

Structuring mining data for RSA Section 12L EE tax incentives

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ABSTRACT

South African gold and platinum mining industries are under pressure to stay internationally competitive. The implementation of Energy Efficiency Interventions (EEI) have the potential to reduce energy consumption while sustaining the same amount of production output. By investing in EEI, mining companies can lower costs and their carbon footprint. Unfortunately, EEI have been met with a number of barriers such as lack of upfront capital, unawareness on energy use and higher production priorities which have hindered energy efficiency investment.

Section 12L of the Income Tax Act, 1962 (Act No 58 of 1962) has been implemented to reward energy efficiency savings. It allows companies a tax deduction of 45 c/kWh for quantified energy efficiency savings (the value is set to increase in future). To receive the benefit, an application which quantifies the EEI impact must be submitted to the South African National Energy Development Institute (SANEDI). This application needs to comply with stringent requirements as set out in the Section 12L Law, Section 12L promulgated Regulations and SANS 50010:2011 Standard. It is therefore mandatory that the application be compiled by an independent South African National Accreditation System (SANAS) accredited Measurement and Verification (M&V) team. Proof of compliancy in the form of supporting documents must be supplied with the application.

The aforementioned mining industries have complex interdependent production and energy supply flows, extending over multiple facilities. Quantifying the impact of holistic EEIs such as energy management systems and training programmes can be challenging, especially when Section 12L compliance is mandatory. Since the M&V team will not have sufficient knowledge of the intricate site details and the EEI project implementation, assistance from industry is required. Effective collaboration between industry and the M&V team is therefore important to ensure that the Section 12L application can be effectively compiled.

This dissertation investigates mining production flow, energy supply chain components, and M&V requirements to understand the complexities involved in analysing facility energy consumption. Different data management techniques are reviewed to identify adequate approaches to handle the large volumes of data generated by a Section 12L application. The

research confirms the need for a methodology that can reduce system complexity, support Section 12L compliance and present data in a traceable manner for the M&V team to quantify the EEI impact.

The developed methodology is split into two main parts. The first part assists in reducing mining interdependency and complexity to enable the selection of a measurement boundary. The selected measurement boundary measured data will be compliant with the Section 12L requirements. The second part streamlines the collection, organising and processing of the measured data and supporting documents. This new methodology enables industry to aid the M&V team in compiling the Section 12L application without the risk of tainting the independency of the process. The design of the methodology is verified by comparing it to statutory documents such as SANS 50010:2011 Standard and the Section 12L Regulations.

The outcome of the methodology was validated by means of two complex mining case studies. In both cases the methodology was applied to identify Section 12L compliant measurement boundaries. The transparent and traceable output of the collected data and supporting documentation illustrated the ultimate auditability of results. The practical application and validation of the methodology confirmed that the original problem statement was sufficiently addressed.

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LIST OF ABBREVIATIONS

CO ₂	Carbon Dioxide
CV	Calorific Value
DFSS	Design for Six Sigma
DMADV	Define, Measure, Analyse, Design and Verify
DMAIC	Define, Measure, Analyse, Improve and Control
GHG	Greenhouse gasses
EEl	Energy Efficiency Intervention
ESCO	Energy Services Company
IEA	International Energy Agency
IPEEC	International Partnership for Energy Efficiency Cooperation
IPMVP	International Performance Measurement and Verification Protocol
IPP	Independent Power Producer
ISO	International Organisation for Standardisation
M&V	Measurement and Verification
OECD	Organisation for Economic Cooperation and Development
PGM	Precious Group Metals
PoD	Point of Delivery
PPA	Power Purchase Agreement
SADT	Structural Analysis and Data Technique
SANAS	South African National Accreditation System
SANS	South African National Standard
SANEDI	South African National Energy Development Institution

LIST OF UNITS

Gt	gigatons
kWh	kilowatt-hour
MJ	megajoule

Chapter 1

INTRODUCTION

1 INTRODUCTION

1.1 BACKGROUND

Energy Efficiency Interventions (EEI) are widely regarded as a feasible option to assist governments with the production of sustainable economic growth [1]. These interventions furthermore help to protect businesses against rising costs and are less costly compared to large scale renewable technologies [2].

Developing countries and the Organisation for Economic Cooperation and Development (OECD) economies have seen a significant reduction in energy intensity over the past 30 years [3]. The International Energy Agency's (IEA) central scenario predicts that the world's energy demand will increase by 37% by 2040 [1]. This rapid increase in energy demand places pressure on countries to supply energy to key end-users. Furthermore, it is illustrated in the IEA's scenarios that this demand will be met by a rise of 13 Gt of CO₂ emissions between 2006 and 2030 [1].

For these reasons it has become crucial for governments to stimulate growth in energy efficiency investment. In 2011, the Netherlands encouraged Dutch companies to invest around US\$ 1.8 billion in energy efficiency technologies [2]. The main reason behind these investments were tax incentives such as accelerated depreciation and deductions. Tax disincentives as is the case with penalties, are also utilised by governments to discourage the use of non-renewable energy sources [4].

The South African government is committed to reduce greenhouse gases (GHG) by 32% by 2020 and 42% by 2025 [5]. This commitment requires the government to take initiative and leadership by implementing and adapting sustainability laws, policies and programmes. Although, the effectiveness of tax incentives and disincentives to stimulate investment is a widely debated subject [6], the South African government will use tax incentives and disincentives to help them reach these goals [7].

In addition, it is necessary for the South African government to assist in the electricity shortages facing the country. The tax incentives can play a role to encourage businesses and consumers to reduce their electricity consumption by investing in energy efficiency technologies.

1.2 ENERGY USE IN THE SOUTH AFRICAN MINING INDUSTRY

The increasing inflation for labour and energy costs, governmental and socio-economic pressure for sustainability, and the volatile global demand for precious metals have placed pressure on the South African mining industry to stay competitive [8]. Furthermore, the National Climate Change Response White Paper, written to achieve the 2020 and 2025 GHG targets, identified the mining and quarrying industry as a potential area for GHG reduction [7].

This reduction potential is due to the mining industry consuming 16% of the South African industrial sector's non-renewable¹ energy sources [9]. Figure 1 indicates that the mining and quarrying industry is the third largest independent consumer of non-renewable energy sources in the South African industrial sector.

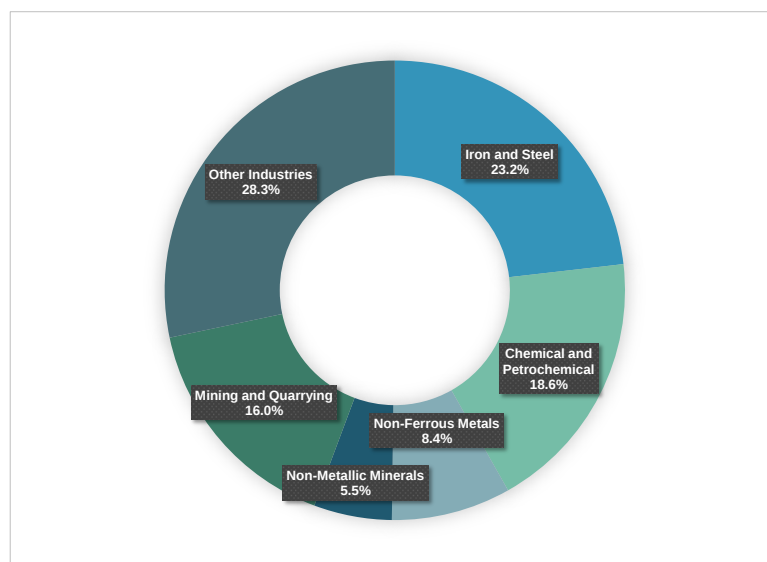


Figure 1: Total average non-renewable energy consumption per major industry²

¹ Non-renewable sources is a collective noun for the following energy sources namely electricity, coal, petroleum products and natural gas.

² The average value of the South African industry energy balance data from 1992 to 2012 was used to construct the graph. The data was supplied by the South African Department of Energy.

Figure 2 below illustrates a breakdown of the non-renewable energy consumption of the mining and quarrying industry.

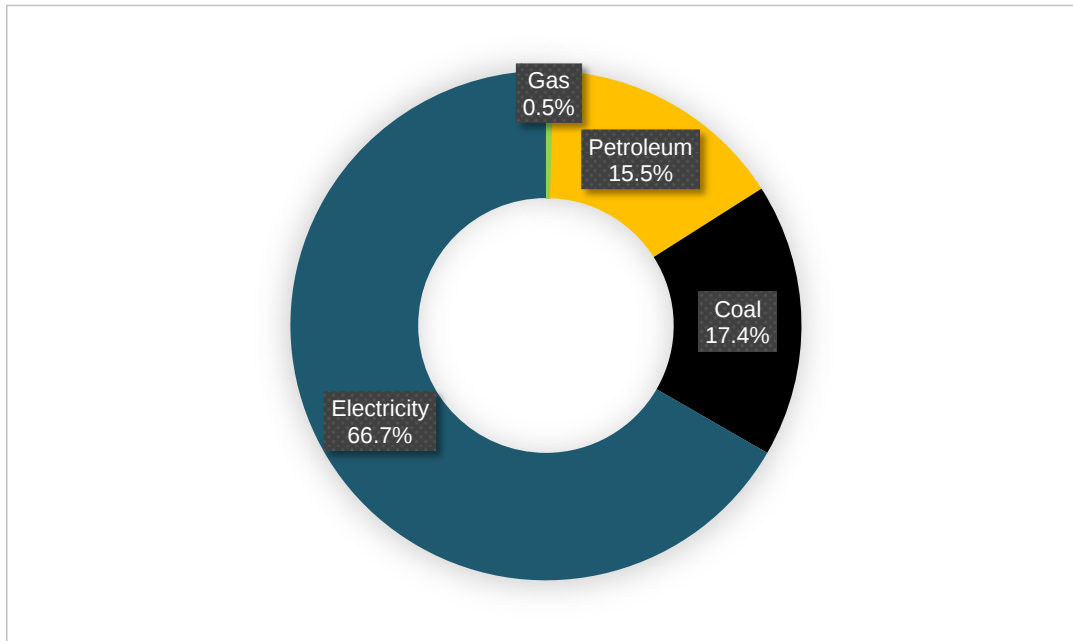


Figure 2: Mining and quarrying industry per energy source breakdown (adapted from [9])

As indicated in the above figure, electricity is the largest energy source consumed, followed by coal and petroleum. The national electricity supplier, Eskom, indicated that the mining industry consumes 15% of the company's annual output. Out of this 15%, gold mining is the largest consumer, using about 47% thereof. Thereafter the platinum mining industry follows with about 33% usage and the remaining 20% is used by the other mining industries [10]. Thus, this dissertation will mainly focus on the gold and platinum mining industries.

