The effect of such an event on project performance can be catastrophic for projects within the new DSM model. This is due to ESCos' obligation to maintain project performance for an extended period.

Force majeure events rarely happen; however, poor management on the ESCos side will result in project performance declining. Unfortunately, the time duration and effect of a force majeure event is unforeseen which increases the risk for ESCos. The proper structure of this process will help to increase the project sustainability, decrease the risk involved, and increase proper time management by:

- The exclusion of uncontrollable poor performance from the total project performance, and
- Decreased turnaround time to mitigate the losses caused by the force majeure event.

Figure 17 illustrates the FMP developed to assist ESCos in managing such an event.

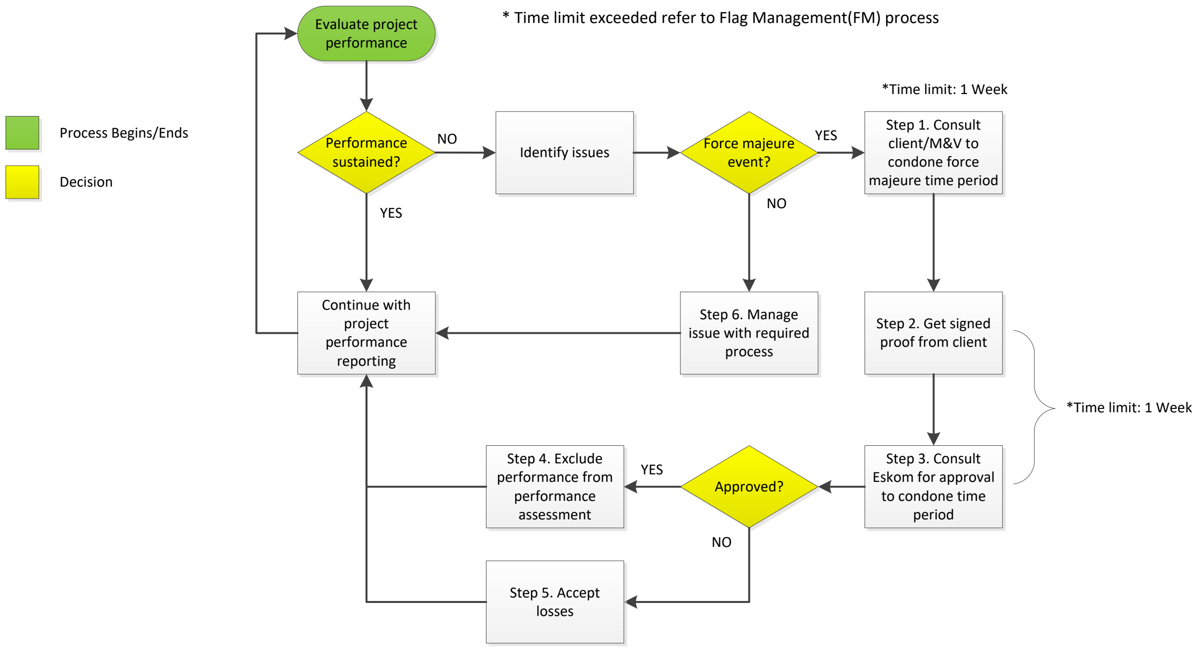

Figure 17: Force Majeure Process (FMP)

Step 1: Consult client – ESCos are obligated to consult the client after the force majeure event has occurred. It is necessary to gather information regarding operation deviations and the force majeure event. If ESCos are unable to perform their duties due to temporary operational changes, it is required that they inform all the involved parties. Thus recurring feedback meetings must be scheduled to inform all parties [25], [49]. This step contains a time limit to address additional risk. If the time limit is exceeded, refer to the FM process.

Step 2: Proof from client – ESCos require confirmation from the client which states that the force majeure is responsible for them being unable to fulfil the contract requirements. The confirmation must include:

- Details of the force majeure;
- Consequences of the force majeure;
- Operational changes due to the force majeure event, and
- Duration of operational change.

Step 2 and 3 contains a time limit of one week, respectively. It is recommended to complete these steps within the recommended time to decrease the turnaround time which will reduce additional risks.

Step 3: Consult Eskom – The gathered proof from Step 2 must be presented to Eskom in order to notify them regarding the force majeure event. The confirmation from the client will act as proof that the ESCo was unable to accomplish the contract requirements.

Step 4: Exclude Force majeure period – After Eskom accepted the ESCos' application to condone the period of the force majeure, ESCos will be required to meet with the M&V team. The M&V team will reassess the project performance excluding the performance of the force majeure period.

Step 5: Accept losses – Insufficient proof can result in Eskom deciding to decline the ESCo's application. This will result in the ESCo accepting the losses caused by the force majeure. The ESCo will be required to manage the issue until normal operation can continue, which can be done by applying an alternative process.

Step 6: Manage issue – If the identified issue is not caused by a force majeure event, the ESCo will be required to apply an alternative process suited for the sustainability issue.

It is crucial for ESCos to acquire acceptable proof and information regarding the force majeure event, which will reduce the chances of Eskom declining the application. The subsequent sections will contain processes developed to assist ESCos in managing technical and system issues.

2.5 Systems and procedures of technical issues

ESCos typically optimise the control of the client's equipment as well as their systems due to ESCos using existing equipment to implement the DSM projects. ESCos rely profoundly on functional equipment in order to sustain project performance. Unfortunately, it is impossible for ESCos to determine the useful life of technical equipment. Although ESCos are not responsible for repairing the equipment, it is their responsibility to manage the process. This will result in ESCos reducing the declining outcome on project performance.

The following subsections contain developed processes to assist ESCos in managing sustainability issues faced under systems and procedures of technical issues. The first process is the Performance Assurance Process (PAP).

2.5.1 Performance Assurance Process (PAP)

In order to sustain project performance, ESCos will be required to monitor and maintain electricity cost savings on a regular basis. Sustaining project performance can be affected by technical issues. Managing technical sustainability issues efficiently can:

- Reduce the resources spent to solve sustainability issues;
- Reduce the time spent to solve sustainability issues;
- Reduce the overall risk of a project, and
- Increase the electricity cost savings.

Figure 18 indicates the Performance Assurance Process (PAP) developed to assist ESCos to monitor and maintain savings on a daily basis. The process contains steps that can be followed by the ESCo to monitor project performance on a regular basis. Dr H.J. Groenewald discussed daily project performance monitoring in his study [49]. The PAP will compliment his performance-centred maintenance strategy process by assisting ESCos with daily performance monitoring.

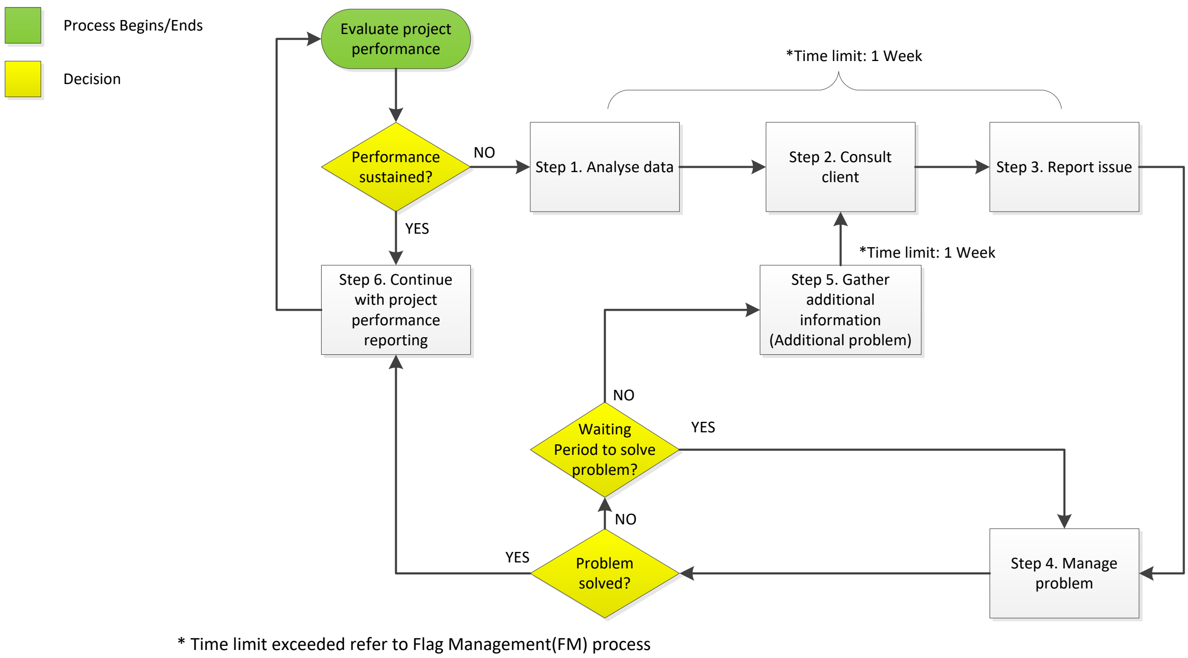

Figure 18: Performance Assurance Process (PAP)

Step 1: Analyse data – The quickest method to determine a decline in project performance is for the ESCo to analyse the available project data. This will give ESCos an accurate representation of when the issue occurred as well as the extent of the issue. This step is high risk as all the following steps build on the knowledge gained from analysing the data. Step 1, 2, and 3 contain a time limit to decrease turnaround time. This reduces the risk as it is possible to get stuck for longer periods within these steps. Refer to the FM process when the time limit is exceeded for further assistance.

Step 2: Consult client – In this step, the ESCo is required to meet with the client to gather more information regarding the issue. In some cases, it might occur that the client is not aware of the issue. Thus the data in Step 1 will give the client an accurate representation of when the issue occurred. This will allow the client to gather more information on their side. It was identified from previous studies that meetings between the ESCo and the client are required for planning and feedback [25], [47], [48], [49]. Thus recurring meetings are required with the client until the sustainability issue is resolved.

Step 3: Report issue – The project engineer responsible for the DSM project will need to inform his/her supervisor. Internal meetings are required between ESCo personnel for feedback purposes [47]. If necessary, more resources can be allocated to the project for the next step. If the identified issue is of such an extent that the project will need to end, the ESCo must notify the M&V team as well as Eskom IDM. This is also the case if the ESCo is required to condone the project performance until the issue is resolved.

Step 4: Manage problem – The ESCo is obligated to manage the sustainability issue as efficiently as possible. This is a high-risk step, as the project performance is affected by the continuous duration of the issue. If required, the ESCo can implement an additional process to manage the issue.

Step 5: Gather additional information – It was noticed from previous studies that they lack this step. Thus it was added to this process. If the sustainability issue still persists and there is no identified waiting period (period before issue is solved), the ESCo will be required to gather additional information in an effort to identify the cause of the sustainability issue. If a waiting period is identified, the ESCo will be required to return to Step 4 and manage the issue. It is recommended that the ESCo use a maximum of one week on this step in order to decrease the turnaround time of the project.

Step 6: Monitor project performance – Immediately after the issue is solved, the ESCo can continue with project performance monitoring. Methods for daily monitoring include [49]:

- Daily feedback reports;
- Daily performance emails, and
- Monthly feedback reports.

The following process consists of the Control System Management Process (CSMP) developed to assist ESCos in managing technical issues.

2.5.2 Control System Management Process (CSMP)

It is recurrently noticed that clients in South Africa use outdated control philosophies on their equipment. This is especially the case with mines in South Africa. Most DSM projects implemented by ESCos consist of applying or updating a control philosophy on the client's equipment. Unfortunately, there are quite a few steps that must be completed by the ESCo to allow ESCos to update these control philosophies. One of the most important factors for mines is production. Thus it is important for ESCos to follow the correct procedure in managing the client as well as the DSM project.

Figure 19 illustrates the CSMP. This process is developed to provide structured steps that ESCos can use to implement a new control philosophy. Various time limits found in the process decreases the risk as well as increases the sustainability of the project by reducing the turnaround time.

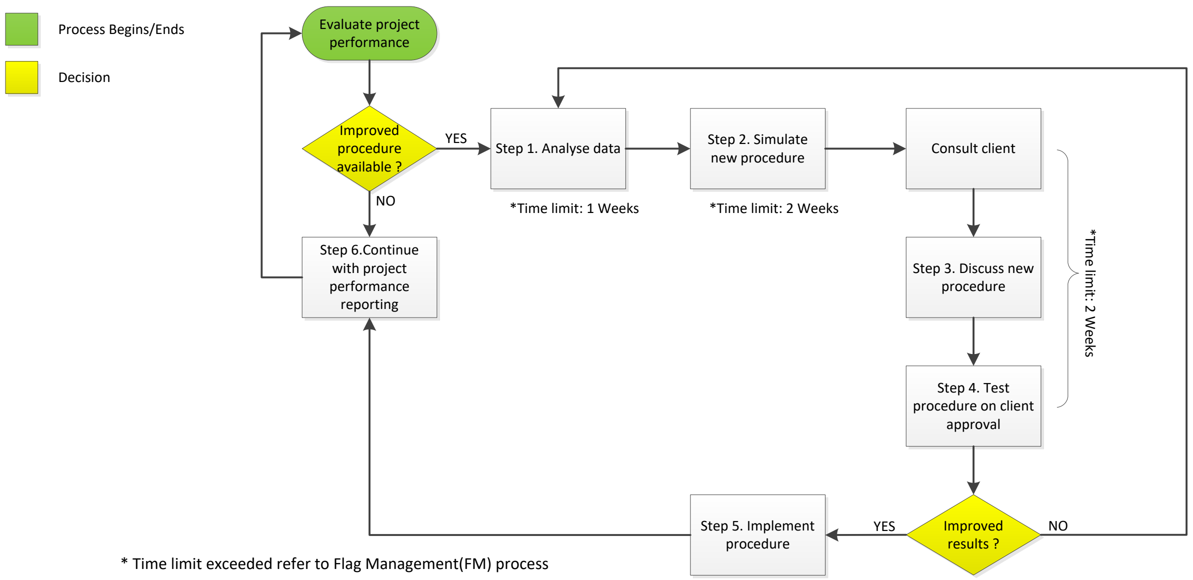

Figure 19: Control System Management Process (CSMP)

Step 1: Analyse data – The first step in developing a new procedure is to analyse the available data of the DSM project. This will provide the project engineer with relative information regarding the system [25]. This will allow the project engineer to confirm whether there is scope for a new control procedure. This step is high risk as all the following steps build on the knowledge gained from analysing the data [25]. It is recommended that ESCos spend a maximum period of one week on this step. Refer to the FM process when the time limit is exceeded.

Step 2: Simulate new procedure – Unfortunately, data alone rarely suffice in convincing the client to implement the ESCo's new control procedure. It is noticed that previous studies recommend simulations for various reasons. Mr. I. Mulder used simulations to prove that various DSM projects can be reinstated [53]. Dr H.P.R. Joubert stated in his study that simulations can reduce the risk of miscalculating project target savings [25], [47], [49]. Thus it was deemed appropriate to include this step when changing or explaining control systems. Simulations can be a time-consuming procedure to complete. Depending on the complexity of the simulation, it is recommended that ESCos complete this step within two weeks. The FM process can be applied when this time limit is exceeded.

It is recommended that the ESCo use the data analysed in Step 1 to develop a simulation of the new control procedure. If necessary, this will allow the ESCo to update the procedure due to operational changes in the future. The simulation will benefit the ESCo by indicating to the client that they understand the system. This step is beneficial to ESCos, although it can be time-consuming depending on the complexity. Thus proper time management will be required.

Step 3: Discuss new procedure – The ESCo should identify all the relevant client stakeholders and present the new procedure. The project engineer responsible for the DSM project should explain the benefits of implementing the new procedure. In addition, the procedure can be verified by using the simulation as well as the analysed information to convince the client. A proper hazard and operability study must be conducted with all the identified client stakeholders for additional risk management.

Step 4: Test new procedure – If the new procedure is approved by the client, the ESCo can start with the test procedure. It is important that the client is involved and aware of the test procedure. It is required for the ESCo to compile a findings report consisting of the test results. The simulation result must be noted in this report as well [25].

Step 5: Implement new procedure – The new procedure can be submitted for implementation after the client is satisfied with the test results. The ESCo can continue with project performance monitoring after the new procedure has been implemented. If the project performance has not been improved, the ESCo will be required to reinitiate the process starting with Step 1.

Step 6: Monitor project performance – Immediately after the new procedure is implemented, the ESCo can start with daily project monitoring. Methods for daily monitoring are discussed in the previous subsection regarding the Performance Assurance Process.

The following section will continue with systems and procedures of technical issues consisting of the process developed to assist ESCos with operational changes from the client.

2.5.3 Non-routine Baseline Adjustment Process (NBAP)

As previously mentioned, the baseline is the electricity data gathered before the ESCo made any adjustments to the client's system. The project performance will be calculated by means of comparing data post-project implementation to the baseline data [25], [54]. The baseline will be used throughout the duration of the entire project. Unfortunately, operational conditions on the client's side do not remain constant. Operational changes are high-risk for ESCos as it can cause project performance to deteriorate. A recurring decline in project performance will occur due to ESCos not managing the process correctly.

Figure 20 illustrates the NBAP. This process is developed to assist ESCos in managing operational changes to mitigate the risk, decrease turnaround times, and increase the sustainability.

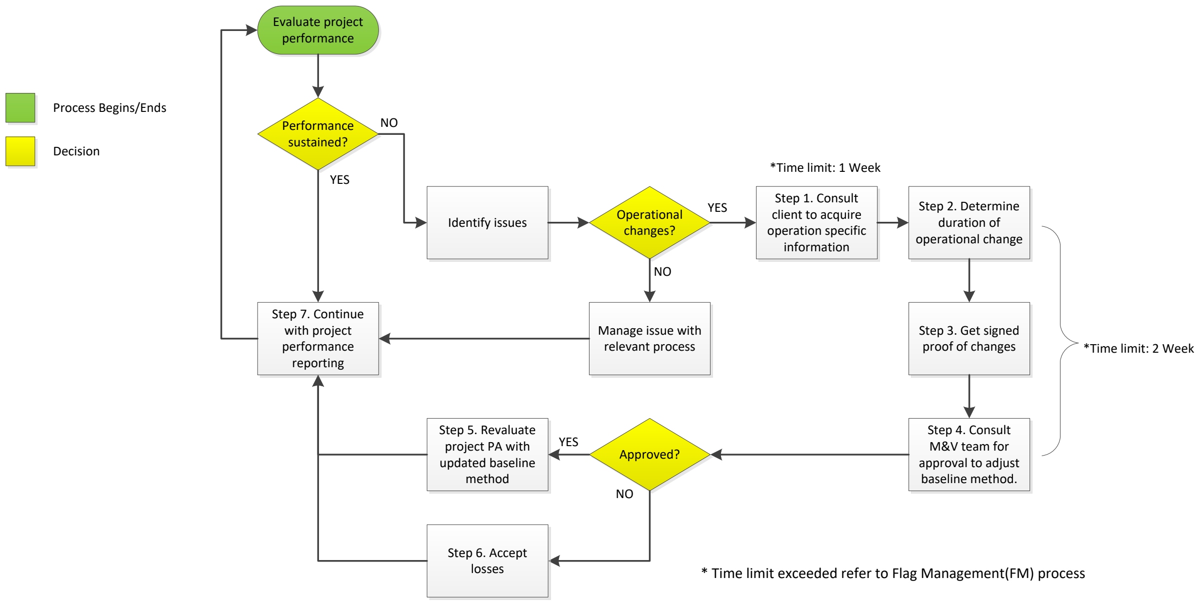

Figure 20: Non-routine Baseline Adjustment Process (NBAP)

Step 1: Consult client – The project engineer responsible for the DSM project should meet with the client to discuss the variation in normal operations. The project engineer must gather information on the cause of the operational change. This step should be initiated immediately after the operational change is identified. A time limit of one week is added to this step as it can be difficult to schedule the required meeting to gather the information. Refer to the FM process if the time limit is exceeded for additional risk management.

It is noticed from previous studies that meetings between the ESCo and the client are required for planning and feedback [25], [47], [49]. Thus recurring meetings are required with the client until the sustainability issue is resolved. If the sustainability issue is not connected to an operational change, the ESCo can apply an additional process to solve the sustainability issue.

Step 2: Determine duration of operational change – This step consists of retrieving information regarding the duration of the operational change. Temporary operational changes will not require a baseline adjustment. It is recommended that the project engineer consider using another process or condoning the affected period if the operational change is temporary. The NBAP is specifically designed for sustainability issues connected to permanent operational changes. It was noted from previous studies that they lack this step. Thus it was added to this process.

Step 3: Get signed proof – In the subsequent step, the ESCo will be required to apply for the baseline to be adjusted by the M&V team. The project engineer will be obligated to present proof in the form of a signed explanation stating that the ESCo is unable to perform their duties according to the project contract due to the operational change. It was noticed from the literature study that previous studies did not mention this step. Experience showed that this is a crucial step when dealing with the M&V team, thus this is added to the NBAP.

Step 4: Consult M&V – In this step the ESCo must apply for the baseline adjustment by the M&V team. The ESCo must explain to the M&V team why they are unable to comply with the contract due to the operational changes. It is noted from previous studies that meetings between the ESCo and the M&V team are required when issues of this type are experienced [17], [49]. Step 2, 3, and 4 contain a time limit of two weeks to mitigate the risk of the project engineer getting stuck in one of the mentioned steps.

Step 5: Revaluate project – If the application gets accepted, the project performance can be revaluated for the affected period. The subsequent PA's will be conducted with the updated baseline or scaling method.

Step 6: Accept losses – Insufficient proof can result in the M&V team declining the ESCo's request to adjust the baseline method. The ESCo will be required to accept the losses caused by the operational change and continue with the following step.

Step 7: Evaluate project performance – The final step in this process consists of the ESCo continuing to evaluate the project performance. Methods for daily monitoring include [49]:

- Daily feedback reports;
- Daily performance emails, and
- Monthly feedback reports.

This concludes the systems and procedures of technical issues section. The following section will consist of the processes developed to assist ESCos with resource management.

2.6 Resource management (People)

Human cooperation is an important aspect of a successful DSM project. This is especially the case with the extended duration of the new DSM model projects. ESCos need to manage their resources effectively to ensure sustainability issues are resolved as soon as possible. Unfortunately, ESCos' resource management is restricted due to DSM projects being implemented at the clients' locations. Three processes are developed in this study to assist ESCos in managing resources efficiently, namely:

- Communication/conflict;
- Contractor management, and
- Handover.

The processes are developed to manage and decrease risks associated with resources by decreasing project turnaround times which leads to improved sustainability. The following sections will provide processes to assist ESCos with sustainability issues where resource management is required. The first process consists of steps to assist the ESCo in managing conflict. This is to avoid sustainability issues caused by poor communication as well as disagreements.

2.6.1 Conflict Management Process (CMP)

Communication is an essential factor in any form of business. ESCos communicate on a daily basis with the client, the M&V team, or Eskom. It is impossible for ESCos to avoid any form of communication. Communication is the base of any successful project [55]. Unfortunately, poor communication can lead to the deterioration of a DSM project. It is often found that engineers on mines are set in their ways. Thus it is crucial for ESCos to plan ahead and focus on proper communication principles. The Conflict Management Process (CMP) in Figure 21 can be used by ESCos to assist in managing conflict between the ESCo and the client. The structure of the process allows ESCos to manage conflict efficiently in order to address the risk caused by the identified issue.

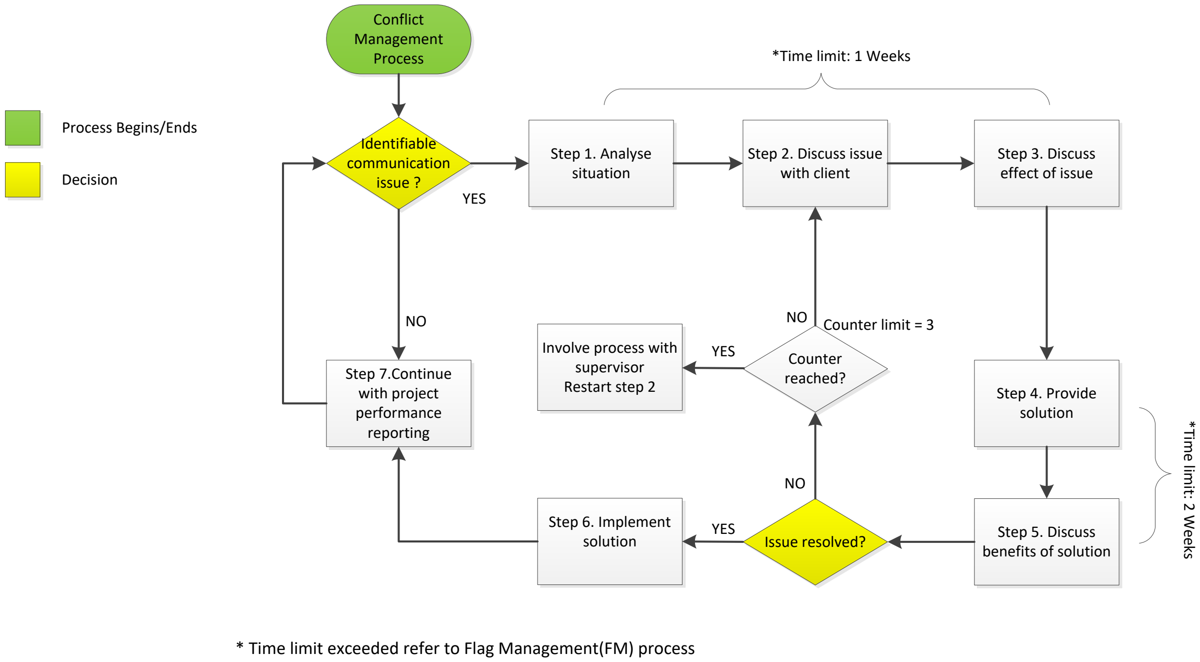

Figure 21: Conflict Management Process (CMP)

Step 1: Analyse situation – In the case where a communication issue is detected by the ESCo, it is their responsibility to assess the problem. It will be beneficial for the ESCo to solve the issue quickly. This could avoid future sustainability issues and increase the relationship between all the participants. A time limit is added, which includes Step 2 and Step 3. This is applied to ensure that the process continues at an acceptable pace. Conflict management is vital; thus refer to the FM process when the time limit is exceeded to mitigate additional risks. Mr. B.G.G. Terblanche's study indicated that this step is crucial in solving communication and conflict issues [47].

This step contains a time limit to address additional risk. If the time limit is exceeded, refer to the FM process in Section 2.3. Step 2 and Step 3 are included in this time limit to reduce the process duration.

Step 2: Discuss issue – It is the project engineer responsible for the DSM project's responsibility to preserve a good relationship with the client. As mentioned, clients can be set in their own ways. Thus when an issue arises it can be challenging to convince clients to change their ways. The ESCo will be required to discuss the issue with the client without making the client feel uncomfortable. It was noticed from Mr. B.G.G Terblanche's study that discussing the issues faced between the ESCo and the client can result in reducing problems as well as increase cooperation [47].

Step 3: Discuss effect of issue – To convince the client of the severity of the issue, the ESCo will need to present evidence. The ESCo must discuss the effect the issue has had on the funds lost due to the issue as well as the effect on the total system. It will be beneficial to connect a cost value to the issue. This will give the client a representation of the severity of the issue. It was noticed that this step is not present in previous studies discussing communication issues. Thus it was deemed important to add it into this process.

Step 4: Provide solution – The ESCo must be ready to provide a solution to the issue; however, identifying the issue will only solve part of the solution process. Simulations and data analysis are boundless methods to convince the client of the negative effects but assist in the next step as well. From Mr. B.G.G Terblanche's study it is found that this step is important in solving communication issues [47]. Thus it was added into this process. This step, in combination with Step 5, contains a time limit of two weeks to ensure the best solution is provided for the issue.

Step 5: Discuss benefits – It was noticed that this step is not present in previous studies discussing communication issues. Thus it was deemed important to add it to this process. The client must understand that the solution is not only beneficial to the ESCo, but to the client as well. This step is important as the client will hesitate to accept the solution if the benefits are explained poorly.

Step 6: Implement solution – The new solution can be submitted for implementation after the client is satisfied with the results. If the issue is not resolved and the counter is reached, the ESCos will be required to bypass the employee and repeat the CP with the employee's supervisor. The counter can be adjusted depending on the situation between the ESCo and the employee.

This step can be repeated various times. It was found that this step is necessary from Dr H.P.R. Joubert's communication process. Thus it is added to this Conflict Management Process.

Step 7: Evaluate project performance – The ESCo can continue with project performance monitoring after the new solution has been implemented.

The next process in this section discusses the method to assist ESCos in managing sub-contractors.

2.6.2 Sub-Contractor Management Process (SCMP)

As mentioned in Chapter 1, third-party contractors are contracted by companies when they (the companies) lack the required knowledge to install equipment. Project performance can be affected by third-party contractors. Thus it is crucial for ESCos to manage third-party contractors in order to address the risks involved. Sub-contractors place additional risks on ESCos as ESCos are responsible for providing the required funds. In order to address the risk, an additional process was developed to evaluate whether the equipment needed is a viable option. Figure 22 illustrates the Equipment Management Process (EMP). It is recommended that the ESCO work through this process before employing a sub-contractor.

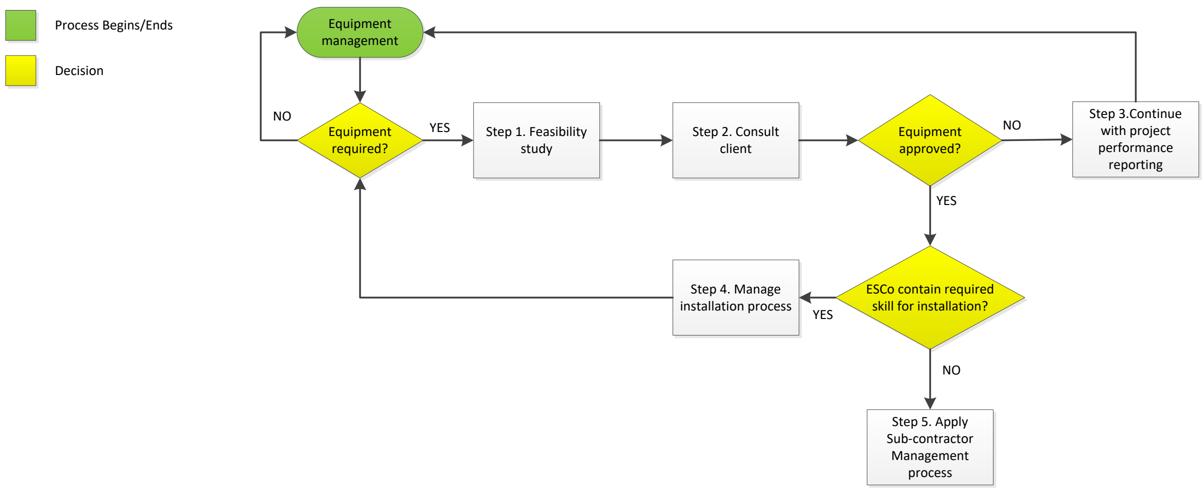

Figure 22: Equipment Management Process (EMP)

Step 1: Feasibility study – The first step in this process involves a feasibility study on the required equipment. The feasibility study is done to determine whether the installation of the new equipment is a viable solution. This involves a cost versus project phase analysis. Depending on the duration of the project, it might not be financially viable to install expensive equipment.