The price of energy has dramatically increased in South Africa [11]. The investment in energy efficiency is therefore a sensible option for the gold and platinum mining industry. This investment will assist in the reduction of operational costs and lowering their carbon footprint.

Research however, has shown that industries have been slow in investing in EEI, despite the economic and financial sense it makes [12]–[14]. This reluctance to invest is linked to the level of uncertainty involved with energy efficiency investment. One of the key issues is the engineering models predictions will not be achieved in the implemented projects “real-world”

results [12]. This phenomenon is known as the energy efficiency gap [13]. The phenomenon has been met with some scepticism especially regarding the size and the calculation methods [13], [14].

Nonetheless, it is clear there are a number of barriers which are associated with EEI. All of these barriers have an impact on the decision regarding a projects feasibility which therefore slows the implementation of energy efficiency incentives. On the consumer side, these barriers are mostly financial, technical and organisational which includes but are not limited to [15]–[19]:

- Lack of upfront capital
- Long project payback period
- Unforeseen project costs
- Insufficient information and lack of awareness on energy use
- Higher priorities in terms of production
- Complex organisation decision-making chain
- Social resistance to change

More recently, research has indicated that consumer behaviour and decision-making processes can have an effect on the energy efficiency gap [17], [19]. To alter consumer behaviour and decision-making, government policy has to include financial incentives to promote EEI and discourage energy inefficient practice [18].

South Africa decided to implement a disincentive in the form of carbon tax [20]. The South African Minister of Finance announced that this disincentive will be implemented in 2016 [21]. The disincentive can increase the gold and platinum mining industry's priority to invest in EEI. However, it still does not address the financial barriers surrounding energy efficiency investment. Consequently, the South African government will assist companies with a number of financial incentives [7]. One of these financial incentives will be in the form of a c/kWh tax deduction for quantified energy savings achieved.

1.3 SECTION 12L AND THE MINING INDUSTRY

The Income Tax Act, 1962 (Act No 58 of 1962) stipulates in Section 12L that a 45 c/kWh tax deduction will be awarded for quantified energy efficiency savings achieved from the implementation of an EEI. Regulations in terms of Section 12L of the Income Tax Act, 1962 (Act No 58 of 1962) were published in the Government Gazette No 37136 on 9 December 2013. These Regulations are effective from 1 November 2013 and any energy efficiency savings achieved in the assessment year is claimable before 1 January 2020 [22].

The promulgated Regulations however, stipulate that the Taxpayer must appoint independent Measurement and Verification (M&V) professionals, which are accredited by the South African National Accreditation System (SANAS), to calculate the energy efficiency savings. This M&V team must quantify the energy efficiency savings in accordance with the South African National Standard (SANS) 50010:2011, Measurement and Verification of Energy Savings Standard. All of these strict recommendations and requirements are to ensure the integrity and accuracy of the energy efficiency savings [22]. The Standard requires that the Taxpayer supply supporting documentation for the energy usage measurements. This supporting documentation can either be energy supplier invoices or proof of calibration of the measurement equipment [23].

The first step in the energy savings quantification process is to identify a measurement boundary for the EEI. A measurement boundary defines all the parameters, variables and factors that need to be measured to calculate the effect of the EEI [23]. The Standard's measurement boundary selection process is based on the International Performance Measurement and Verification Protocol (IPMVP) Volume 1.

The mining industry has a complex and interdependent energy supply chain and production flow [24]. Some of the main challenges facing the mining supply chain are risk management, inaccurate data, decreasing ore grade, high volume raw material, lack of understanding of facility interdependence, etc. [25]. Additionally, the mining production flow consists of numerous regional facilities. Each facility will have its own specific type of production related energy consumption.

Mining companies can encourage energy efficiency by implementing high-level energy efficiency policies and strategies e.g. training programmes, opportunity identification, switching of non-essential campaigns, ISO 50 001 energy management, etc. It is therefore, difficult to isolate these EEI to just one facility. The interdependency between the facilities for raw material and energy supply also adds to the complexity of facility isolation. Each of the production facilities have multiple energy usage measurement points.

The M&V team will therefore require assistance from industry to understand the intricate site and the EEI project implementation. After a suitable measurement boundary has been selected, the mining company will be responsible to collect the data and documentation for each of the identified measurement points for the M&V team. The data and supporting documentation will be collected across different systems, databases and can have different storage formats. To make the collected data and documentation traceable and accessible for the M&V team, a data and documentation structure will need to be developed.

1.4 MOTIVATION AND AIM

1.4.1 PROBLEM STATEMENT

The gold and platinum mining industries have a complex interdependent production flow and energy supply chain. These industries are investing in EEI such as energy management systems and training programmes. The impact of these types of EEI are beneficial. However, the system interdependency complexity combined with the holistic energy management system approach complicates the process of quantifying and isolating the EEI impact.

Quantifiable energy efficiency savings are claimable under Section 12L of the Income Tax Act, 1962 (Act No 58 of 1962). To claim this tax incentive, the Section 12L Regulations requires that a SANAS accredited M&V team quantify and report the impact of the EEI. The M&V team's quantification approach must conform to the Section 12L Law, promulgated Regulations and the SANS 50010:2011 Standard's framework of requirements. This framework is to ensure the accuracy, quality, integrity and traceability of the data used for the calculations. These data principles are verified by requiring that the applicant provide supporting documentation.

Quantifying the overall EEI impact over intricate mining facilities with these mandatory requirements will require insight into the mining system's interdependent complexities and EEI implementation. The M&V team will therefore require assistance from industry. However, the opposite is applicable to industry which does not have the accreditation or the knowledge of the M&V EEI quantification process and the Section 12L requirements. Cooperation between the M&V team and industry is therefore necessary to compile the Section 12L application.

1.4.2 DISSERTATION AIM

The aim of this dissertation is to develop a methodology to assist industry to simplify mining complexity and identify Section 12L requirements compliant measurement points. This will enable industry and the M&V team to then select a suitable measurement boundary. Thereafter, the applying company will need to collect, organise and process the necessary data and supporting documents for the M&V team.

To understand the complexity of quantifying and isolating mining facility energy consumption, an investigation is conducted into the gold and platinum mining industries sources of system interdependency. A detailed study of the Section 12L of the Income Tax Act 1962, this Section's promulgated Regulations and the SANS 50010:2011 Standard requirements are prerequisite to ensure the compliancy of the developed methodology. Subsequently, methodologies should be examined to reduce system complexity and to ensure that the final data and supporting documentation is compliant with all the Section 12L requirements.

A high volume of data and supporting documentation must be made available to the M&V team in a traceable and transparent manner. There is thus a need to develop a suitable storage structure. All the data collected will also need to be processed to one data format for the EEI impact calculation. The methodology will need to be verified by ensuring that the end result produces a Section 12L Law, Regulations and Standard compliant dataset for the M&V team to quantify the EEI impact. The methodology will then be applied to a platinum and a gold mining case study, thereby validating if this methodology can be successful in its implementation.

1.5 OUTLINE OF DISSERTATION

Chapter 1:

This chapter's aim will be to state the purpose of "why" the research will be conducted. It will introduce the reader to the concept of Section 12L, energy usage in the mining industry and identify the dissertation problem statement and the aim.

Chapter 2:

The literature review will provide the necessary overview to assist with the development of the methodology. It will discuss published literature methodologies and theoretical findings in research topics important to the study. The research topics that will be investigated include the following:

- Mining complexity
- Section 12L rules and regulations
- The M&V process, focusing on measurement boundary selection
- Data collection and structuring techniques

Chapter 3:

This chapter will focus on the development of the methodology. The methodology consists of two parts. The first part will be to identify a SANS 50010:2011 compliant measurement boundary for the mining company. Secondly, a structured approach for the management of the required data and documentation will be developed. Each of these parts will assist the reader to simplify the complexity of the mining process and to reduce the "trial and error" approach.

Chapter 4:

The methodology developed will be implemented on two case studies; one platinum mining company and one gold mining company. The results of these case studies will be discussed.

Chapter 5:

How the problem statement was addressed is discussed in this chapter by concluding the dissertation. Chapter 5 also provides recommendations for further study.

Chapter 2

LITERATURE

2 LITERATURE STUDY

2.1 INTRODUCTION

This chapter will focus on the main challenges identified in the problem statement. These include understanding the interdependency complexity of quantity the EEI impact together with the M&V requirements and the Section 12L requirements. In addition the need to present the data and documentation in a traceable manner for the M&V team should also be addressed. Published theoretical literature and methodologies developed on these specific topics will be researched. This research will then be used to develop a methodology to address these changes.

2.2 MINING INTERDEPENDENCY COMPLEXITY

An EEI will reduce energy usage while maintaining the same amount of production output [26]. To understand the complexity involved with isolating holistic EEI and determining the energy consumption reduction of the mining facilities in accordance with the mandatory Section 12L requirements, this section will investigate three main focus areas of mining interdependency complexity namely:

- Production flow and metallurgy
- Energy supply flow
- Data collection and storage

Each of these areas operational components will also be discussed. To reduce these system complexities, the high-level structured approach of the Structured Analysis and Data Technique (SADT) is investigated.

2.2.1 PRODUCTION FLOW AND METALLURGY

i. Overview

Decreasing ore grade is one of the main contributors of mining interdependency complexity [24]. This is because the ore grade has a significant impact on the metallurgy and production flow between facilities. For the gold and platinum mining industries, the production flow primarily consist out of five main processes namely exploration, mining, concentrating, metal extraction and refining, as shown in Figure 3. Each of the mining stages together with contributing mining complexity factors will be discussed in Figure 13.