Step 2: Consult client – The second step entails that the ESCo discuss the results obtained from the feasibility study with the client. Depending on the outcome of the feasibility study, it might be that the client decides to finance the equipment for future benefit. The responsibility falls to the ESCo to manage the installation process although they are not funding the equipment.

Step 3: Continue with project performance – If both parties decide that the equipment is not worth the risk, the ESCo will be required to continue with project performance reporting for the remaining duration of the project.

Step 4: Manage installation process – If the equipment is approved, the ESCo will be required to manage the installation process depending on the skill and resources required. The ESCo will be required to compile a detailed quality management plan for the installation of the new equipment.

Step 5: Apply SCMP – In some cases the necessary equipment requires knowledge and skills that the ESCos and the client do not possess. Thus there is a need for a contractor possessing the required skills to install the necessary equipment. The SCMP is developed to assist ESCos in obtaining and managing the sub-contractor who has the required skill set. The ESCo is required to implement quality control during the course of the project. Figure 23 illustrates the SM process.

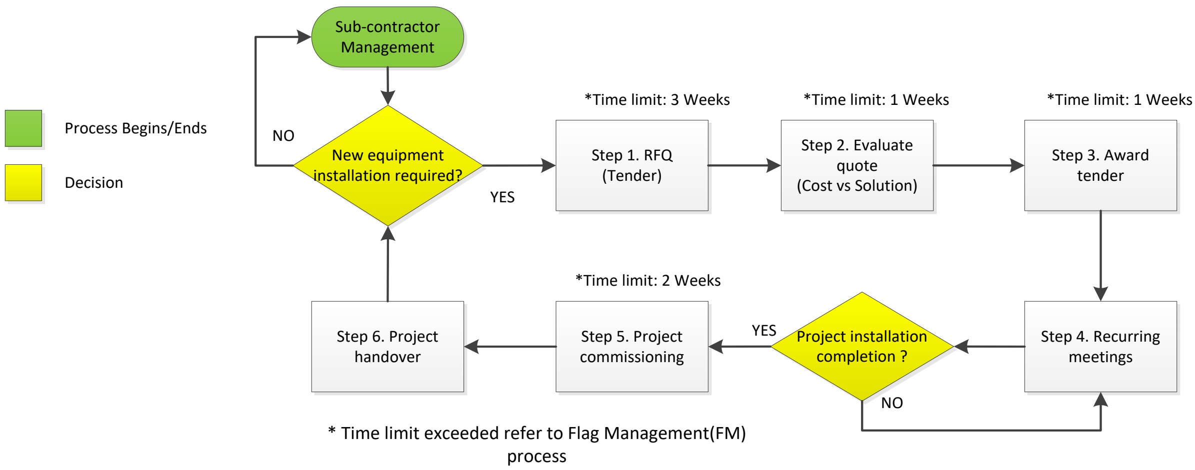

Figure 23: Sub-Contractor Management Process (SCMP)

Step 1: RFQ – The ESCo is required to create a Request for Quotation (RFQ) which contains the scope of the project. A time limit of three weeks is provided for external companies to supply the ESCo with their quotations. The time limit may vary depending on the ESCo. The quotations received within the time limit are considered.

Step 2: Evaluate quote – In this step, the quotation as well as the project plan received within the deadline are evaluated. A cost versus solution is done to verify which company provides the best solution at an acceptable rate and completion date. The cheapest company may not always be the best option. Thus vigilant consideration is required from the ESCo.

Step 3: Award tender – Following the evaluation, the ESCo will contain the required information to award the tender to the most suitable sub-contractor.

Step 4: Schedule recurring meetings – Regular project feedback meetings are required between the ESCo and the sub-contractor for additional risk management. The ESCo is required to evaluate the project against the project plan, thus addressing the risk caused by poor time management.

This step is highlighted in Dr H.J. Groenewald's study [49]. In his performance-centered maintenance process he stated that it is important to schedule recurring meetings for planning and feedback purposes. Thus this step is included for ESCos to schedule recurring meetings with third-party contractors as well as other parties.

Step 5: Project commissioning – This step contains the commission of the project where the solution is tested. ESCos are required to implement quality control after project completion. If the results do not meet the scope document requirement, the ESCo will be required to refer back to Step 7. Depending on the contract, ESCos are obligated to release the third-party contractor's retention after the tasks in the scope document are accomplished. Dr H.P.R. Joubert stated in his study that it is important to add the retention amount when managing third-party contractors [25]. This will ensure that all third-party contractors comply to their commitments.

Step 6: Project handover – The project handover commences after the commissioning is completed. This step consists of the sub-contractor giving the project to the ESCo for further management.

The next process in this section discusses the method to assist ESCos in managing their internal resources.

2.6.3 Handover Process (HP)

The HP is specifically developed to assist ESCos with their own resources. Unfortunately, employees are not consistent, whether it be for resignations or project team transfers. This opens the DSM projects to various sustainability issues. New employees will have limited knowledge regarding a project. It is crucial for ESCos to manage the HP as efficiently as possible to minimise the negative effect a new employee will have on project performance. The HP reduces the risk involved with transferring a project form one engineer to another. The risk is reduced by means of:

- Applying a structured process;
- Assigning an adequate resource, and
- Addressing the issue within an acceptable time duration.

The project engineer responsible for the specific DSM project is also responsible for gathering as much information regarding the project as possible. The information must be compiled in a document called the handover document. The handover document must be discussed with the new project engineer responsible for the DSM project. Figure 24 illustrates the HP. This process will assist ESCos in transferring project-specific knowledge from one project engineer to another.

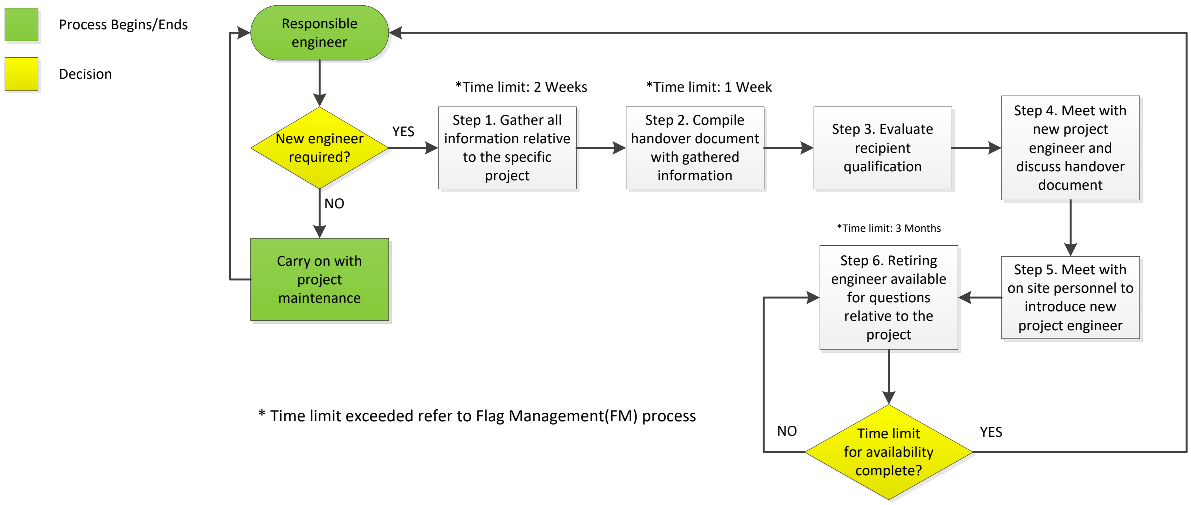

Figure 24: Handover Process (HP)

Step 1: Gather information – The first step in this process is to gather information regarding the specific DSM project. This includes:

- Project duration
- Project contract
- Control philosophy of the project
- Past sustainability issues and solutions
- Site personnel contact details
- Site location

This step is high risk as the project performance will depend on the knowledge contained by the new project engineer. This step should not extend a two-week duration. If Step 1 extends over the time limit, it is flagged, and refer to the FM process.

Step 2: Compile handover document – The previous project engineer responsible for the project must compile a handover document. This document must contain the information gathered in Step 1 as well as additional information deemed important. This step contains a time limit of one week. If the time limit is exceeded, refer to the FM process.

Step 3: Evaluate recipient qualification – In order for the new responsible engineer to receive training, a qualification assessment is required. This is done to verify that the new responsible engineer contains the required knowledge and background to manage the specific project.

Step 4: Meet with the project engineer – The previous project engineer is responsible to meet with the new engineer and give him the handover document. A detailed discussion regarding the handover document will be required to ensure that the new engineer understands the project.

Step 5: Meet on-site personnel – It is important to introduce the new engineer to the client. The client will need to know who will be responsible for the project. This will allow the new engineer to gain knowledge of where the site is.

Step 6: Be available – The former responsible engineer must be available for information regarding the project after the handover is completed. The duration for availability is not a predetermined period, though it is advised that the engineer be available for at least three months following the handover, whether it is by phone call or a quick meeting.

The HP can assist ESCos to limit future sustainability issues when engineers are reallocated. The following sub-section contains information on the verification of this study. This section is used to verify that the developed processes meet the objectives listed in Chapter 1.

2.7 Verification of developed processes

As mentioned, this sub-section contains information proving that the developed processes meet the requirements set by the objectives. This is achieved by means of a verification survey. Typical sustainability issues are presented to multiple engineers involved in the field of DSM projects.

Due to the steep decline in active ESCos, a specific ESCo was targeted for this survey [28]. The ESCo contains more than a hundred energy engineers, with ten engineers involved within the DSM field. Six of the ten engineers involved with DSM projects were requested to complete the survey. The engineers hold various levels of expertise within the DSM project field. Table 6 provides information regarding the engineers and their respective knowledge in this field. Consent was received from each engineer before the survey was completed.

Table 6: Survey participants

Participants	Level of expertise	Years of experience
Engineer 1,2	Contains limited knowledge in the field of DSM research.	0 – 3

Engineer 3,4	Knowledge is limited to the new DSM model.	0 – 5
Engineer 5,6	Contain knowledge from both the old and the new DSM model.	6 +

Each of the engineers represented in Table 6 were given the survey in order to complete four questions regarding three sustainability issues. Table 7 represents the results obtained from the verification survey. The survey is added in Appendix D.

Table 7: Verification survey results

		Engineers						
Sustainability problem	Question	1	2	3	4	5	6	Average
1	1	80%	100%	90%	80%	80%	90%	87%
	2	100%	100%	70%	70%	90%	80%	85%
	3	90%	90%	90%	80%	90%	70%	85%
	4	100%	90%	80%	90%	90%	80%	88%
2	1	100%	90%	80%	80%	70%	80%	83%
	2	100%	90%	70%	70%	70%	70%	78%
	3	100%	90%	90%	80%	90%	70%	87%
	4	100%	90%	80%	90%	90%	80%	88%
3	1	100%	100%	90%	90%	80%	80%	90%
	2	80%	90%	90%	60%	70%	70%	77%
	3	90%	90%	80%	80%	70%	80%	82%
	4	80%	80%	80%	90%	60%	70%	77%
Average								84%

It was noticed from the survey that the processes scored an overall average of 84%. It was observed that Engineer 1 and 2 rated the processes higher (93%) than the remaining engineers. This is due to a lack of experience held by Engineer 1 and 2. As seen in the table, the engineers with the most experience rated the processes with the lowest average (78%). As these engineers contain the most experience within the DSM field, they were able to scrutinise the processes. Figure 25 illustrates the verification results focusing on the study objectives. The objectives of this study are to:

- Develop processes that will assist ESCos
- Solve issues as efficiently as possible while reducing the effect on project performance
- Supply ESCos with a guideline to manage sustainability issues
- Reduce risk involved with the new DSM model

As can be seen from Figure 25, the first objective achieved an average of 87%, relating to an average score of 8.7 out of 10. The survey results indicate that the engineers believe the processes will be able to assist them in solving sustainability issues.

The second objective achieved an average of 80%. As can be seen from Figure 25, this objective achieved the lowest average compared to the remaining objectives. Further analysis indicates that this was due to the score achieved from engineers with the most expertise with DSM projects.

The third and fourth objective achieved an average of 84% each. The results indicate that the engineers believe that the processes will assist the ESCo in managing sustainability issues. As mentioned in Chapter 1, most of the risk involved with DSM projects have shifted towards the ESCo. Therefore, having processes in place to address sustainability issues will reduce the overall risk and increase the profitability of applying DSM projects.

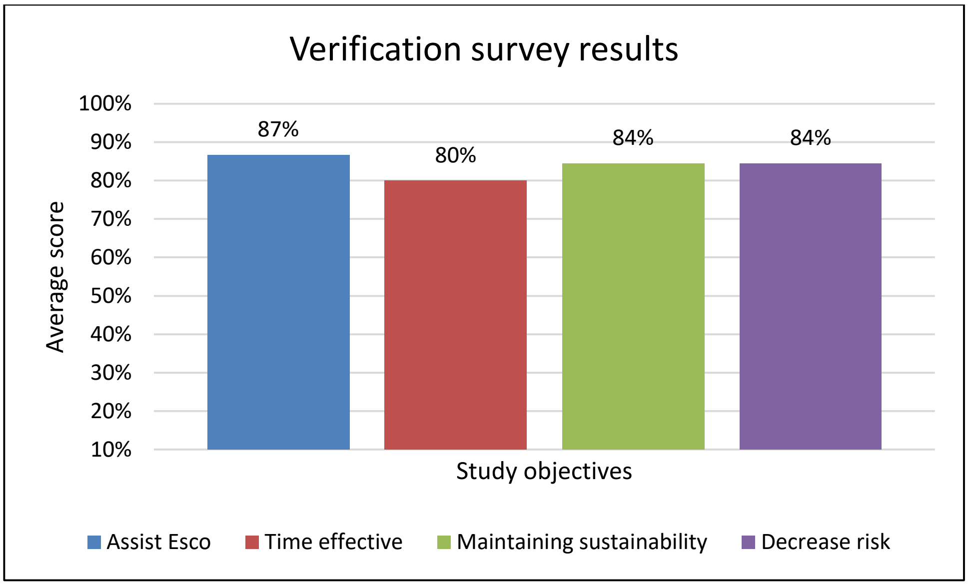

Figure 25: Verification survey results

As previously mentioned, the survey consisted of three sustainability problems, with four questions each addressing an objective of this study. It is noticed from the results that the engineers believe that the processes developed in this study can assist ESCos. The results obtained from the survey verifies that the processes meet the objectives. The following subsection concludes Chapter 2.

2.8 Conclusion

This chapter consists of processes developed to assist ESCos in managing sustainability issues found within:

- M&V
- Technical and systems
- Resource management

The processes consist of knowledge gained by an ESCo from DSM projects implemented in the new DSM model. The knowledge was combined with literature in Chapter 1 to compile the processes. The aim of each process is to reduce the risk, resources, and time spent solving sustainability issues as well as increasing project performance.