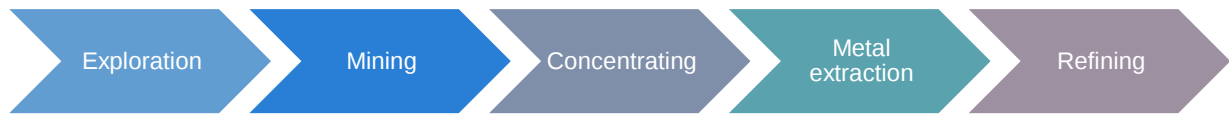


Figure 3: Mining production stages (adapted from [27])

ii. Exploration and mining

The exploration phase will explore the geology of areas to discover new naturally occurring precious metal reserves for ore extraction [28]. This is because with the decreasing ore grade, the mining phase of the production flow is not sustainable therefore leading to the necessity for these new mining areas [29]. These new areas can fall within the existing mining area or different regions entirely, increasing mined ore transportation distances for further processing [28]. Furthermore, the naturally occurring ore grade and impurity levels will vary from area to area which will have a significant impact on the downstream metallurgy and production equipment [27][30]. All these factors add to mining logistical and operational complexity.

The gold and platinum mining industries have similar ore extraction processes in the mining phase. These processes include different types of underground (deep-level shafts) and surface (opencast) mining techniques. The mining technique used will depend on the operational costs, mining area geological properties and the ore grade [28], [30]. Additionally, each of these mining techniques will require specific operational resources therefore furthering supply chain complexity [30].

iii. Concentrating

To prepare the mined ore for metal extraction the ore will be concentrated. This mainly requires the reduction of the ore size. In gold mining, concentrating processes will consist out of crushing and milling. For platinum, the mined ore will undergo crushing, milling and flotation [27]. As aforementioned, the ore grade and impurity levels have a significant impact on the downstream metal extraction chemical specification. In the platinum production flow, this entails that the concentrate needs to be moved between processing facilities. This is to ensure that the impurity levels of the material does not exceed the chemical specifications of the production equipment, for example, high levels of impurities can damage critical equipment, such as the smelting furnace [31].

iv. Metal extraction and refining

Metal extraction plants will not only process self-produced mining concentrate, but can process concentrate obtained from regional affiliated mining operations or old mining waste. This fact increases the difficulty of measurement boundary selection and EEI impact quantification because if more concentrate is externally brought into the production flow and less is self-produced, the production flow energy consumption will reduce resulting in inaccurate findings.

The gold and platinum mining industries have different separation processes to extract the precious metal from the concentrate. The gold concentrate is dissolved in cyanide (leaching). The dissolved gold is removed by adding activated carbon in the solution. Electro-winning will be used to deposit the gold onto steel wool. The gold will then be smelted and sent to a refinery [27].

The platinum concentrate will be sent to a smelting furnace. The resulting product of the smelting furnace, called furnace matte will undergo further processing in a converting process. The converted matte is sent to a base metal refinery. In this refinery, base metals like nickel, copper and cobalt are extracted and refined. The remaining material is sent to a precious metal refinery where the Precious Group Metals (PGM) like palladium, platinum, rhodium, ruthenium and iridium are extracted. An amount of gold will also be extracted in this refinery [27].

The metal by-products like chromite or uranium in the raw material add an additional complexity dimension to the production flow. This is due to the metal by-product rich material which is sold to external parties or transported in-house to processing facilities. These facilities operate, in most cases, on the same region or facility as the mining operations. In some cases the energy supply chain will therefore be extended to these facilities [8].

2.2.2 ENERGY SUPPLY FLOW

As identified in Chapter 1, the mining industry consumes commercial energy sources such as electricity, coal, petroleum and natural gas. These energy sources will be referred to as energy carriers. These carriers are consumed to drive the production and supporting activities [32]. The production outputs that drive the energy carrier consumption will be referred to as energy drivers. An EEI will reduce energy carrier consumption while maintaining energy driver output which results in energy efficiency savings [8][26]. With the holistic view of energy management system, switching of non-essential programmes and training programmes means that all the energy carriers on the mining facility can be targeted for optimisation. Hence, one should understand the types of energy carriers consumed at each mining facility, as well as the complexity of accurately determining the consumption. Figure 4 shows the mining production stages and the relevant energy carriers consumed and energy driver outputs.

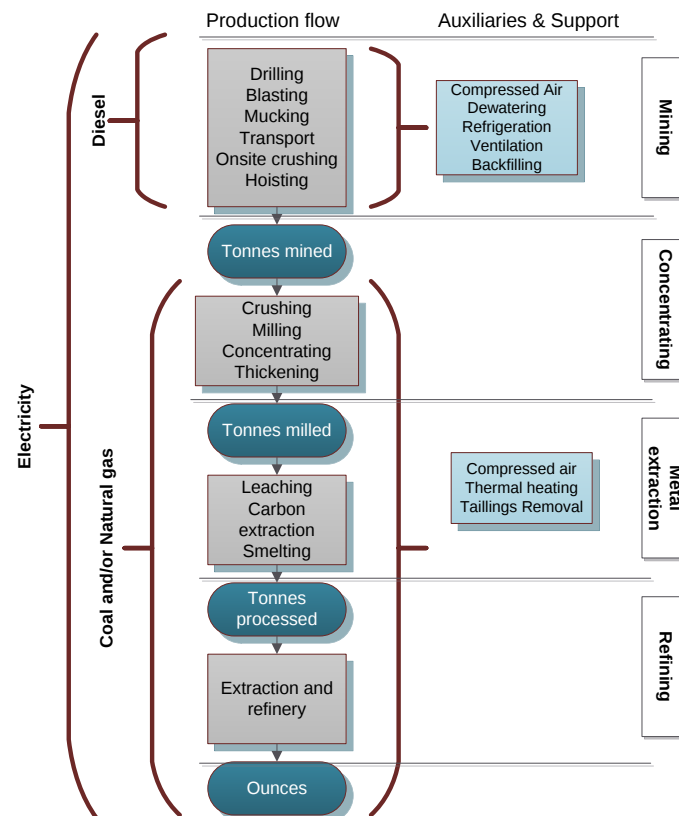


Figure 4: Energy carriers used in production stages (adapted from [8], [32], [33])

Electricity is consumed throughout the production flow as is seen in Figure 4. Electricity is the main energy source for supporting activities like compressed air generation, mining dewatering, ventilation, lighting, etc. [10]. South Africa's gold and platinum industries only have one bulk state owned electricity supplier, Eskom. This utility will only supply electricity

delivery points. The mining company will need to construct an internal distribution network from these points. The supplier will then invoice the company collectively for electricity supplied. A facility can be supplied by multiple points of delivery [34].

The SANS 50010:2011 framework of requirements identifies electricity supplier invoices as a suitable source for energy usage data [23]. It is difficult to find Section 12L compliant measurement points within the internal distribution network to isolate facilities, because the installed power meters will in most cases not have the necessary supporting documents to prove data accuracy and integrity. This adds to the mining interdependency complexity.

Coal is mostly used to generate heat throughout the production flow [25]. This means that coal is bought in bulk, stockpiled and transported to the equipment. The coal consumption is measured for example by surveying the coal stockpile or conveyor belts scales. Therefore, quantifying the coal consumption using these measurement techniques together with the Section 12L mandatory requirement for measured data will be difficult.

The coal composition and Calorific Value (CV) play an important role in the metallurgy, specifically if the coal is added to the raw material. If the coal composition has high-volatile impurities, moisture and/or ash content, the consuming production equipment becomes inefficient [35]. Therefore, the availability of coal sources with the necessary chemical specifications range can be scarce, adding to supply chain logistical monopoly and larger stockpiles. The coal supplier and, in some cases the coal consumer, will take periodical samples of coal batches for chemical analysis. These analyses will state a CV for that specific coal batch. These CVs are then used to calculate the energy (MJ) produced by the kilograms of coal consumed [36].

Petroleum products like diesel and petrol are used in the ore extraction phase for ore transportation and hauling. Mechanisation of underground deep-level mining techniques have also increased the use of petroleum products [33]. These products are generally available from a variety of suppliers. This means that a mining production flow can have multiple points of measurement and a high volume of petroleum product data. Petroleum products are produced in a more controlled environment therefore a standard/average CV is specified for

the product. However, the petroleum product producer can also take periodical analysis of the product for quality control.

Badenhorst identified compressed air as one of the energy carriers on a platinum base metal refinery [37]. Compressed air is used for various operational and production reasons in mining operations. Mining production facilities located in the same region will make use of central compressed air rings to supply their operational needs. Compressor houses that generate the compressed air are placed at certain strategic locations [30]. If a facility makes use of the ring's compressed air and the facility is isolated, the compressed air is seen as a facility energy carrier.

In addition, the energy supplier distributor will focus their attention on product supply. This means the utilisation and efficient use is the responsibility of the client. However, the client will have higher production priorities. A marketing barrier is created in terms of energy efficiency, because the effective and efficient use of the energy carrier is not specified to the client [38]. Energy Service Companies (ESCOs) can overcome this barrier by evaluating the client's energy usage. These companies can then market incentives and EEI to the client for improve energy efficiency [39].

2.2.3 DATA COLLECTION AND STORAGE

The gold and platinum mining production flows are unique because there are multiple facilities and production stages. Therefore, high volumes of data from multiple disparate sources need to be collected, consolidated, transformed and analysed every day, resulting in departmental distribution, replication and “data massaging” before data is used for decision-making purposes [40]. The various departments exchange of data will in most cases be in Microsoft Excel spreadsheets [25].

The raw data for these spreadsheets will be extracted from facility databases or production reports. The facility databases can have hundreds of data input sources from all over the facility, in most cases within real-time capacity. These data source inputs can either be manual or automated. In addition, with the volatility surrounding the precious metal market and daily uncertainties inherent with the complexity of mining operations, mining operators and executives rely more and more on data for decision-making. Hence, mining personnel are

increasingly installing automation and sensors. These systems will either be integrated with existing databases, or new databases will be created adding to the complexity [40].

There is therefore a need for a holistic view of the mining operation which identifies with clarity and accuracy where the vital points of measurement are for the EEI impact quantification process.

2.2.4 REDUCING COMPLEXITY – SADT TECHNIQUE

High-level thinking can be used to reduce the complexity of a problem [24]. The structured approach will consider the mining production flow as a whole throughout the simplification process. This approach focuses on the output of the whole system and identifies the dependency and interdependency variables that will impact the output.

A SADT uses a top-down hierarchy approach that will structure the process. The design's aim is to illustrate the transformation of the input to the output. An operational activity is shown as a box. All the inputs, controls and mechanisms flow into the box. The main product output flows out of the box (Figure 5). The general interpretation is that the input is converted into the output. The converting process can have influencing variables and supporting activities [41].