Verification was achieved by means of a verification survey completed by multiple engineers within the DSM field. The engineers held various levels of knowledge within the DSM field. It was determined that the processes scored an overall average of 84% during the verification of this study, and that the engineers believe that the processes will be able to assist ESCos to improve DSM performance as well as increase the sustainability of various DSM projects. The verification results located in Section 2.7 verifies that the processes meet the requirements set by the objectives.

Chapter 3 contains the results of this study. The purpose of Chapter 3 is to validate that the developed processes can assist ESCos in managing sustainability issues. This is achieved by applying the developed processes in Chapter 2 to sustainability issues found within case studies. The case studies consist of industrial DSM projects.

CHAPTER 3 – VALIDATION THROUGH IMPLEMENTATION

3.1 Introduction

Chapter 2 consisted of developing processes from knowledge gained when implementing projects under the new DSM model. The developed processes can assist ESCos to reduce the time spent solving issues, resources, and the risk involved in managing projects under the new DSM model. The processes are developed to target sustainability issues within the following sections:

- M&V
- Technical and system
- Resource management

This chapter will consist of applying the developed processes to industrial DSM projects. In this chapter, the DSM projects will be represented as case studies. The chapter contains two case studies comprising a pumping project and a refrigeration project. Various developed processes from Chapter 2 are applied to the case studies. The purpose of this chapter is to verify whether the developed processes improve project performance. The following subsections contain information regarding the case studies as well as the results obtained from applying the processes.

3.2 Case Study A – Pumping

An enormous amount of water is consumed on a daily basis for various mining applications. The water quantity varies according to dam storage capacities, mine sizes, and the rate of production. The main purposes for using water in the mines are [32]:

- Dust suppression
- Cleaning

Water is transferred via a gravity-feed from surface towards the mine's underground production levels. The water is recycled after use by means of pumping the water from underground to the surface. The water is cleaned on the surface and reintroduced into the water reticulation system to be used for the abovementioned purposes.

The reticulation system is divided between two divisions, a refrigeration system containing chill water, and a dewatering system containing hot water [29],[56]. The dewatering system's main purpose is to pump hot water from underground to the surface after use. This system is high risk, as the mine will flood if not managed correctly. Figure 26 provides a high-level representation of a gold mine's underground dewatering system. The gold mine in Figure 26 contains four pumping levels with multiple pumps on each level. The pumps are controlled via a master Programmable Logic Controller (PLC) found on each level. Each PLC contains a Human Machine Interface (HMI) that displays pump-specific information. The information displayed on the HMI can be retrieved by the operators located in the control room via the mine's SCADA system.

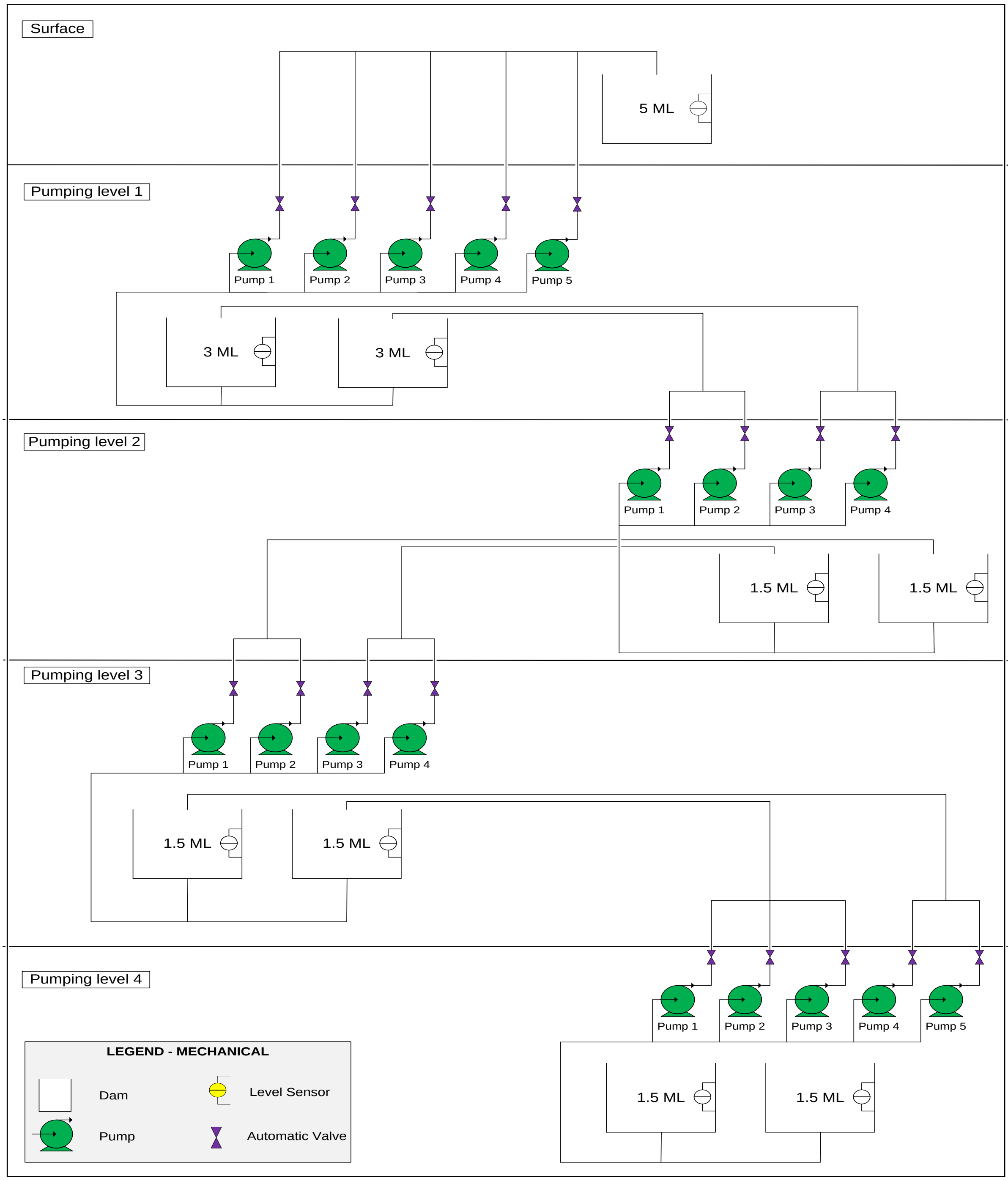

Figure 26: Gold mine underground dewatering system

Due to the complexity of the dewatering system and the health and safety risks involved, the mine decided to use operators to control the dewatering system. Extensive training was delivered by the mine to provide the operators with the necessary knowledge to control this system effectively.

The following subsection contains information regarding the DSM project as well as the sustainability issues confronted during the project duration.

3.2.1 DSM Project information

The ESCo investigated the possibility to implement a DSM project, consisting of an evening LS on Case Study A's dewatering system. The goal of this DSM project is to reduce the gold mine's electricity consumption during Eskom's evening peak period between 17:00 and 19:00 in the winter and 18:00 and 20:00 in the summer. The LS project was implemented on the dewatering system shown in Figure 26.

The DSM project includes all the pumps located in Figure 26, although one pump on each pump station is used as a standby unit. Numerous meetings were scheduled by the ESCo to determine the potential as well as the system limitations. The project target was determined by the ESCo and accepted by the M&V team as 2 MW. The target consists of an average evening peak performance. The ESCo made use of the assistance provided by the control operators to support them in testing as well as continuous project performance.

The control operator's knowledge regarding the technical characteristics of the dewatering system is limited. Thus extensive training was provided by the ESCo to advance the operator's knowledge within this field. Figure 27 provides a representation of the project performance for Case Study A as well as the project target.

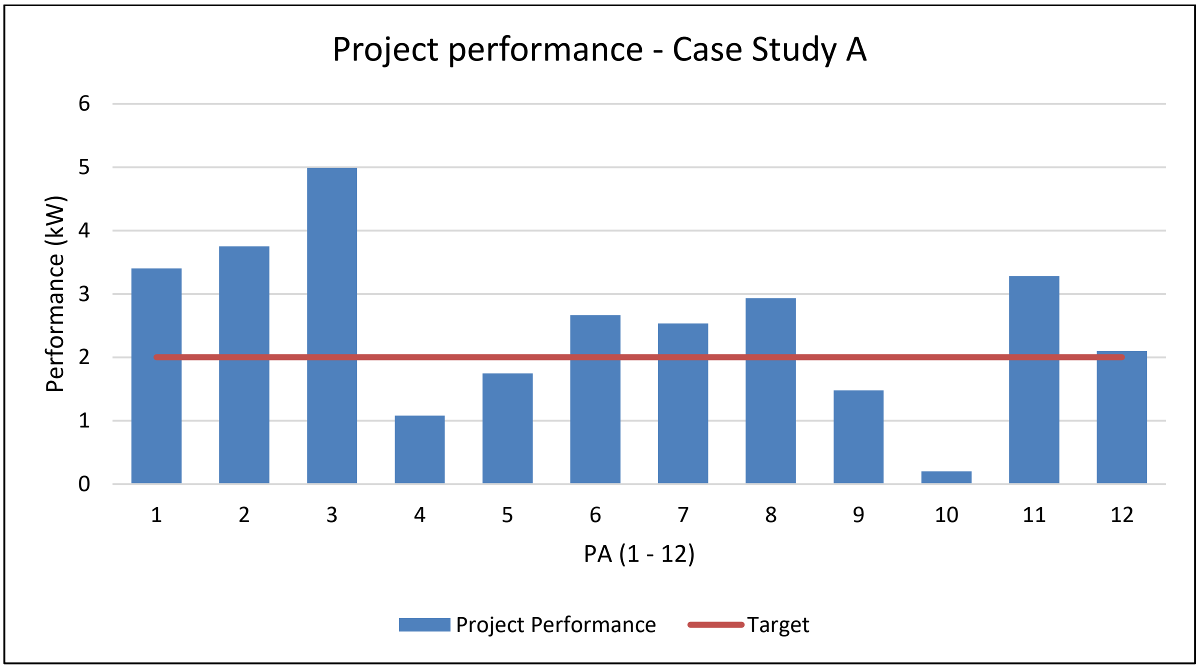

Figure 27: Project performance - Case Study A

The X-axis represents the PA's from 1-12. The Y-axis represents the project performance in MW. Each PA consists of the average project performance of a three-month period. It was noticed by the ESCo that the project performance deteriorated rapidly on multiple instances during the project duration. These occurrences can be seen in Figure 27 from PA 4 and PA 10. The ESCo was required to apply various developed processes from this study in an effort to improve the project performance. The sustainability issues encountered by the ESCo are discussed in the following subsection.

3.2.2 Case Study A sustainability issues

As seen in Figure 27, the project performance deteriorated rapidly on two occasions, PA 4 and PA 8. The project performance decreased from 4.99 MW to 1.01 MW in PA 4. It was determined that the deterioration was due to poor operator communication. As previously mentioned, the control room operators are responsible for controlling the mine's dewatering system. Unfortunately, the control room operators are not capable of starting and stopping the pumps. This responsibility falls to the pump operators underground. The control room operators indicate to the underground pump operators when to alter the pump statuses.

The project engineer found that in some cases, the pump operators could not be reached in order to prepare the underground dams for the evening's LS. This led to the mine pumping through the Eskom evening peak period in order to extract the necessary water. Various processes were implemented to mitigate this negative affect. Details regarding the implemented processes are discussed in the following subsection.

3.2.3 Processes implemented

As previously mentioned, the control room operators indicate to the underground pump operators when to alter the pump statuses. This process is time sensitive as it affects the project performance. To resolve the issue caused by poor communication between the control operators and the underground pump operators, the ESCo applied the Conflict Management Process (CMP) shown in Figure 28. The steps applied by the ESCo for this process are as follows:

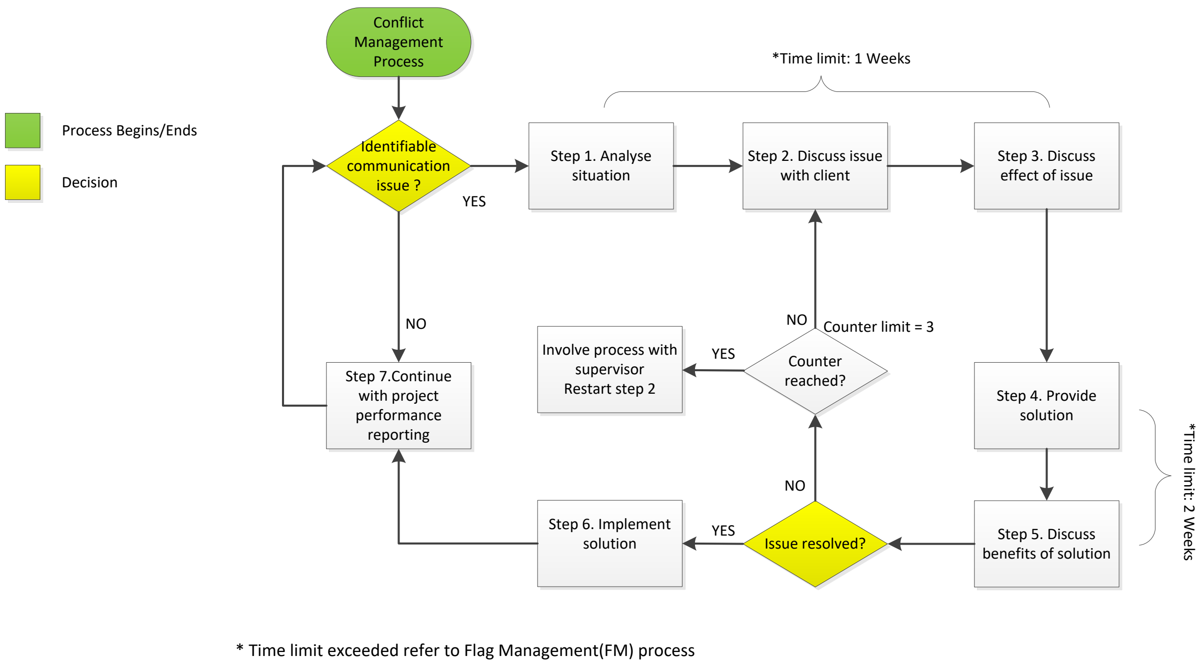

Figure 28: Conflict Management Process (CMP)

Step 1: Analyse situation

As previously mentioned, the ESCo identified a deterioration in the project performance from PA 8. The ESCo discovered that the cause of the deteriorating project performance was due to the communication issue between the control operators and the underground pump operators.

Step 2: Discuss issue

The ESCo discussed the issue with the client and informed them regarding the identified issue. This step is important as the ESCo can receive more information regarding the issue from the client. In this step, the ESCo was able to gather enough information to find a solution to the problem.

Step 3: Discuss effects of the issue

In conjunction with the previous step, it is important to discuss the negative effect the issue has not only for the ESCo but for the mine as well. The project engineer responsible for the DSM project explained to the client the costs involved as well as how much they could have saved if this problem was resolved.

Step 4: Provide a solution

In this step the solution is discussed with the client. The solution generated by the ESCo for this specific sustainability issue is a scheduler programmed on the mine's SCADA system. The main objective of the scheduler is to inform the pump operators when to start and stop a pump. This scheduler is developed to display on the HMI's underground for the pump operators to see as well as the control room operators on the surface. Appendix B contains more information regarding the scheduler.