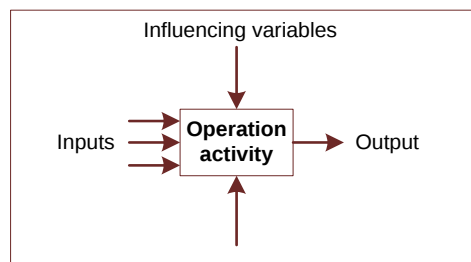


Figure 5: SADT activity box (adapted from [41])

To reduce the system complexity a top-down hierarchical decomposition for each process is developed. Figure 6 illustrates this concept in more detail. The top level/activity box represents the entire system under investigation. This activity is then hierarchically broken down in different sub-levels or sub-systems. This decomposition process can be continued until a suitable level of detail is reached for the model builder [41]. For the purpose of this study, a low level of detail will be used focusing on the activity box principle. This will assist in reducing the complexity and interdependency of the system.

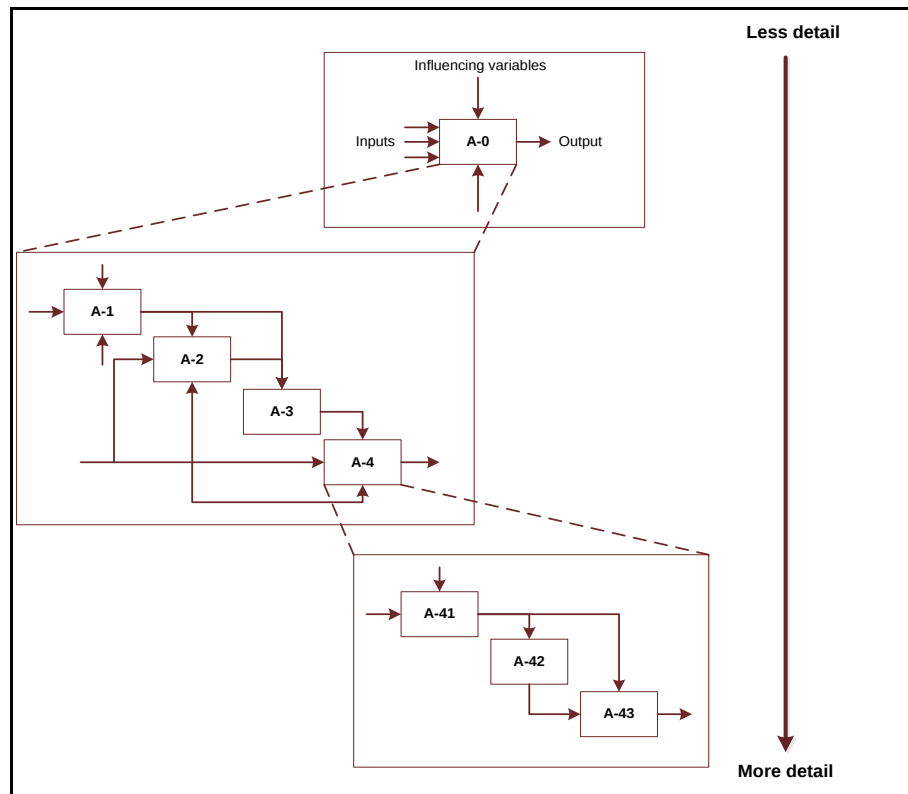


Figure 6: Top-down hierarchical decomposition (adapted from [41])

2.3 INTRODUCTION TO SECTION 12L

The aim of this dissertation is to assist industry and the M&V team to quantify the EEI impact to receive the Section 12L tax incentive. It is therefore necessary to investigate the requirements of the Section 12L Law, this Section's promulgated Regulations and the Regulation requirements regarding the quantification of the EEI impact.

The Minister of Finance, Trevor Manuel, announced in 2009 that there would be tax incentives for those that can validate energy efficiency savings achieved [42]. Section 12L on the allowance for energy efficiency savings was inserted into the Income Tax Act, 1962 by the Taxation Laws Amendment Act No. 17 of 2009 [43]. This section was further adjusted by the Taxation Laws Amendment Act No. 7 of 2010 [44]. However, the entire section was substituted with Section 29 of the Taxation Laws Amendment Act No. 22 of 2012 [45]. This substituted section has also been further adjusted in the Taxation Laws Amendment Act No. 31 of 2013 [46].

Section 12L stipulates that a Taxpayer can receive a deduction from their taxable income in respect of energy efficiency savings in any year of assessment before 1 January 2020. For each kilowatt-hour (kWh) or kilowatt hour equivalent of energy efficiency savings achieved, the Taxpayer can receive a 45 cent deduction from their taxable income [46]. Section 22 of the 2015 Taxation Laws Amendment Bill will increase the 45 c/kWh amount to 95 c/kWh. This value came into operation from 1 March 2015 [47].

The Law also stipulates that the published Section 12L Regulation should be prescribed to an institution, board or body to issue a certificate to the Taxpayer. The certificate should contain [45]:

- The energy usage/baseline of the Taxpayer operations before the year of assessment
- The reported energy usage of the assessment year
- The energy efficiency savings achieved together with the calculation and quantification methodology
- Any information requirements as prescribed in the published Regulations

This certificate can then be used to obtain the tax deduction. Any energy efficiency savings achieved as a result of a concurrent benefit or limitation energy source is not eligible for the tax deduction [45].

The Section 12L Regulations were promulgated into Law on 9 December 2013 in Government Gazette No 37136 by the Minister of Finance, Minister Pravin Gordhan, in consultation with the Minister of Energy and the Minister of Trade & Industry [22]. However, on 6 March 2015 an amendment to the 9 December 2013 Regulations was published in Government Gazette No 38541 [48]. The 6 March 2015 Regulations redefined the limitation energy sources and added concurrent benefits which will be discussed in more detail in Section 2.3.2.

The Section 12L Regulations outline the processes and methodology for claiming the tax incentive and stipulate the requirements for calculating the energy efficiency savings. The Regulations prerequisite that an energy saving report must be complied containing the EEI impact calculation methodology followed. The calculation methodology should conform to SANS 50010:2011 Standard calculation methodology [22].

The savings report must be compiled by SANAS accredited M&V Professionals. This savings report will then be submitted to the South African National Energy Development Institute (SANEDI). This institution is responsible for facilitating the process of issuing the Section 12L savings certificate. As required by the Income Tax Act, 1962 the Section 12L Regulations also stipulates the limitation of the tax allowance regarding concurrent benefits and limited energy sources [22].

Understanding the claiming process will assist to comprehend the development of the methodology. Energy efficiency savings that constitute as a concurrent benefit or a limitation of energy resources will need to be ring-fenced and excluded from the quantification process and stipulated in the savings report. Both the claiming process and the specified concurrent/limitations projects will need to be discussed further to ensure methodology compliance.

2.3.1 SECTION 12L REGULATIONS - TAX INCENTIVE CLAIMING PROCEDURE

For each year of assessment the application process must be conducted. The parties directly involved with the tax payer are seen in Figure 7. Each of the parties' individual roles will be discussed in more detail below.

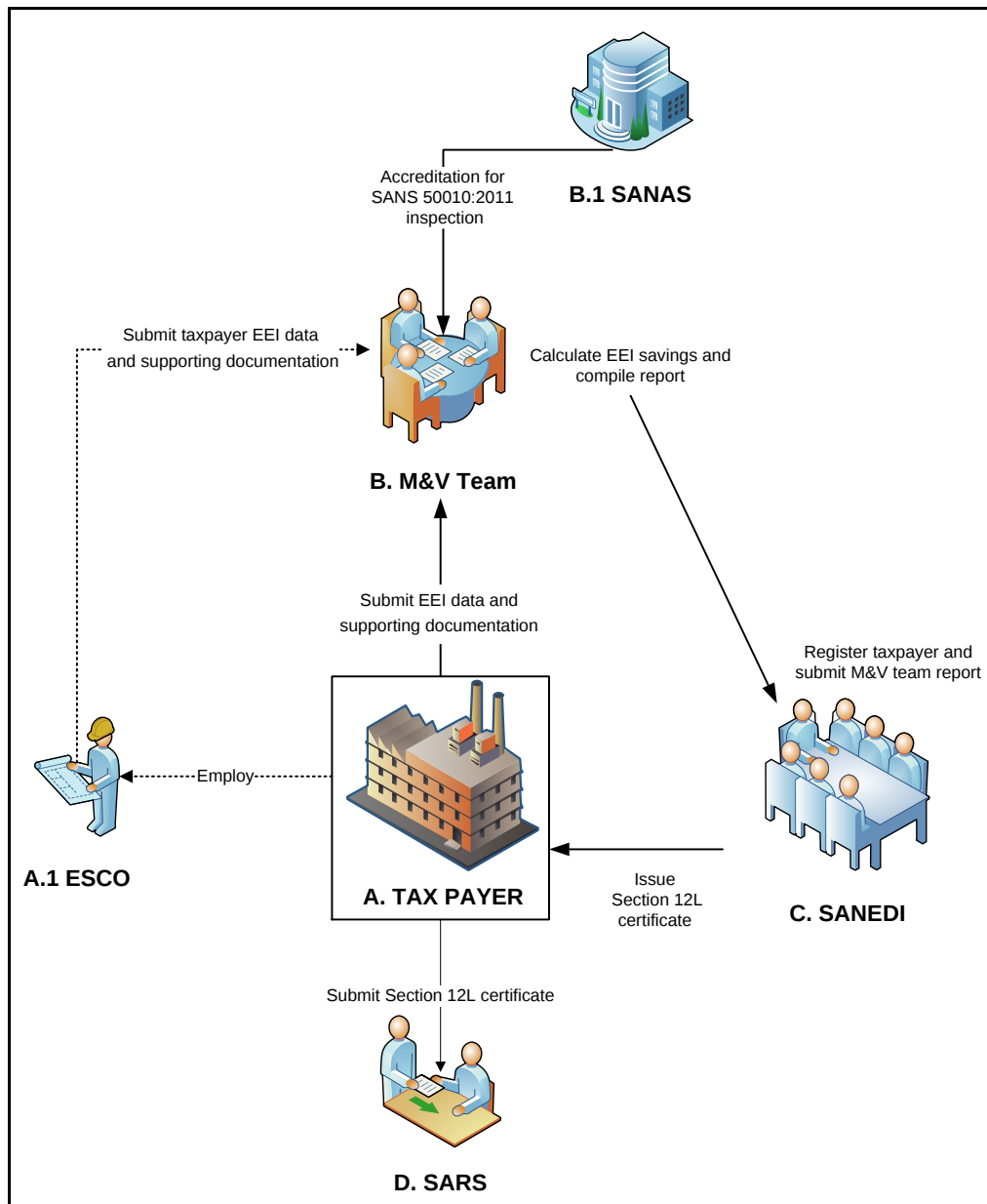


Figure 7: Section 12L application process

A. Taxpayer

The Taxpayer is the party that has implemented an EEI and will apply for the financial incentive.

A.1 ESCO

With the complexity of industry systems and the lack of visibility most Taxpayers have in terms of systems dependencies and interdependencies on energy usage. The Taxpayer can employ an ESCO to evaluate their implemented EEI. The ESCO will be the liaison between the M&V team and the Taxpayer.

B. M&V Team

The M&V team is a group of professionals that will independently evaluate and inspect the result and implementation of the Taxpayers EEI. This team will also need to quantify the impact of the EEI on the energy usage. The methodologies and verification techniques as outlined in the SANS 50010:2011 Standard will be used by the M&V team to calculate the impact.

B.1 SANAS

To ensure that the appointed M&V team is competent to conduct a SANS 50010:2011 inspection, the Regulation requires that this team be accredited by SANAS as an inspective body. This accreditation entitles that the M&V team formally demonstrate their technical competence in accordance with the SANAS TR 81-04 document (Technical requirements for the application of SANS/ISO/IEC 17020:2012 in the assessment of inspection bodies' application of SANS 50010:2011 Measurement and Verification of energy savings) [49].

C. SANEDI

Although the M&V team is an external body that will calculate and inspect the Taxpayer's EEI systems, an independent body must evaluate and approve the final application. As specified, SANEDI is the governing institute. To obtain a Section 12L certificate from SANEDI the Taxpayer must first register with the institute. After the registration a Section 12L application for review can be submitted. This application will consist out of the M&V team's energy efficiency savings report and the Taxpayer's details. The institute must appoint a panel of technical experts to evaluate the application. When this panel feels confident in the accuracy, integrity and traceability of the energy efficiency saving, SANEDI will issue a Section 12L certificate with the Regulation specified details.

D. SARS

The South African Revenue Services (SARS) is responsible to audit the calculation process followed and collect the amount taxes payable by the Taxpayer. The Taxpayer will deduct the issued certificate tax deduction value from their taxable income. The Section 12L certificate will be sent to SARS to justify the tax deduction.

2.3.2 SECTION 12L REGULATIONS - LIMITATIONS AND CONCURRENT BENEFITS

The Regulations refer to the term “energy efficiency” in accordance with the Standard. Hence, the Standard’s definition should be used, which is the following:

“efficient utilization of an energy carrier or resource” [22].

Since the Standard’s definition for energy efficiency is applicable, the definition for an EEI can also be used. This definition is as follows,

“implementation of hardware, software or changes in behaviour or operational patterns to reduce or avoid energy use” [23] .

However, the Regulation has stipulated limitations and additions to the types of EEI energy savings that can be claimed. The following EEI energy savings are eligible for the tax incentive:

1. Energy awareness and conservation

The energy efficiency saving achieved by the implementation of energy management systems can be claimed. Energy awareness initiatives like training, switching of non-essentials, etc. which promote energy conservation savings is also eligible [23].

2. Modify equipment

Equipment, structures and/or process are replaced or modified to improve the energy efficiency of the equipment, structures and/or process [23].

3. Combined heat and power

The Regulation defines combined heat and power as,

“the production of electricity and useful heat from a fuel or energy source which is a co-product, by-product, waste product or residual product of an underlying industrial process” [22].

This means that waste heat recovery and co-generation systems energy savings are claimable.

There are four EEI energy savings that are considered concurrent benefit projects and/or limited energy sources. Each one will be described in the following pages.

1. Captive power plant

A captive power plant in terms of the Regulation is a plant that generates energy for the purpose of own consumption [22]. Therefore, the generated energy does not leave the system boundary of the consuming facility. The Regulation stipulates that the tax allowance will not be given to a person that utilises a captive power plant unless the energy conversion efficiency is greater than 35%. The Regulation defines the energy conversion efficiency of a captive power plant as the percentage difference between the inputted energy sources, for example heat, and the outputted energy sources, for example electricity [48].

2. Renewable energies

A person may not receive the tax incentive for energy efficiency savings generated as a result of renewable sources. These renewable sources are listed as biomass, geothermal, hydro, ocean currents, solar, tidal waves or wind [22]. On 6 March 2014 SANEDI presented a “Section 12L of the Income Tax Act” tutorial at the Cape Town Commercial Sector Energy Efficiency Forum [50]. This presentation highlights if a renewable captive power plant energy conversion efficiency is greater than 35%, the energy efficiency savings can be claimed. Hence, the captive power plant rule can be seen as an exception for renewable sources. However, this contradicts to the Regulations and amended Regulations.

3. Concurrent benefits

The Regulation restricts the allowance to only EEIs that have been implemented in the Taxpayer's own capacity. EEIs that have received funds in the form of allowance, grants, cost recovery agreement or any other similar benefit from any sphere of government or any public entity as listed in Schedule 2 or 3 of the Public Finance Management Act, 1999 (Act No. 1 of 1999) is considered as a concurrent benefit. Any concurrent benefit located in the measurement boundary of the EEI must be ring-fenced and excluded from the calculations. The following are public entities which support energy efficiency [51]:

- Eskom (Demand-Side Management initiative)
- Industrial Development Corporation (Green Energy Efficiency Fund)

- Technology Innovation Agency
- Clean Energy Fund
- Independent Development Trust, etc.

4. Power purchase agreement

The Government Gazette No 32378 of 5 August 2009 defines a Power Purchase Agreement (PPA) as a contract between an Independent Power Producer (IPP) and a buyer for the purchase of electricity, electricity generation capacity and/or supplementary services. The IPP bid programme is the tender process in which a person can bid for additional generation capacity or supplementary services from IPPs [52]. The 6 March 2015 published Regulation stipulates energy efficiency savings due to any IPP bid programme or the purchase and/or sale of electricity between an IPP and a client will constitute as a concurrent benefit [48].

2.4 THE SECTION 12L EEI IMPACT CALCULATION METHODOLOGY

To ensure that the M&V team receive the necessary data and documentation to calculate the energy efficiency savings one should understand the calculation procedure. The Section 12L Regulation stipulates that an M&V team must quantify and inspect the Taxpayers EEI impact according to the SANS 50010:2011 Standard. The SANS 50010:2011 Standard process is based on the framework as outlined in the IPMVP Volume 1. Therefore this Standard methodology and relevant requirements must be specified.

2.4.1 SANS 50010:2011 FRAMEWORK

The main aim of the M&V methodology is to determine the scope and impact of the EEI. This methodology's main principles are to ensure the accuracy, transparency, traceability, relevancy and conservativeness of the data and documentation used to calculate the energy savings [53]. In Figure 8, the IPMVP basic M&V approach is shown.

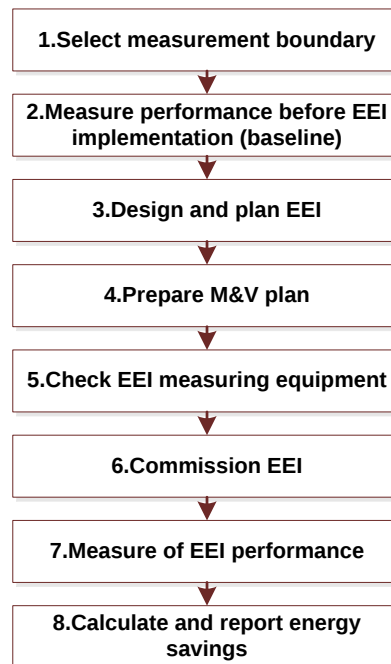


Figure 8: The M&V approach (adapted from [54])

Figure 8 shows that there are eight steps involved in the M&V approach. The M&V team will not necessarily be directly involved with the M&V methodology followed to implement the EEI. The M&V team however, should validate the process followed and calculate the baseline and energy savings with the data supplied.

The SANS 50010:2011 Standard provides a framework of requirements and considerations to aid this M&V approach. This framework will enforce the above-mentioned M&V principles. Figure 9 gives the outline of this framework. Refer to the assigned heading numbers for a discussion on each of the framework sections. The discussion will be based on the requirements of the Standard. However, the IPMVP Volume 1 principles and relevant literature regarding the subject area will also be discussed. Consequently, they will be directly referred to the “the Standard” or “SANS 50010:2011 Standard” if the requirements and/or definitions are Standard related.