Step 5: Discuss benefits

In order for the solution to be implemented, the ESCo will be required to explain the solution in the previous step as well as the benefits that could be obtained from the solution. The main benefits for this solution were:

- The HMI's are located at the pump station
- Quicker responses from the operators
- Scheduler can be updated if required
- Alarm to indicate when a pump status must be altered

Step 6: Implement solution

The new solution was submitted for implementation after the client was satisfied with the outcome. If the issue is not solved within the counter limit, the ESCos will be required to bypass the employee and repeat the CM process with the employee's supervisor. This step can be repeated various times. Fortunately, this step was not required with this issue as the mine accepted the solution.

Step 7: Evaluate project performance

The ESCo can continue with project performance monitoring after the new solution has been implemented. If the project performance has not been improved due to the identified issue, the ESCo will be required to reinitiate the process starting with Step 1.

In conjunction with the CM process was the EMP applied to evaluate whether the equipment required is a financially viable solution for the ESCo. It was determined from the EM process that the equipment is necessary and the ESCo will be responsible for the financial implications. Unfortunately, the ESCo did not possess the necessary expertise to implement the scheduler system. Various forms of programming and equipment installations were required to implement this solution.

The ESCo was required to obtain a third-party contractor in order to solve this issue. The SCMP was implemented to assist the ESCo in managing the third-party contractor. Figure 29 displays the SCM process applied. The steps applied by the ESCo for this process are as follows:

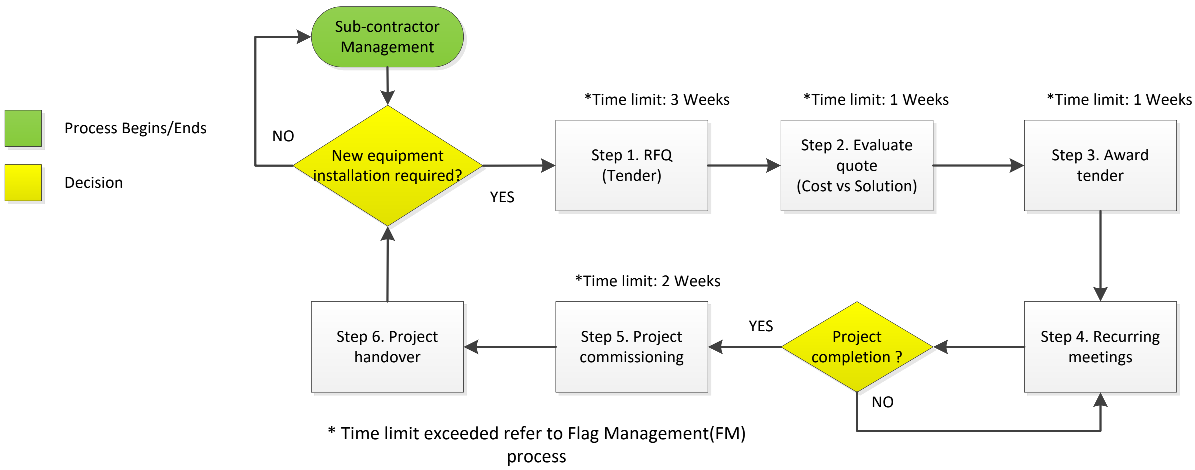

Figure 29: Sub-Contract Management Process (SCMP)

Step 1: RFQ

The ESCo created the RFQ containing the scope document for the project. A time limit of three weeks was provided for sub-contractor companies to respond. Only quotations received within the time limit were considered.

Step 2: Evaluate quote

In this step, the quotation as well as the project plan received within the deadline were evaluated. A cost versus solution was done to verify which company provides the best solution at an acceptable rate and completion date.

Step 3: Award tender

Following the evaluation, the ESCo awarded the tender to the most suited sub-contractor.

Step 4: Schedule recurring meetings

Recurring project feedback meetings were scheduled to evaluate the sub-contractor's performance against the provided project plan. This was done to verify whether the installation procedure was going according to schedule. Throughout the recurring meetings, various manufacturing issues were identified which caused project delays. This caused the ESCo and the sub-contractor to change the completion date of the project.

Step 5: Project commissioning

In this step the ESCo assisted the contractor with the commissioning of the project. All the project features were tested. ESCos are required to implement internal quality control after project completion. This means that the project results must be evaluated against the scope of the project.

Step 6: Project handover

The project handover commenced after the commissioning was completed. The sub-contractor signed the completion documents stating that their job is finalised and the ESCo can commence with the DSM project.

3.2.4 Results of implemented processes

The ESCo was able to resolve sustainability issues by applying the CM process in conjunction with the SCM process. This allowed the project engineer to implement the solution to solve the identified sustainability issue.

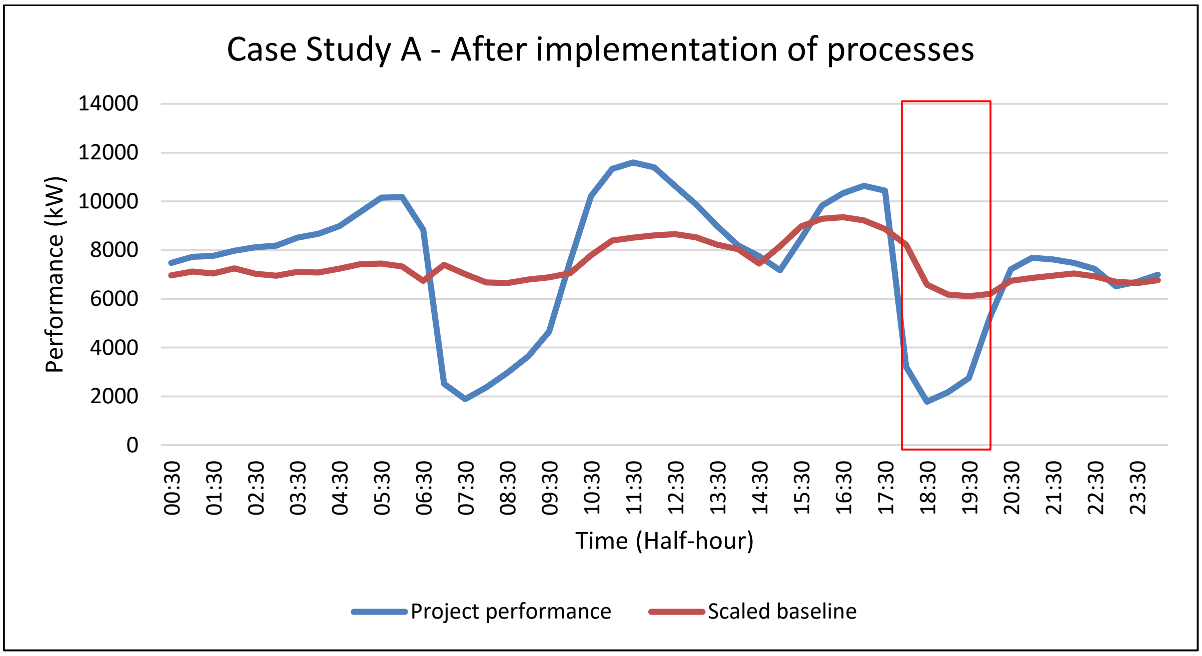

Figure 30: Project performance after process implementation

Due to the manufacturing issues, the project was commissioned at a later stage. The ESCo was able to increase the project performance to an average of 3.28 MW during PA 11 with the applied solution. Figure 30 displays the project performance for PA 11 after the required processes were applied. The processes applied solved the sustainability issues efficiently due to the increase in project performance. These processes were used by the ESCo as a guideline to address risks involved with the projects under the new DSM model. The following subsection contains information on Case Study B.

3.3 Case Study B – Refrigeration

Underground temperatures in the South African mining industry can be dangerously high, especially in deeper mines such as gold mines. Gold mines can reach up to 4 000 m below surface with rock temperatures of up to 60 °C [7], [32]. It is deemed unsafe when operational areas underground exceed a wet-bulb temperature of 27.5 °C [32]. Mine's use complex cooling systems to maintain safe working temperatures underground. Typical cooling systems consist of the following elements [7], [32]:

- Water storage dams for hot and cold water
- Pre-cooling towers
- Refrigeration system (Fridge plants)
- Bulk air cooler (BAC)

Figure 31 displays the refrigeration system of a gold mine in South Africa. As can be seen, this refrigeration system consists of numerous dams, fridge plants, pumps, and cooling towers.

Due to the complexity of this cooling system and the health and safety risks involved, the mine decided to employ operators to control the cooling system via a SCADA system. Extensive training was obtained by the operators to provide them with the necessary knowledge to control this system.

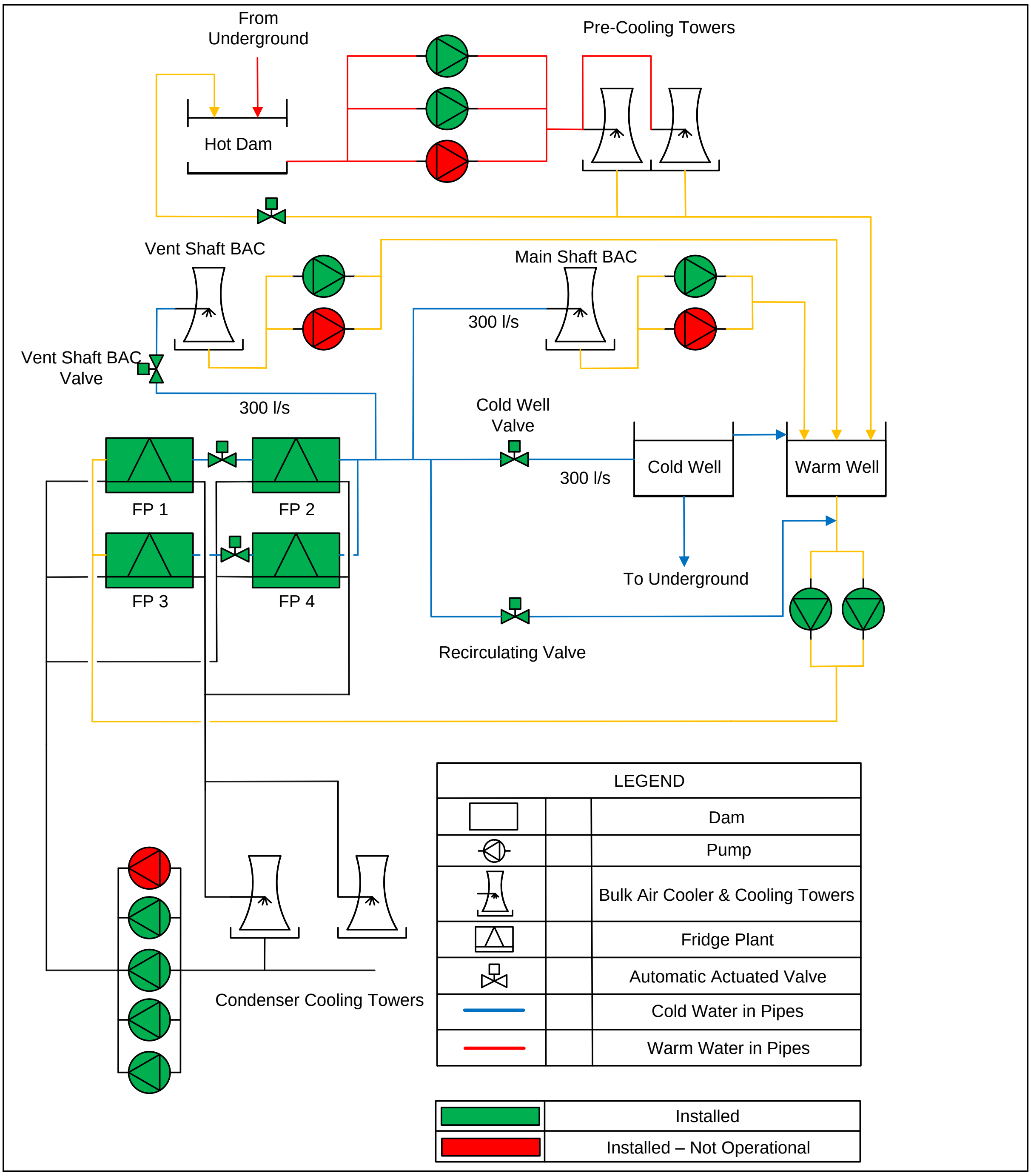

Figure 31: Case Study B - Site information

The following subsections contains information regarding the DSM project as well as the sustainability issues confronted during the project duration.

3.3.1 DSM project information

The ESCo investigated the possibility to implement a DSM project, consisting of an evening LS on Case Study B's refrigeration system shown in Figure 31. The goal of this DSM project is to reduce Case Study B's mine's electricity consumption during the Eskom evening peak period between 17:00 - 19:00 in the winter and 18:00 - 20:00 in the summer. Due to Case Study B's constant water flow requirements for the main shaft as well as the vent shaft, the project was limited to the surface fridge plants as well as the BACs. This was achieved by excluding the evaporator pumps from the LS project.

As seen in Figure 31, the DSM project includes four fridge plants, where one fridge plant is used as a standby unit. Numerous meetings were scheduled by the ESCo to determine the potential as well as the project limitations. The project target was determined by the ESCo and accepted by the M&V team as 3.3 MW. The target consists of an average evening peak performance.

The ESCo relied on assistance provided by the control operators to support them in testing as well as the continuous project performance. The control operator's knowledge regarding the technical characteristics of the cooling system is limited. Thus extensive training was provided by the ESCo to advance the operator's knowledge within this field. Figure 32 provides a representation of the project performance for Case Study B as well as the project target.

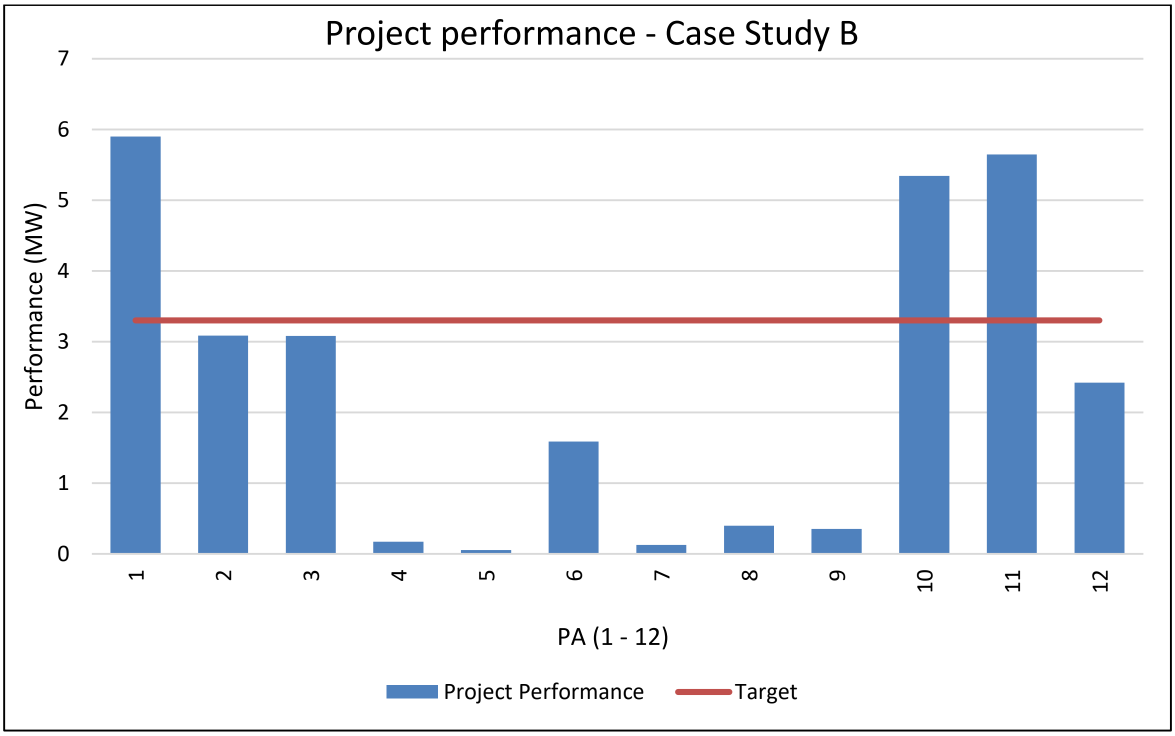

Figure 32: Project performance - Case Study B

The X-axis represents the PA's from one to twelve. The Y-axis represents the project performance in MW. As previously mentioned, a PA consists of the average project performance during a three-month period. It was noticed by the ESCo that the project performance deteriorated rapidly on multiple instances during the project duration. These occurrences can be seen in Figure 32 from PA 4 to PA 9. The ESCo was required to apply various processes from this study in an effort to improve the project performance.