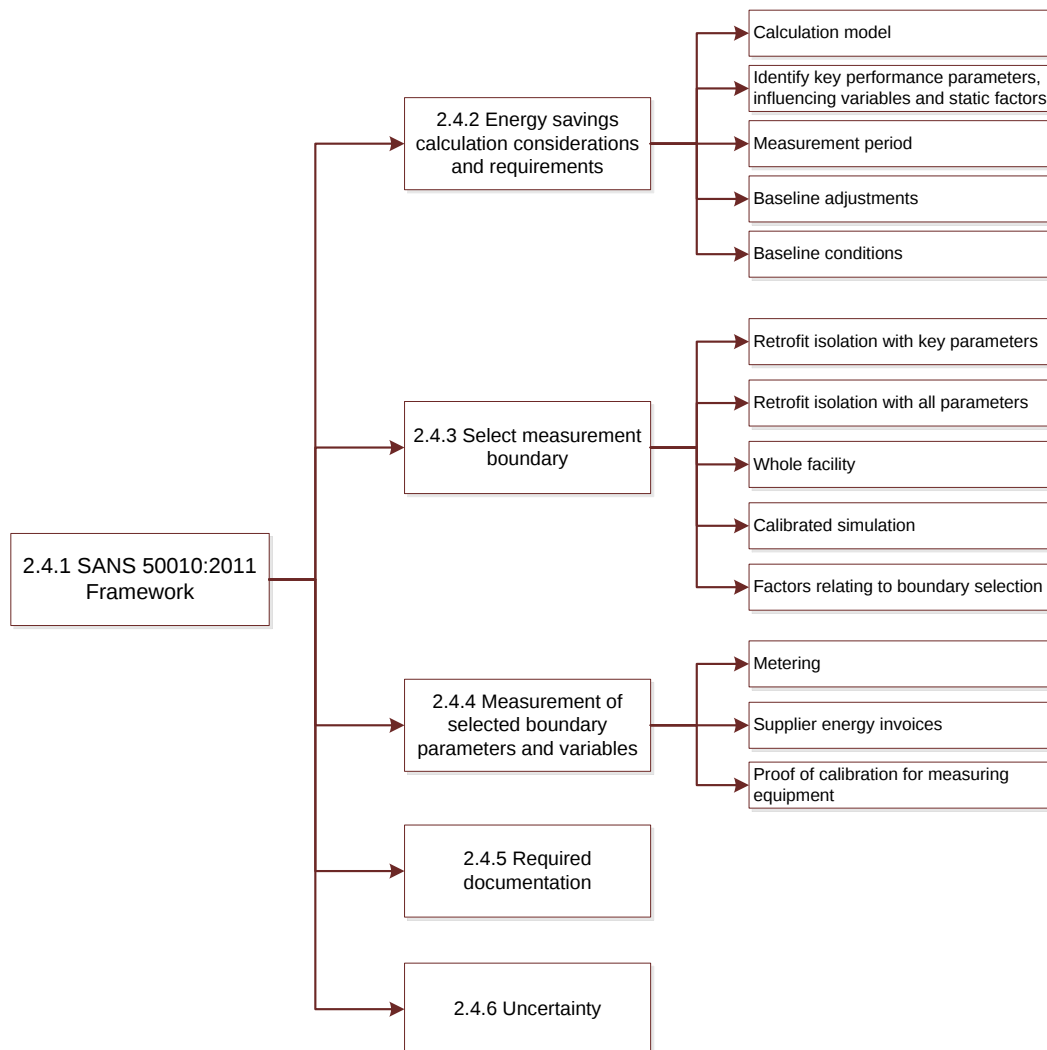


Figure 9: SANS 50010:2011 M&V requirements framework

2.4.2 ENERGY SAVINGS CALCULATION CONSIDERATIONS AND REQUIREMENTS

This section will outline the following requirements and considerations that will need to be taken into account when the energy savings is calculated.

i. Calculation model

The amount of energy carriers consumed per energy driver output is defined as operational energy intensity [26]. An EEI will reduce the consumption of the energy carriers while maintaining the same amount of energy driver output [8]. This indicates that the process has become more energy efficient, which results in operational energy intensity reduction and energy efficiency savings. In addition, operational energy intensity shows that the energy savings is due to the reduction in energy usage and not the result of energy driver output reduction. Figure 10 demonstrates this principle.

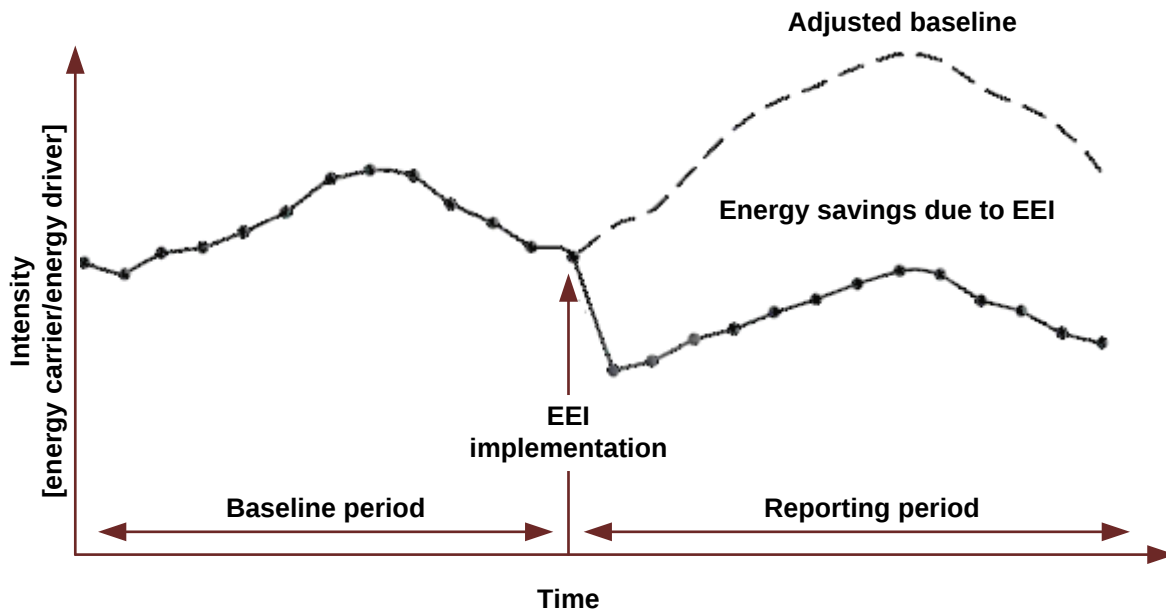


Figure 10: Determining energy savings (adapted from [23])

As is seen in Figure 10, the operational energy intensity is measured before the implementation of the EEI, hereafter referred to as the baseline period. The impact of the EEI is then determined by measuring the same operational energy intensity key performance parameters and influencing variables. This period of measurement is referred to as the reporting period. The difference between the baseline and the reporting periods is the energy savings. The Standard defines the energy saving as [23]:

$$E_s = B_{period} - R_{period} \pm A$$

Where, E_s is the energy savings, B_{period} is the baseline period, R_{period} is the reporting period and A is baseline adjustments. The baseline adjustments can be zero which means that the operational condition for both the baseline and the reporting period was unchanged. If the operational condition has changed within the baseline or the reporting period, the baseline should be adjusted accordingly. This change can be a result of influencing variables or a static factors[23].

Amundson T, *et al.* identified the following methodology to develop a regression based energy savings model to determine energy efficiency savings [55]. Figure 11 shows the key steps in the methodology. Step 1 and step 2 in Figure 11 are relevant to this dissertation.

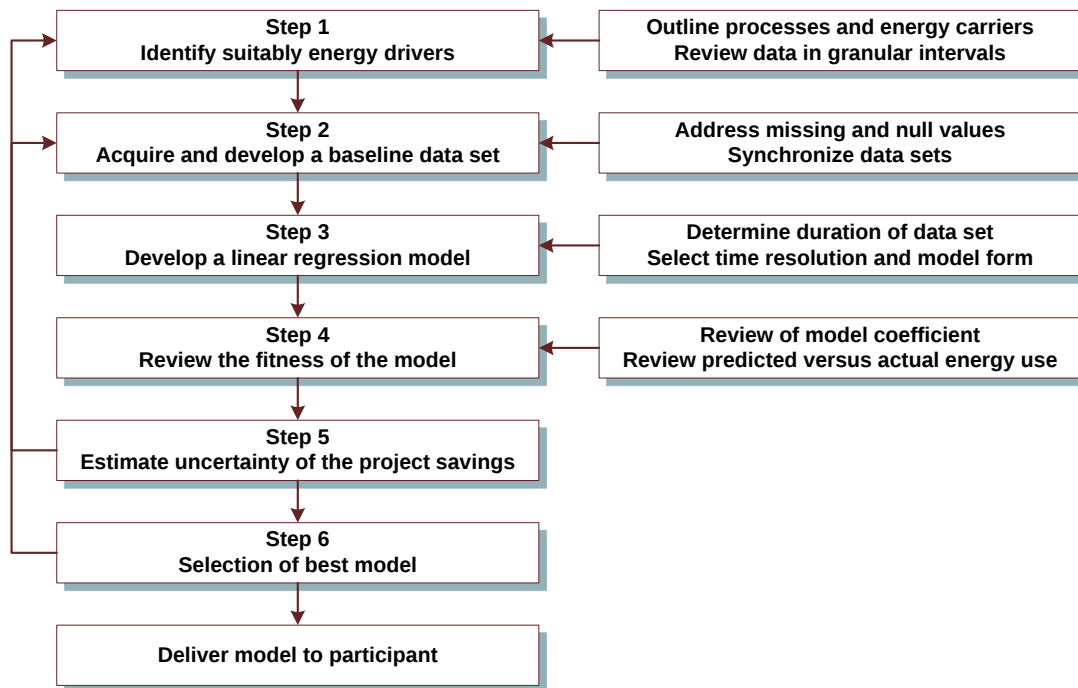


Figure 11: Key steps In Energy Model Development Process (adapted from [55])

The first step in Figure 11 methodology is to identify a potential energy driver with the precious metals, large amounts of waste material is extracted. This waste material is then gradually removed along the production flow. This adds to the difficulty to find a compliant energy driver measurement point that captures the operational energy intensity of the production flow [8].

To establish a baseline dataset, all the energy carriers will have to be in the same measurement unit. As above-mentioned, the mining industry can have multiple disparate data sources with different units of measurement. Hence, the data will need to be converted to the same unit to obtain a suitable dataset. The electrical energy consumed over a period is expressed in kWh [56]. The kWh is an energy unit and is equal to 3.6 MJ. The amount of energy produced due to the combustion of fuels, like coal and diesel, is expressed by the fuels CV. This unit of energy is expressed as the energy produced per amount of fuel combusted or MJ/kg. Therefore, multiplying fuel consumption (kg) with the CV will produce an energy equivalent value (MJ) [56].

ii. Identify key performance parameters, influencing variable and static factors

Different types of data will need to be measured or estimated. The data will then be applied to the savings equation. The data types are defined in the context of this dissertation as follows:

- *Key performance parameters*: These parameters have a direct relation to determining the impact of the EEI. The parameters will be measured or estimated within the measurement boundary which will include the energy usage, energy driver outputs, power factor, etc.
- *Influencing variables*: These are variables that will cause routine and expected changes in the energy usage. The variables can be operational or environmental. It is important that these variables are also measured and evaluated.
- *Static factors*: are defined as influencing variables that remain the same throughout the baseline and the reporting periods for example facility size, personnel occupancy, independent equipment specification, number or working hours, etc.

In Step 1 of the Amundson T, *et al.* methodology, a visual method was used to identify key performance parameters (energy drivers and energy flows) [55]. The result of this method is shown in Figure 12. A holistic perspective is shown when identifying the energy carriers' and energy drivers' measurement points on the production flow. This approach can assist in identifying the necessary measurement points for the EEI impact.