As seen in Figure 32, the project performance deteriorated rapidly from PA 4. It was determined that the deterioration was due to poor internal resource management from the ESCo. The project engineer responsible for the DSM project in Case Study B neglected this specific project. This was due to other projects having a higher priority. The project performance decreased from 3.1 MW to 0.43 MW over the following six consecutive PAs. Figure 33 represents the power profile prior to the ESCo implementing the required processes to mitigate the low-project performance.

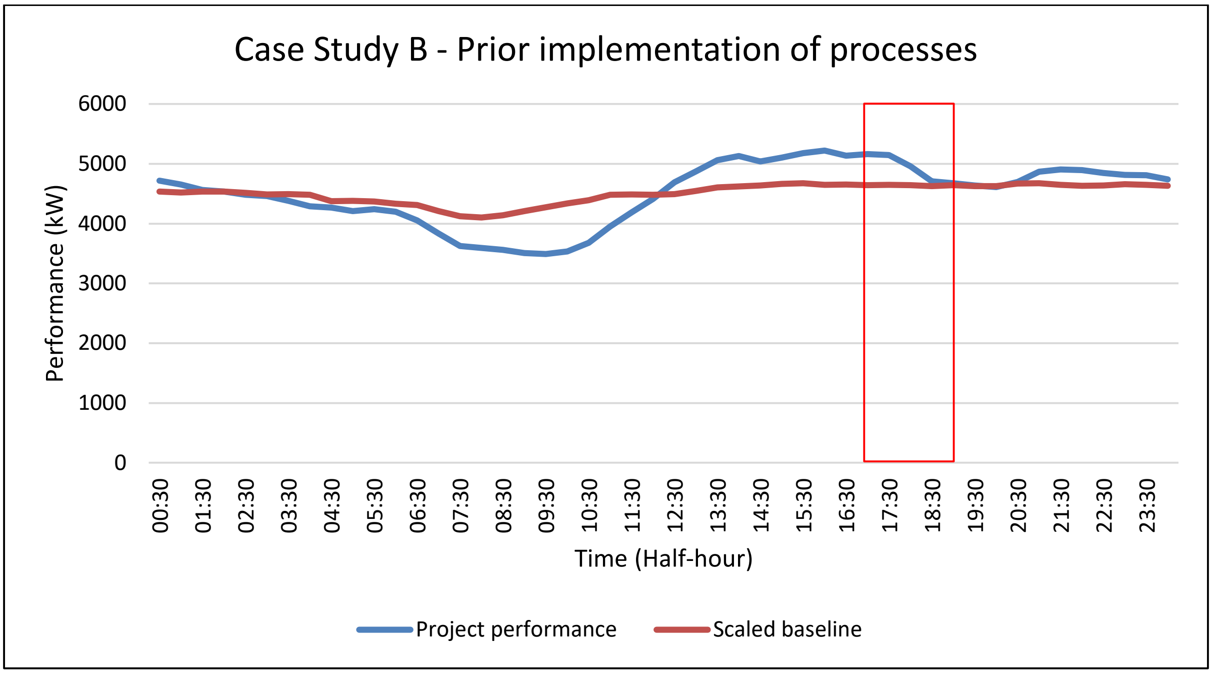

Figure 33: Project performance prior to process implementation

The red block in Figure 33 represents the Eskom evening peak period in winter months where it can be seen that no LS is attempted. Further analysis led to the ESCo discovering an operational change within the mine's cooling system. The mine was capable of achieving acceptable underground temperatures while running one less fridge plant. Unfortunately for the ESCo, this effected the DSM project performance as the baseline was calculated with the additional fridge plant. The following subsection contains information on the processes the ESCo implemented to mitigate the negative effects of the sustainability issues on the project performance.

3.3.2 Processes implemented

In order to resolve the sustainability issue caused by poor resource management, the ESCo applied the Handover process. This allowed the ESCo to handover the responsibility of the DSM project from the retiring engineer to another project engineer. The steps the ESCo applied for the Handover process are as follows:

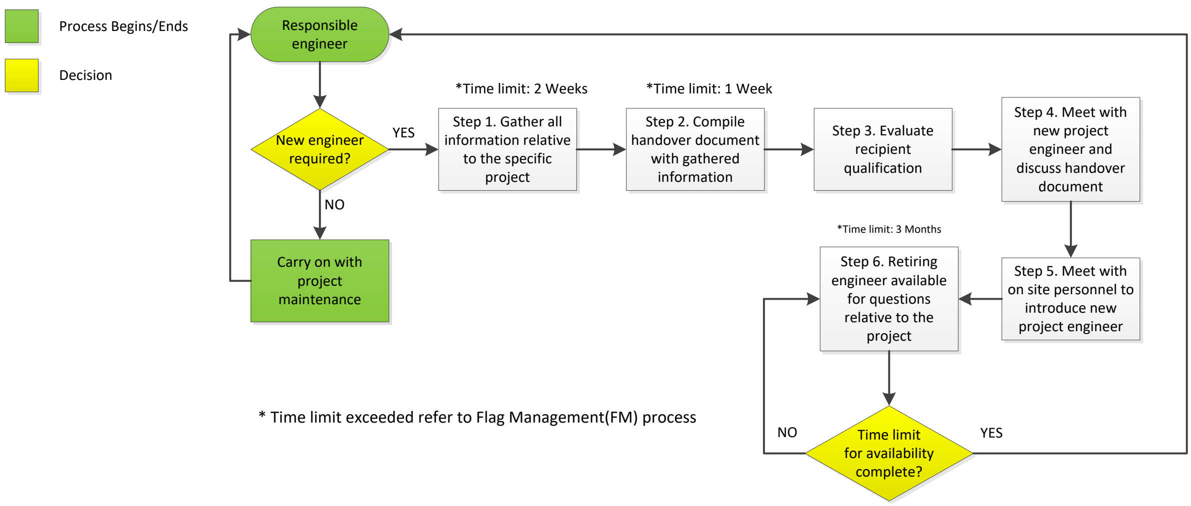

Figure 34: Handover process

Step 1: Gather information

In this step the retiring project engineer gathered the available information for this project. The information included the following:

- Project duration
- Project contract
- Control philosophy of the project
- Past sustainability issues and solutions
- Site personnel contact details
- Site location

Step 2: Compile handover document

A handover document with the project related information was created for the new project engineer. Appendix A consists of a handover template used by the ESCo. Additional information can be added to the template, depending on the project.

Step 3: Evaluate recipient qualification – An assessment was done on multiple recipient's qualifications to evaluate whether the recipients contain the necessary knowledge to manage the specific project. The best suited recipient was chosen to be responsible for the DSM project.

Step 4: Meet with project engineer

The handover document is discussed with the new project engineer (recipient) and additional personnel if needed. The retiring project engineer must make sure that the new engineer understands the information contained in the handover document.

Step 5: Meet on-site personnel

The retiring project engineer must ensure that the new engineer met the relative on-site personnel. Site personnel must know that the new engineer is responsible for the project further on.

Step 6: Availability

The new project engineer must be guided to fully understand the project. The retiring project engineer must be available for questions and guidance if needed. It is recommended that the retiring engineer be available for at least three months. The time limit may vary due to project complexities.

In addition to the HP, the PAP was applied. This process was applied due to the lack of project devotion. The new project engineer applied this process to mitigate the negative effect on project performance. Figure 35 displays the PAP applied to Case Study B. The steps applied by the ESCo are as follows:

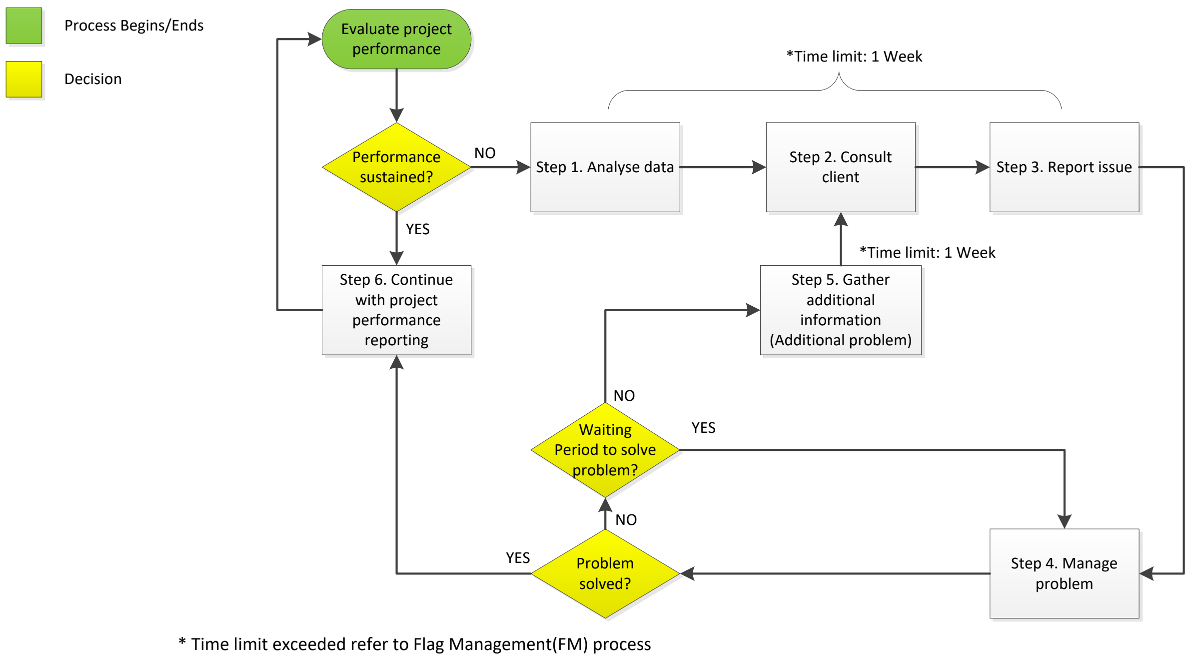

Figure 35: Performance Assurance Process (PAP)

Step 1: Analyse data

The project performance was analysed by the project engineer. It was established that no LS was applied to the refrigeration system. Further investigation revealed that the control operators were not controlling the refrigeration system as instructed.

Step 2: Consult client

The project engineer scheduled recurring meetings with the client to remind them of the project requirements as well as the electricity cost savings that were missed.

Step 3: Report issue

The issue was reported to the project engineer's supervisor as well as the necessary on-site personnel.

Step 4: Manage problem

Recurring training sessions were scheduled for the control operators by the ESCo. This was done to remind the operators of the project importance and the negative effect on the project performance when neglecting LS opportunities.

Step 5: Gather additional information

Except for the training duration, no waiting period was required. The sustainability issue was solved during the first iteration of the process.

If the sustainability issue still persists and there is no identified waiting period (period before the issue is solved), the ESCo will be required to gather additional information in an effort to identify the cause of the sustainability issue. If a waiting period is identified, the ESCo will be required to return to Step 4 and manage the issue.

Step 6: Monitor project performance

This process is applied daily by the project engineer responsible for the DSM project in order to monitor project performance. This step is done by means of the following [32]:

- Daily feedback reports
- Daily performance emails

Monthly feedback reports are sent to the client in order to remind them about the project performance as well as the electricity cost savings they were able to achieve. It was established by the ESCo that the project performance increased due to the applied processes developed in this study.

Unfortunately, the project target was not achieved. Further investigations by the project engineer led to the discovery of an operation change on the client's refrigeration system. As mentioned in the previous subsection, the mine was able to achieve acceptable underground temperatures without running three fridge plants. The mine only requires two fridge plants with two additional fridge plants on standby.

In order to resolve this issue, the project engineer applied the Non-Routine Baseline Adjustment Process (NBAP) to the DSM project. Figure 36 displays the NBAP that was applied to the DSM project in order to resolve the outdated baseline/scaling method. The steps applied by the ESCo are as follows:

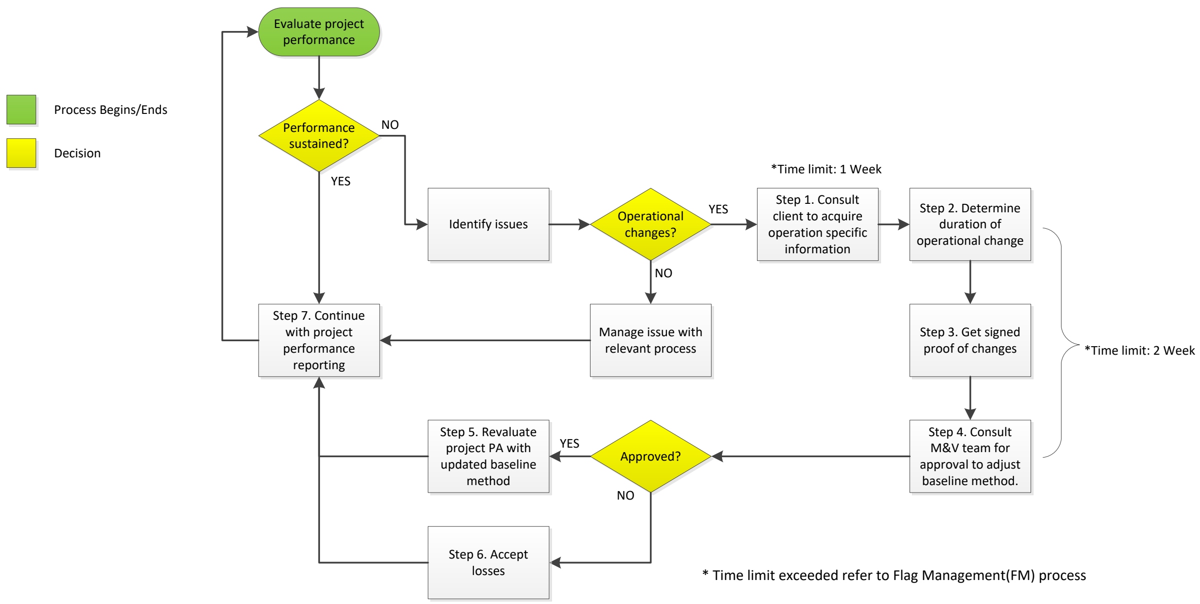

Figure 36: Non-Routine Baseline Adjustment Process (NBAP)

Step 1: Consult the client

In this step the project engineer consulted the client to retrieve operational information. From this step it was determined that the mine was using two fridge plants instead of three. Due to the information gathered, the ESCo verified that the NBAP is the appropriate process to apply to this sustainability issue.

Step 2: Determine the duration of operational change

Unfortunately, the mine was unable to specify the duration of the operational change. As this is a health and safety concern, the mine may need to start an additional fridge plant to maintain acceptable underground temperatures. For this reason, the ESCo decided to implement a scaling method update rather than creating a new baseline.

Step 3: Get signed proof

The ESCo is advised to request a signed letter from the client stating that the operational change has indeed been implemented due to a specified reason. This letter is used in the following step.

Step 4: Consult M&V

The ESCo consulted the M&V team dedicated to the DSM project with the additional information regarding the operational change. The new scaling method is presented to the M&V team for approval. This can be a time-consuming step if not managed correctly. Appendix C shows the approved scaling method applied by the ESCo to mitigate the negative effect of the operational change on the project performance.

Step 5: Re-evaluate project

The project performance is re-evaluated once the scaling method is updated, which is done by the M&V team. It is the ESCo's responsibility to confirm whether the electricity cost savings are calculated correctly according to the new scaling method.

Step 6: Accept losses

In this step, the ESCo is required to accept any losses caused by the sustainability issue. Fortunately, this step is not required as the M&V team accepted the scaling method update presented by the ESCo.

Step 7: Evaluate project performance

If the new baseline or scaling method adjustment has not been improved, the ESCo will be required to continue with project performance. Methods for daily monitoring include [49]:

- Daily feedback reports
- Daily performance emails
- Monthly feedback reports

The following subsection contains and explains the results obtained from applying the processes developed in this Case Study.

3.3.3 Results of the implemented processes

Handover Process & Performance Assurance Process

The ESCo was able to resolve the sustainability issue by applying the Handover process in conjunction with the PAP. This allowed the new project engineer to focus on the load shift project as well as the recuperation of poor ESCo/client relationships. The ESCo was able to increase the project performance to 2.36 MW within a time frame of two weeks. Unfortunately for the ESCo, this process was applied to the project during the last quarter of the project duration. This had a negative effect on the project performance and could have been avoided if the processes had been applied earlier.

Figure 37 displays the project performance after the ESCo implemented both the Hnadover process and the PAP. Figure 37 displays the effect of applying both processes. The red block in Figure 37 represents the Eskom evening peak period in winter months.

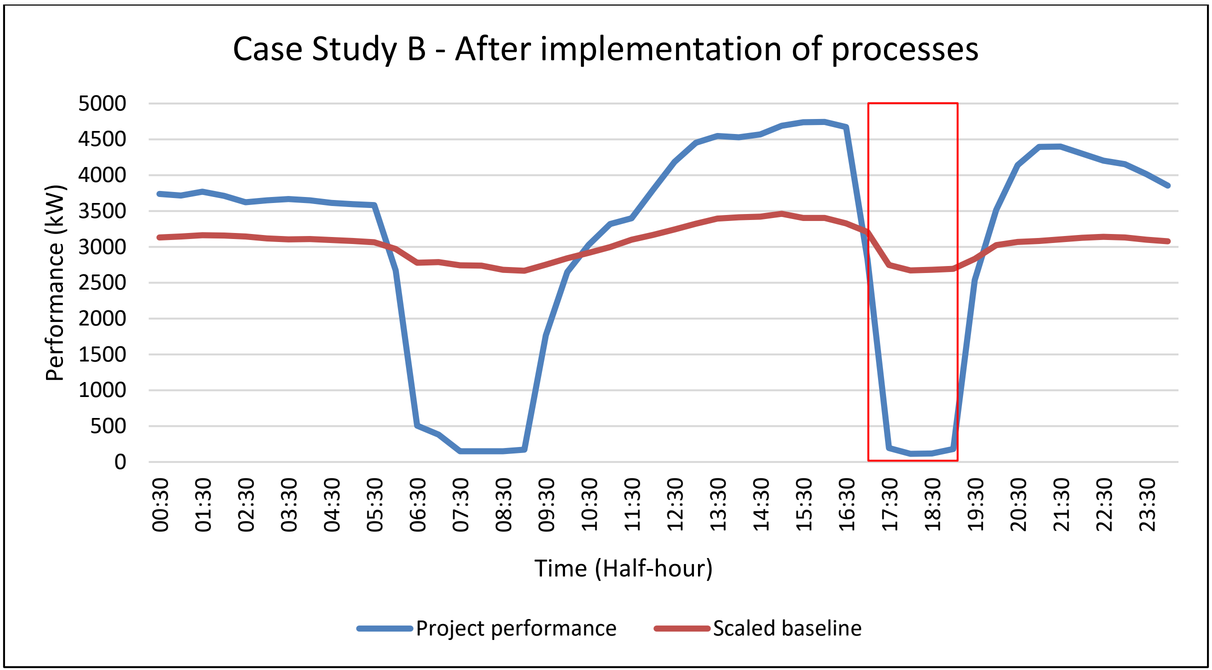

Figure 37: Project performance after process implementation

Non-Routine Baseline Adjustment Process (NBAP)

As mentioned in the previous subsection, an operational change occurred on the refrigeration system of Case Study B. The operational change directly influenced the DSM project performance to such an extent that the ESCo was unable to reach the project target. It was decided by the ESCo to implement the NBAP. This was done to update the scaling method in an effort to mitigate the negative effect of the operational change on the project performance. Figure 38 displays the results the ESCo was able to achieve by applying the NBAP. The results displayed consist of the average performance for the period of PA 11.

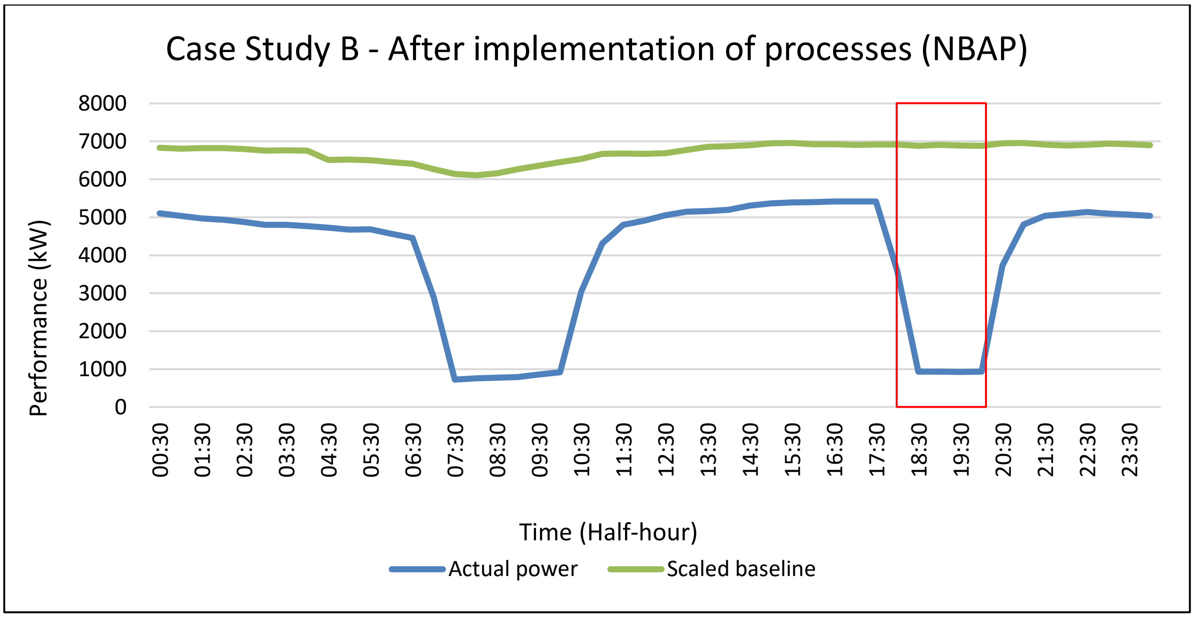

Figure 38: Project performance after process implementation (NBAP)

The ESCo was able to achieve improved electricity cost savings due to the approved new scaling method. The project performance increased from 2.36 MW, which can be seen in Figure 37, to 5.35 MW, which is represented in Figure 38; thus reaching the project target of 3.3 MW and overachieving on the project performance. The effect of applying the processes show clear improvements regarding the project performance of Case Study B. As previously mentioned, the processes solved the sustainability issues by increasing the project performance. The ESCo used the processes as a guideline to address sustainability while reducing the risk involved with the new DSM model; thus addressing the objectives of this study.

3.4 Conclusion

The aim of this chapter is to validate the methodology of this study. Different methods were applied to achieve validation. The methodology was validated by means of applying various processes to multiple industrial DSM projects in order to improve and sustain project performance.

Case Study A consisted of a pumping project on a gold mine in South Africa. A LS project was implemented by the ESCo to reduce the mine's energy electricity costs. The project target set by the M&V team for the LS project is 2 MW. Sustainability issues were encountered by the ESCo causing a deterioration in project performance. The ESCo applied various processes from this study to mitigate the negative effect of the sustainability issues. The ESCo was able to increase the project performance from 0.2 MW to 3.28 MW; thus achieving 164% of the project target. Unfortunately, the entire project duration is not included in this study. It is expected that the project target will be reached for the remaining project duration if the appropriate processes are applied.

Case Study B consisted of a LS project. The LS project is applied to a refrigeration system on a gold mine in South Africa. The project is implemented by the ESCo to reduce the mine's electricity consumption during the Eskom peak periods. The target set by the M&V team is 3.3 MW. Sustainability issues were encountered by the ESCo causing a deterioration in project performance. It was noticed that an operational change occurred on the refrigeration system of Case Study B. The ESCo applied various processes from this study to mitigate the negative affect of the sustainability issue.

The ESCo applied the NBAP in order to develop a new scaling method to accompany the operational change. The ESCo was able to achieve an increase in project performance of 2.99 MW; thus achieving 162% of the project target. Both case studies show clear improvements with an increase in project performance of more than 80%. As indicated, it might be necessary to apply multiple processes to mitigate the negative effect of sustainability issues. Thus the obtained results validate that the processes address the sustainability issues as well as increase the projects' performance. The results are discussed in more detail in the previous subsections.

The following chapter contains information on the conclusion of this study as well as recommendations for consideration by ESCos.

RECOMMENDATIONS AND CONCLUSION

4.1 Summary

Eskom is the largest provider of electricity in South Africa. Unfortunately, Eskom is undergoing enormous pressure to sustain South Africa with the required amount of electricity. This led to Eskom developing the first DSM model. The goal was to implement industrial DSM projects subsidised by Eskom IDM to reduce electricity usage during the Eskom peak periods. ESCos are responsible for managing the industrial DSM projects. In 2015, Eskom updated the old model to a new DSM model. This introduced a compulsory maintenance period with a three-year duration.

The maintenance period introduced new challenges as ESCos were responsible for maintaining industrial DSM projects for longer periods. The previous DSM model entailed that ESCos were required to maintain industrial projects for a three-month period. History indicates that processes developed for the first DSM model did not focus on maintaining project performance for longer periods. Thus ESCos contain limited knowledge in maintaining projects for durations extending a three-month period.

The ESCo is required to sustain DSM project performance for a 36-month period. The extended maintenance period has a significant impact on the profitability of DSM projects as ESCos' revenue is dependent on the project performance. The extended project duration resulted in an increase in sustainability issues resulting in project performance deteriorating, thus decreasing the profitability of ESCos implementing industrial DSM projects. ESCos require a guideline to assist them in managing and sustaining DSM projects.

The solution developed in this study encompasses processes to assist ESCos in managing industrial DSM projects. These processes were developed by integrating knowledge gained from previous studies with experience gained by an ESCo. The aim of each process is to reduce the risk, resources, and time spent solving sustainability issues as well as increasing project performance within the following categories:

- M&V
- Technical and systems
- Resource management

Chapter 2 contains detailed information regarding the developed processes. By sustaining the DSM project performance, the ESCo will be able to increase the profitability of implementing DSM projects in the future.

A verification survey was distributed amongst various engineers holding different levels of experience within the DSM project field. It was noticed that the engineers holding the least experience with DSM projects tend to rate the processes higher. This was due to the experienced engineers scrutinising the processes. The processes achieved an average score of 84%, verifying that the processes meet the requirements set by the objectives.

Chapter 3 contains the results of this study. Some of the developed processes in Chapter 2 were applied on two case studies. Each case study consists of an industrial DSM project. Various processes were applied to each case study in order to improve and sustain the project performance.

Case Study A consists of a pumping project on a gold mine in South Africa. An LS project was implemented by the ESCo to reduce the mine's energy consumption during the Eskom evening peak periods. A gap in communication between the operators was identified which led to the project performance deteriorating by 93% over a duration of two performance assessments. The ESCo applied the Conflict Management Process (CMP) as well as the contractor management process in order to solve the sustainability issue. The ESCo was able to improve the project performance by achieving 164% of the project target. It is expected that the project will continue to overperform due to the ESCo applying the required processes.

Case Study B consists of a LS project applied to a refrigeration system on a gold mine in South Africa. Multiple sustainability issues were detected by the ESCo causing a deterioration in project performance. The ESCo found that the project performance decreased by 86% over multiple performance assessments. This was rectified by the ESCo applying the Handover Process developed in this study. An increase in project performance was obtained in the succeeding performance assessments.

An additional process was applied by the ESCo after further investigation. The ESCo applied the NBAP in order to develop a new scaling method to rectify the identified sustainability issue. The ESCo was able to achieve an increase in project performance of 2.99 MW; thus achieving 162% of the project target.

Both case studies show clear improvements, validating that the processes were successfully applied to the DSM projects. As indicated, it might be necessary to apply multiple processes to mitigate the negative effect of sustainability issues. It is recommended that ESCos apply the processes as time effectively as possible. This will reduce the overall turnaround time and the effect of the sustainability issues.

The objectives of this study are:

Develop processes that will assist ESCos

Chapter 2 contains ten processes developed to assist ESCos to address sustainability issues within three different categories.

Solve issues as efficiently as possible while reducing the effect on project performance

As seen from Chapter 3, the ESCo was able to increase the project performance on both case studies as well as reduce the negative effect of the sustainability issues. Time limits were applied to the processes to ensure ESCos complete a focus action within a specific process. The Flag Management process is developed to assist ESCos when a process is flagged due to exceeded time limits. The NBAP had a turnaround time of two weeks after being implemented to Case Study B. As seen from the verification survey, this objective achieved 80% success rate.

Supply ESCos with a guideline to manage sustainability issues

Chapter 2 provides the processes developed to assist ESCos with sustainability issues. As seen from Chapter 2, the verification survey indicates that multiple project engineers responsible for various DSM projects use these processes to assist them. The survey verifies that the processes contain the necessary requirements to assist ESCos in managing issues with the goal to increase project sustainability.

Reduce risk involved with the new DSM model

With the new DSM model, all the risk involved with implementing DSM projects is shifted towards the ESCo. By having access to structured processes specifically developed to assist ESCos in managing sustainability issues, the risk in implementing these projects is addressed. This is verified by the verification survey results. Processes developed to address risk increases the profitability of implementing DSM projects under the new model.

Various project performances will be affected differently to the processes developed in this study. It can thus be concluded that the processes developed in this study are capable of improving and sustaining the project performance of industrial DSM projects within the new DSM model. The processes are capable of providing assistance for ESCos in managing industrial DSM projects. Multiple industries can find value in this study as the processes can be used on various performance-based contracts. The study was tested and verified that the processes contain the requirements to increase project performance.

4.2 Recommendations for further work

The processes from this study were developed from the knowledge gained from the first DSM projects under the new DSM model. It is recommended that ESCos continuously update the processes as more experience and knowledge are gained with the new DSM model. As new projects are implemented, new sustainability issues will arise. This creates opportunity for ESCos to develop new processes to sustain project performance.