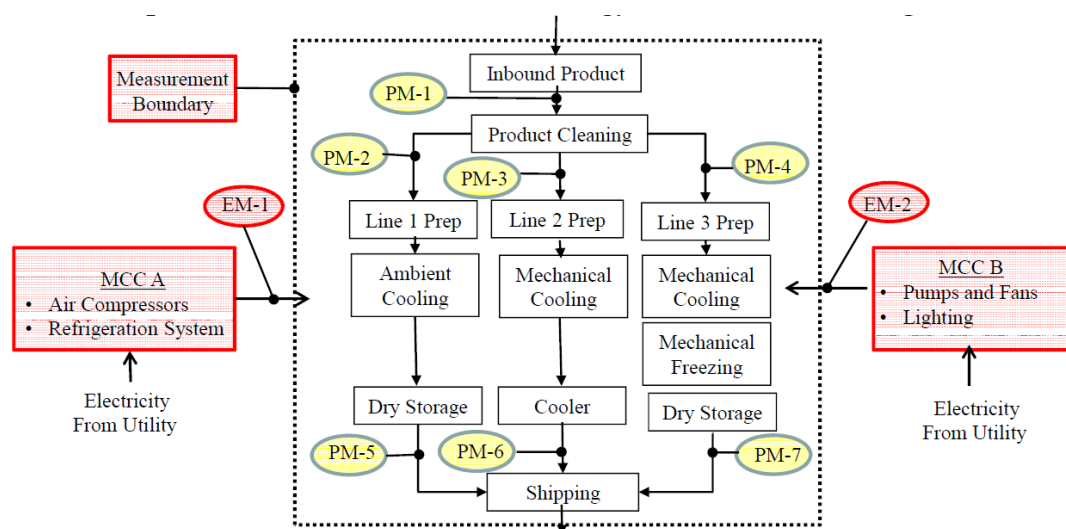


Figure 12: Visual method to identify energy drivers and energy carriers (from [55])

iii. Measurement period

The Standard does not specify an exact time frame for the measurement period. Instead the measurement period must be established to comply with the following requirements [23]:

- Under normal operations within the time frame of the measurement period, the maximum and minimum energy usage of the operation facility should be seen
- The measurement period should be in a normal operational cycle
- Should only be when the influencing variables are known and the period is fixed
- The baseline period selected should preferably be the time immediately before the EEI implementation, therefore it will be representative of the impact

The Section 12L Regulations however, requires that the assessment period be 12 consecutive months of measurement. The selected 12 months should still be in accordance with the Standard's methodology. The first year of assessment will be the following year's baseline. This will encourage the continuous implementation of EEIs for energy efficiency savings [22].

iv. Baseline adjustments

The Standard specifies two types of baseline adjustments namely [23]:

- *Routine adjustments* will be adjusting the baseline and/or the reporting period according to the influencing variables pattern and cyclical changes. These changes include yearly scheduled maintenance, seasonal changes, etc.
- *Non-routine adjustments* are when the static factors change unexpectedly. Examples are facility size increase or decrease, unexpected plant shutdowns, facility occupancy due to labour action, etc. The Standard specifies that the non-routine static factors must also be measured for the same measurement period if a whole facility approach is taken.

v. Baseline conditions

The operational conditions surrounding the baseline measurement and/or estimation period must be recorded and stored. The Standard specifies that the following must be included in the baseline documentation [23]:

- The selected baseline measurement period
- The energy carriers usage and energy driver outputs
- Influencing variables
- Static factors impact
- The operational conditions of the facility, other than the influencing variables

- The baseline condition that does not comply with the Standard requirements
- The baseline adjustments necessary

2.4.3 MEASUREMENT BOUNDARY SELECTION

Within the M&V methodology it is necessary to firstly identify a measurement boundary for the quantification of the EEI. This is to determine which parameters and variables need to be measured for the calculation. However, with the mandatory Section 12L requirements regarding data accuracy principles, supporting documentation requirements and concurrent/limitation projects, it will be necessary to first identify measurement points that are compliant before selecting the measurement boundary. The SANS 50010:2011 Standard measurement boundary selection process is based on the IPMVP Volume 1 principles. Examples of governments, organisations and businesses that have also adopted the IPMVP measurement boundary selection principles in their M&V methodology are,

- The Government of New South Wales - Measurement and Verification Operational Guide
- US Department of Energy - M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 3.0
- CEATI International – Energy Savings Measurement Guide following the IPMVP
- International Partnership for Energy Efficiency Cooperation (IPEEC) Clean Energy Ministerial - Measurement & Verification Process for the Calculation and Reporting on Energy and Demand Performance – General Guidance
- Eskom – The Measurement and Verification Guidelines for Energy Efficiency and Demand-Side Management (EEDSM) Projects and Programmes

All these documents, processes and the Standard identify four types of measurement boundaries that can be selected. Each of these measurement boundaries will be discussed in more detail in the following sections.

i. Retrofit isolation, key-parameter measurement

With this boundary, the EEI is isolated from the rest of the facility. The energy efficiency savings is calculated by identifying the key performance parameters that will influence the savings calculations. The same parameters must be measured for both the baseline and assessment periods. Energy usage influencing variables can be estimated by using historical data, laboratory tests, equipment manufacturing specifications and engineering judgement.

However, these estimated values can only be used if the probable error of the combined impact of these estimates will have no significant impact on the overall savings calculations. This error impact can be calculated by mathematical modelling of engineering calculations. If a variable can only be measured in either the baseline or the assessment periods, this variable must be handled as an estimate. When selecting the key parameters and identifying which variable must be estimated, one should consider the contribution of each of the parameters and variable will have on the uncertainty of the savings calculations.

ii. Retrofit isolation, all-parameter measurement

The savings calculation requires the measuring of all parameters which determines the energy usage of the equipment in the retrofitted isolation. The variables that influence the energy usage within the measurement boundary must also be measured and not estimated. This option has a greater level of certainty in the saving calculations as the above mentioned option.

iii. Whole facility

The measurement boundary is drawn around the entire facility or sub-facility level. The energy performance of the entire facility are assets for the savings calculations. This option utilises the facilities existing utility and auxiliaries' meters. Energy invoices billed consumption amounts can be used with this option. The whole facility measurement boundary option is ideal when long assessment periods and continuous monitoring of energy savings is required. The challenge with this boundary is to identify and determine the impact of routine and non-routine adjustments.

iv. Calibrated simulation

When important data is missing or not available for extended periods, a calibration simulation approach can be used to predict the energy saving that would have been achieved. The calibrated simulation approach makes use of computer software to develop predictive simulation models. These models must predict the energy usage pattern and energy driver

output of the equipment and/or facility in question. A number of estimates are made with this option. The accuracy of the simulation models are determined by comparing the simulation model output with relevant calibrated measured data. The error difference evaluation result can be used to adjust the input variables. This process can be repeated until the error difference variance between model and the actual data are acceptable.

v. Factors relating to boundary selection

A number of factors must be taken into consideration when selecting a measurement boundary. The flow diagram in Figure 13 below shows these factors. All these factors will need to be considered when selecting a measurement boundary to quantify the EEI impact.

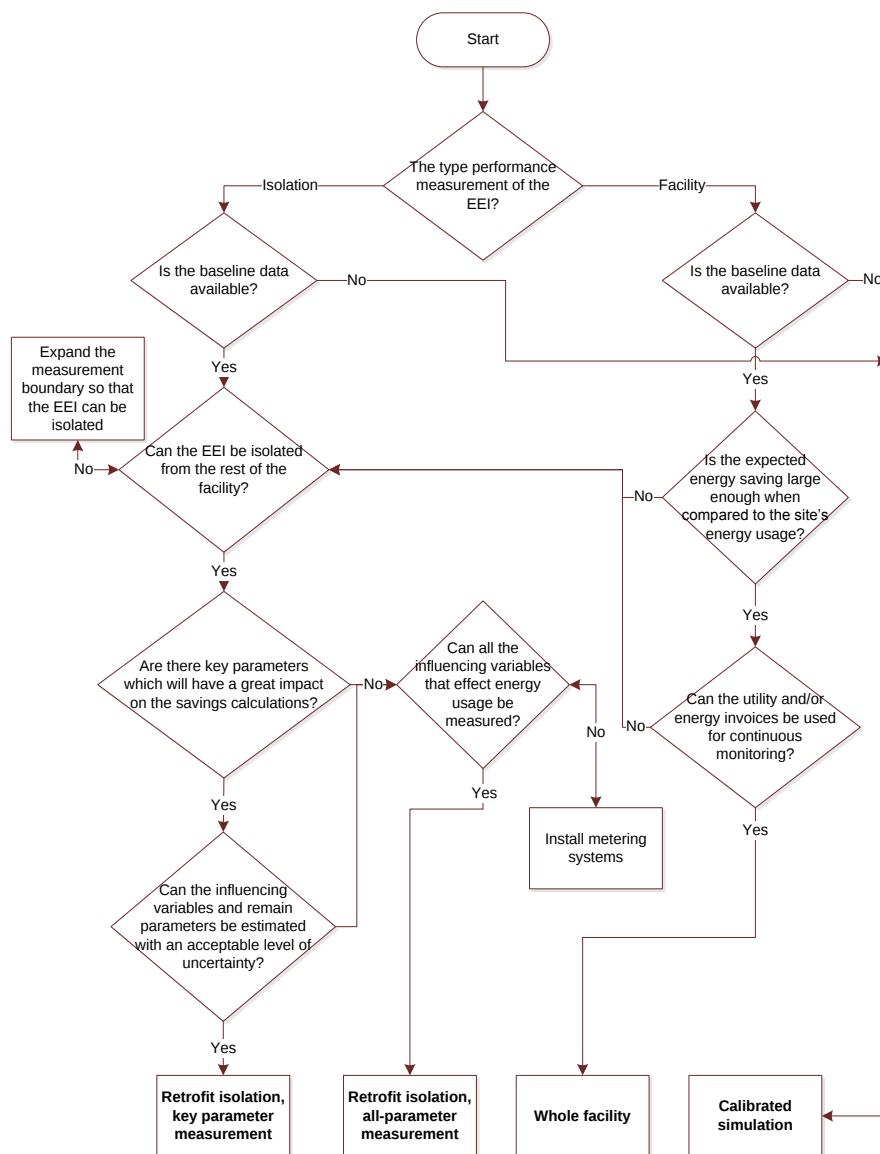


Figure 13: Factors relating to measurement boundary selection (adapted from [57])

2.4.4 MEASURING PARAMETERS AND VARIABLES WITHIN SELECTED BOUNDARY

After the measurement boundary has been selected the key parameters, influencing variables and static factors should be measured and/or monitored. The Standard has the following requirements regarding the monitoring and metering of these parameter, variable and factors.

i. Metering

Each of the discussed measurement boundaries will have performance parameters and influencing variables that will have to be measured or estimated. The SANS 50010:2011 Standard stipulates a number of measurement specifications. One or more of these specifications are applicable depending on the selected measurement boundary. These specification are as follow [23]:

- The measurement period can either be continuous or short periodical intervals
- All the parameters and variables must be measured separately. The measured data can be combined within the modelling phase of the quantification process
- Utility and production meters can be installed to isolate the EEI from the rest of the facility
- The consumption data from energy supplier invoices can be used to quantify the EEI energy usage impact. All the equipment and meters used to measure the relevant data should have proof of calibration

The Standard further specifies the following when energy supplier invoices and/or measurement equipment is used.

ii. Supplier energy invoices

The Standard specifies that the energy supplier invoice consumption data must be based on direct consumption measurements, for example power meter data. In the case of energy carriers that are stored or stockpiled on-site such as coal, petroleum products and natural gas calibrated measurement equipment must be used [23].

iii. Proof of calibration for measurement equipment

To ensure the accuracy of the data used for the saving calculations, the measurement equipment or programme must be calibrated. The recommended equipment manufacturing calibration process must be followed. This recommended process, where applicable, must conform to recognised national and international calibration measurement authorities standards. The Standard stresses the issues of accurate measurement equipment selection [23].