It was noticed during this study that project targets of industrial DSM projects are poorly selected. It can be seen from Case Study B that the project overperformed on multiple instances. Unfortunately, ESCos are not compensated for overperforming on project performance. Thus, ESCos require a method to determine the project potential of industrial DSM projects. This will financially benefit the ESCo if a higher project performance is achievable.

Within Case Study B it was noticed that developing a scaling method can be resource-intensive. A process is required that will calculate which method of scaling is necessary for the specific type of project. When required, the correct scaling method will be available for use.

It was noticed from the verification survey that one of the engineers believe that safety should be addressed within the developed processes. Thus it recommended that a process be developed to address the safety aspects within these processes. This will allow ESCos to address additional risks introduced by unsafe working conditions.

It is recommended that ESCos test the feasibility of the processes developed in this study on performance-based contracts. Performance-based contracts contain maintenance periods. Thus the processes should assist ESCos to maintain project performance.

Six of the ten processes were used due to the available case studies. It is recommended that the remaining processes should be tested.

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APPENDIX A

Handover document example

Project name

Existing control philosophy

Current sustainability issues

- [Problem 1 and what has/can be done to solve it]
- [Problem 2 and what has/can be done to solve it]

Contact details

Name	Position	Office #	Cell #	Email

Data source

What data is available and how to retrieve the data?

Remote login details

Is remote login available and what are the details?

Server name	IP address	Username	Password

Site access procedure

Additional information required to obtain site access.

Site location

Screenshot of directions as well as physical location.

APPENDIX B

Case study A – Scheduler project

The objective of this project is to achieve an evening LS which will generate energy cost savings. This is possible because the mine has a variable tariff structure. Sibanye-Stillwater is on Eskom's Megaflex tariff structure which allows for an energy cost saving when load is shifted from the Eskom peak periods.

The deliverables for the projects are as follows:

- A scheduler must be developed which indicates the recommended number of pumps to achieve an evening LS.
- The control schedule must be displayed on the HMIs which are found underground at each pump station.
- Supply and install lights which will indicate to the operators when change is required in the number of pumps running.

Figure 39 displays one of Case Study A's level HMIs underground. This figure displays the final results of the solution, indicating the number of pumps as well as the recommended number of pumps.

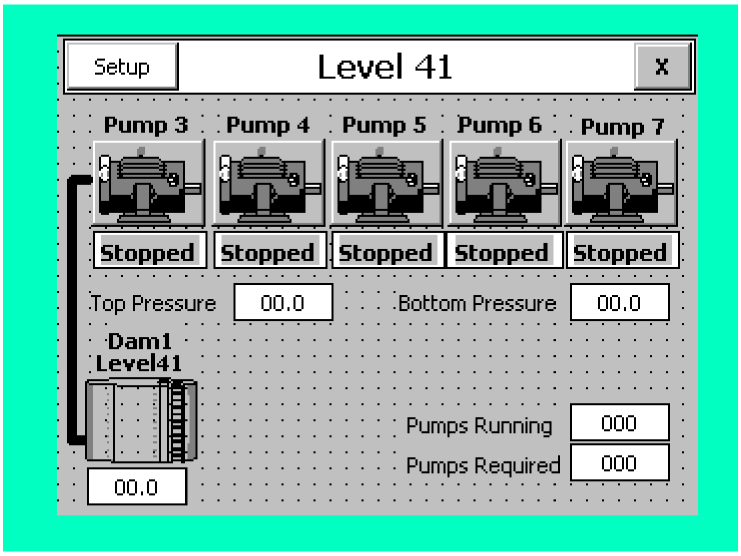


Figure 39: HMI results

Figure 40 displays Case Study A's SCADA system found in the surface control room. This figure displays the final results of the solution, indicating the number of pumps as well as the recommended number of pumps. As previously mentioned, the scheduler will verify how many pumps are available before the required number of pumps are increased. If the pumps have lost communication or are non-functional, the scheduler will exclude those pumps from the algorithm and the SCADA will identify these pumps with a different colour as displayed in Figure 40.

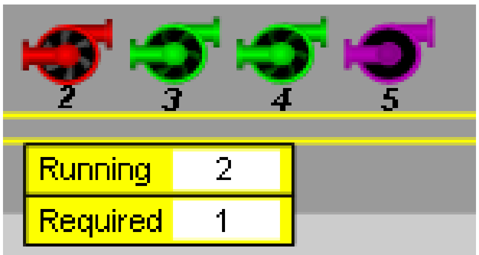


Figure 40: Case Study A - SCADA results

APPENDIX C

Case Study B – Scaling method update

In order for the ESCo to develop a new scaling method, it was necessary for the project engineer to analyse the baseline period data. It was noticed by the ESCo that an average of 800 l/s of water flow through the fridge plants in the baseline period. Thus 800 l/s with the operational characteristics of the baseline period.

With the operational change detected in the 10th PA by the project engineer, it was impossible to reach the same flow of water through the fridge plants. The ESCo used the difference in water flow through the fridge plant as the scaling factor. The formula developed for the new scaled baseline is as follows:

Equation 3: Scaled baseline

$$Scaled\ baseline = (Power_{BL} \times SF) + X(Power_{BL} \times SF)$$

Table 8: Updated scaling factor formula explanation

$Scaled\ baseline$	Data the actual power will be compared to, in order to calculate the project performance.
$Power_{BL}$	Power data in kW of the baseline period.
SF	Scaling factor as used in original formula.
X	Error ratio of baseline flow to current actual flow.

With the updated scaling method applied, the ESCo was able to achieve an improved project performance. The results can be seen in Chapter 3.

APPENDIX D

Verification analysis survey: Sustainability processes

The purpose of this voluntary survey is to verify whether the processes developed in this study contain the attributes to meet the requirements of the objectives set in this study. The survey contains three sustainability problems with four questions each. A rating from zero to ten is provided for each question, zero stating you do not agree with the question and ten you fully agree with the question.

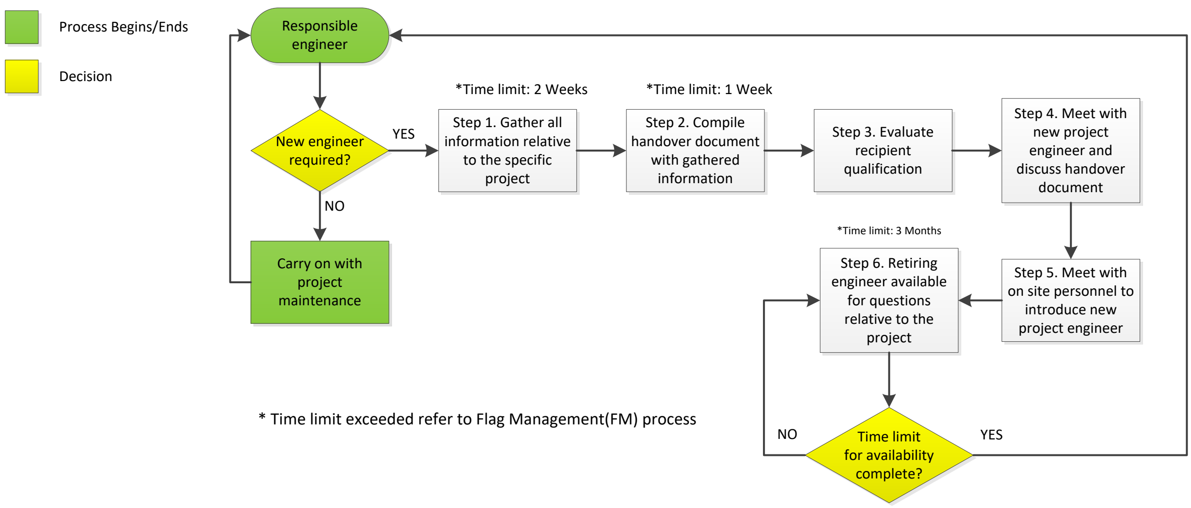
Sustainability problem 1

Problem statement:

Project performance deteriorating due to lack of attention. Project engineer preoccupied with other projects.

Solution applied:

The **Handover** process found below was applied to the sustainability issue.



Question 1

Do you believe that this process will be able to assist an ESCo in solving the sustainability issue?

0 = Do not agree

10 = Completely agree

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____
____
____

Question 2

With regards to time. Do you believe that this process is an efficient solution?

0 = Do not agree

10 = Completely agree

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____
____
____

Question 3

Based on the experienced problem. Do you believe that this process/guideline will help to assist ESCos in maintaining the sustainability of a project?

0 = Will not assist ESCos in maintaining project performance

10 = Will assist ESCos in maintaining project performance

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____

____

____

Question 4

Based on the experienced problem. Do you believe that this process decreases the risk involved with the experienced sustainability issue?

0 = This process does not decrease any the risk involved with the sustainability issue

10 = This process decreases the risk involved with the sustainability issue

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____

____

____

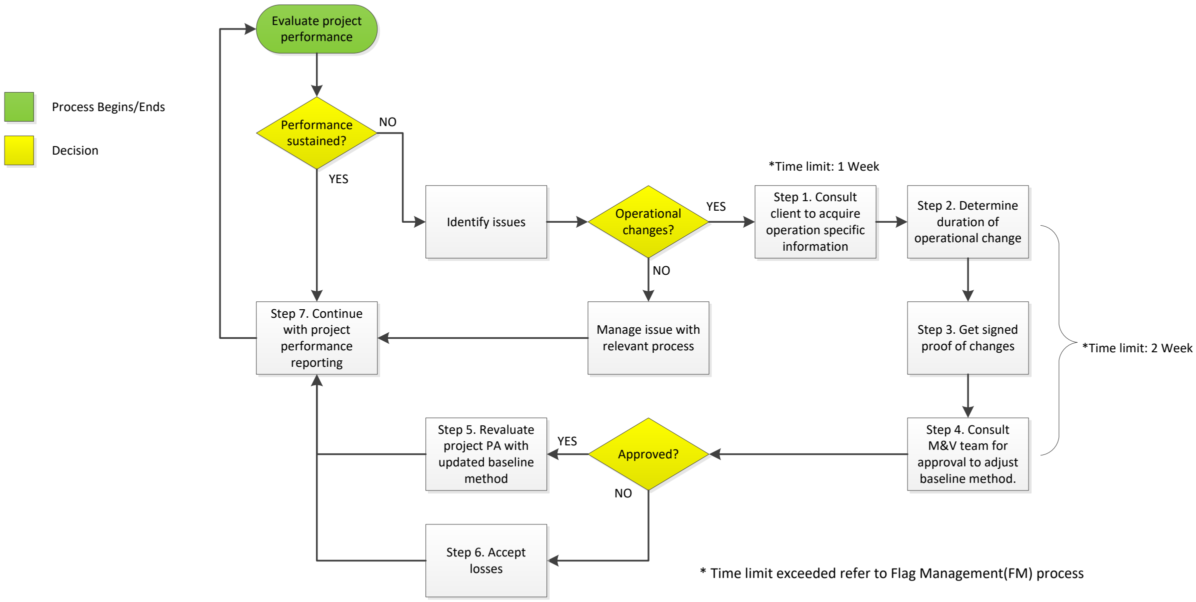
Sustainability problem 2

Problem statement:

Project performance deterioration due to an operational change. Client was able to achieve similar results by operating less equipment.

Solution applied:

The **Non-Routine Baseline Adjustment Process** found below was applied to the sustainability issue.



Question 1

Do you believe that this process contains the necessary requirements to solve the sustainability issue?

0 = Do not agree

10 = Completely agree

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____
____
____

Question 2

Do you believe that this process is an efficient solution to solve the sustainability issue?

0 = Do not agree

10 = Completely agree

Answer: ___

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

What can be added to improve this process relative to the question?

____
____
____

Question 3

Does this process contain the required attributes to maintain project performance for an extended duration?

0 = Will not assist ESCos in maintaining project performance

10 = Will assist ESCos in maintaining project performance

Answer: ___

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

What can be added to improve this process relative to the question?

____
____
____

Question 4

As risk is a high priority within the new DSM model. Does the processes address some of the risk involved with the sustainability issue?

0 = This process does not decrease any the risk involved with the sustainability issue

10 = This process decreases the risk involved with the sustainability issue

Answer: ___

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

What can be added to improve this process relative to the question?

____
____
____

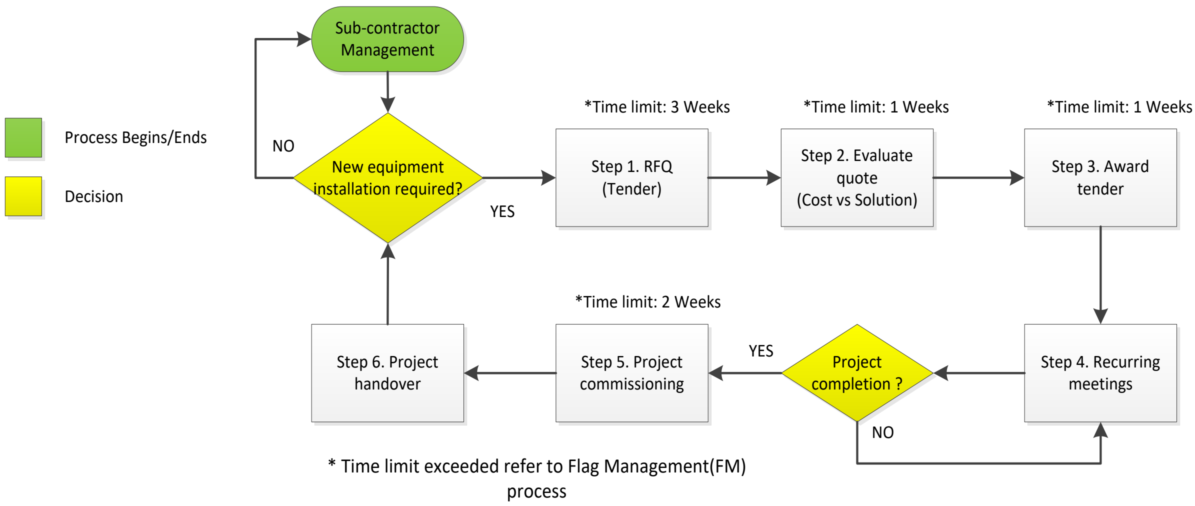
Sustainability problem 3

Problem statement:

Project performance deteriorating. The ESCo is required to install equipment to rectify the sustainability issue. Unfortunately, the ESCo does not contain the required knowledge to install the additional equipment.

Solution applied:

The **Contract Management** process found below was applied to the sustainability issue.



Question 1

Do you believe that this process will be able to assist an ESCo to manage the sub-contractor?

0 = Do not agree

10 = Completely agree

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?

____
____
____

Question 2

With regards to time. Does this process contain the necessary requirements to manage sub-contractors efficiently?

0 = Do not agree

10 = Completely agree

Answer: ___

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

What can be added to improve this process relative to the question?

____
____
____

Question 3

Based on the experienced problem. Do you believe that this process/guideline will help to assist ESCos in maintaining the sustainability of a project?

0 = Will not assist ESCos in maintaining project performance

10 = Will assist ESCos in maintaining project performance

Answer: ___

0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

What can be added to improve this process relative to the question?

____

Question 4

Based on the experienced problem. Do you believe that this process addresses the risk involved with employing sub-contractors?

0 = This process does not decrease any the risk involved with the sustainability issue

10 = This process decreases the risk involved with the sustainability issue

Answer: ___

0	1	2	3	4	5	6	7	8	9	10

What can be added to improve this process relative to the question?