2.4.5 DOCUMENTATION REQUIREMENTS

With the inspection of the EEI, the Standard requires that the following documentation be available on requested [23]:

- The EEI scope
- The measurement data used to develop the baseline model
- Identification and locations of the measurement point and equipment used
- The methodology and equations applied
- The reported savings

2.4.6 UNCERTAINTY

The reported savings must be conservative. The SANS 50010:2011 Standard does not require that the exact impact of uncertainty be quantified. The uncertainty should be managed and taken into account in the accurate measurements or the M&V process. Additionally, uncertainty cannot be justified by lowering the energy savings amount. In the context of the Standard this is defined as invalidating the results [23]. According to the Standard, the management of uncertainty should include:

- All measured and estimated values
- Both the baseline and the reporting period energy usage
- The considerations of influencing variables
- Methodology chosen
- The impact of interactive effects

The Standard defines interactive effects as the activities that take place outside of the measurement boundary that can have a direct impact of the activities inside the measurement boundary [23].

2.4.7 ENSURE COMPLIANCE

The data and documentation collected must conform to the outlined requirements of both the Section 12L Regulation and the SANS 50010:2011 Standard. A quality management system is a type of business process that will be developed to ensure that the end product or process meets the “client’s” specifications [58].

There are a number of quality management systems approaches available today which include, Total Quality Management (TQM), Six Sigma, Zero Defect, ISO 9000 series of standards, Malcolm Baldrige National Quality Award, Continuous Quality Improvement (CQI), etc.[59]. The Six Sigma methodology has been applied to many types of industries to analyse and improve energy management [60]–[64]. Mowris, R *et.al* 2006 and Mowris, R *et.al* 2007 developed methodologies which incorporated both Six Sigma and the IPMVP approaches to improve energy efficiency programmes and standards [65], [66]. Therefore this methodology will be discussed in more detail.

The Six Sigma approach is a structured methodology that seeks to improve process outputs by reducing the measuring defects. This approach will focus on identifying the main cause of these measuring defects and minimise the variation variability within the business process [60], [67]. There are two viewpoints on the application of Six Sigma namely statistical and business [68]. The statistical viewpoint focuses on determining the number of defects per million opportunities. The Sigma will represent the variations around the process average. In the world of business, the Six Sigma focuses on customer satisfaction. It is a business strategy which will increase the effectiveness of all operations to meet the needs and requirements of the customer [69].

The main techniques and strategies for this approach is based on two models namely the Define, Measure, Analyse, Improve and Control (DMAIC) process and the Design for Six Sigma (DFSS) methodology [68]. The DMAIC process is a problem-solving closed-loop methodology which identifies and eliminates unproductive process steps for continued improvement [60][67]. Table 1 demonstrates the key process associated with each of the process steps.

Table 1: Key steps in Six Sigma DMAIC process [68], [70]

DMAIC process	Key process actions
<i>Define</i>	- Understand the business process by mapping the business flow - Define the customer requirements for the process or product - The system boundary needs to be identified and understood
<i>Measure</i>	- Identify measuring system and develop data collection plan - Measure the customer satisfaction need within the process - Collect the data and compare
<i>Analyse</i>	- Analyse compared data and determine cause of defects - Identify source variation in the process - Determine the business process steps that are value/non-value adding
<i>Improve</i>	- Develop and implement enhancement/solution plan - Eliminate the source variations - Improve the process
<i>Control</i>	- Develop control systems to satisfy customer requirements - Implement control strategy - Monitor system control

The DFSS methodology, also known as the Define, Measure, Analyse, Design and Verify (DMADV) approach, focuses on new product and process design to meet customer needs. In the early stages of design the DFSS technique should predict design quality outset which complies with the customer's requirements. This will then drive quality measures and predict improvements throughout the whole design [71]. Table 2 identifies the key action within this approach.

Table 2: Key steps in Six Sigma DMADV process [71]

DMADV approach	Key process actions
<i>Define</i>	Define design problem and establish resources available
<i>Measure</i>	Determine the key customer requirements
<i>Analyse</i>	Select the best design
<i>Design</i>	Detail design that meets the manufacturing and functional design requirements
<i>Verify</i>	Ensure that the design can be manufactured and conforms to the outlined quality, reliability and cost requirements

2.5 DATA ORGANISATION AND STRUCTURING

Industry will have to make the data and supporting documentation available for the M&V team to conduct their inspection and calculate the EEI impact, see Figure 7. This data can have multiple sources and data formats. It is therefore necessary to develop a folder hierarchy for the electronic storage of all these files. All the collected data will need to be processed into the same unit for the EEI calculations. A database table can be used for this purpose.

i. Folder hierarchy

The data and documentation collected will be in a combination of hard copy files and electronic data files. The hard copy files can be scanned to create electronic copies. The electronic files will need to be stored on a central server. However, an organisational structure will need to be developed to make the data and documentation easily accessible and traceable. A simple folder hierarchy can be used to organise the data. As illustrated in Figure 14, a folder hierarchy forms a tree structure. The files will be organised into folders and sub-folders.

It is not always the case that the folder hierarchy will have two levels before file storage. Whittaker, S *et al.* identified two types of folder hierarchies namely broad and shallow or deep and narrow [72]. A broad and shallow hierarchy will allow the user faster access to the required files, however, the time to find the correct folder increases. The deep and narrow option allows for a faster folder finding time, but the user will need to access more folders to find a file. Whittaker, S *et al.* concludes that the researched group tended to use a wide and shallow approach to folder structuring [72]. Jones, W *et al.* noted that the folder structure is also a source of information pertaining to the understanding of the content of the sources files. However, they identified the following limitations to folder hierarchies [73]:

- Folders can hide or obscure information within the structure
- A folder hierarchy is restrictive, the file can have multiple informative properties

As is seen from Figure 15 a database table has three main properties. A record will be related to a specific entity's information. The database table record entry will consist out of a number of fields. Each of these fields is related to an independent property of the specific entity information. The database table label identifies the different field's independent properties. There are mainly two database types, namely flat-file and relational [74].

A flat-file database is simply a single database table which can have an unlimited number of fields and records. A good example is a Microsoft Excel spreadsheet. A relational database will consist out of multiple database tables that are linked together. This type of database is ideal for multiple record entries that need to be changed or altered, for example a female employee is married and changes her surname. With a relational database this change will only need to be made once in the information table. This record change will when be automaticity changed within other tables that are linked to this specific table [74].

2.6 CONCLUSION

Decreasing ore grade is one of the main contributors to the gold and platinum mining complexity. The ore composition and content have a significant impacted on the downstream metallurgy and production, resulting in mid-production material being shifted between facilities to ensure that the product impurities do not exceed critical equipment specifications. Mid-production material can also be obtained from external parties and the re-processing of old mining waste, therefore adding to the complexity of quantifying operational energy intensity to accurately calculate the impacted of the EEI.

The metallurgy and production complexity is also extended to the energy sources supply chain. Mining companies make use of commercial energy sources like electricity, coal, petroleum products and natural gas. Due to equipment requirements, these sources' supplies are in most cases restricted to one supplier which supplies multiple facilities. A compliant means of measurement is energy supplier invoices consequently multiple facilities can be billed with one invoice. This makes it difficult to isolate the EEI impact.

To reduce the complexity of the mining operation, the top-level SADT methodology will be used which uses an activity box to represent a facility. This activity box will be representative

of the entire facility only focusing on the energy inputs which are converted into production outputs.

Section 12L of the Income Tax Act, 1962 specifies that to obtain the tax deduction the Taxpayer must obtain a tax certificate. The published Regulations specified that SANEDI is responsible for the facilitation of process of obtaining this tax certificate. The SANEDI application process requires that a SANAS accredited M&V professionals compile an energy efficiency savings report. The calculation methodology followed within the report should comply with the SANS 50010:2011 framework of recommendations and requirements. The principles of the Six Sigma quality assurance methodology will be used to ensure that the final dataset shared with the M&V team are Standard compliant.

The energy efficiency savings achieved by captive power plants with a less than 35% energy conversion, renewable energy sources, government funded energy efficiency projects and IPP bid programme tenders are limited by the Section 12L Regulations. Hence, these projects will need to be identified and excluded from the calculations.

High volumes of energy data and supporting documentations will be generated and obtained to justify the data used for calculations. A wide and shallow folder hierarchy will be used store and organise all of these files. The energy data received will not necessarily be in the same unit of measurement. Hence, the average CV needs to be used to normalise all the energy data to the same unit of measurement. A flat-file database table can be used to structure the file dataset for calculations.

Chapter 3

METHODOLOGY

3 DEVELOPMENT OF METHODOLOGY

3.1 INTRODUCTION

The objective of this chapter is to develop a methodology to assist industry to reduce system complexity, identify Section 12L compliant measurement points, select a measurement boundary and then collect, organise and process the necessary data and supporting documents for the M&V team to quantify the EEI impact. The methodology should not taint the independency of the M&V team auditing process.

In Chapter 2 the process and requirements for a successful Section 12L tax application was explained. The methodology developed should facilitate the M&V team basic approach to conform to the Section 12L Law, promulgate Regulations and the SANS 50010:2011 Standard. However, the methodology will only focus on industries' responsibility to construct a traceable, transparent and compliant key performance parameters folder structure and processed database that can be used by the M&V team to calculate the EEI impact. Figure 16 outlines the structured approach that will be undertaken to build a Standard compliant flat-file database.

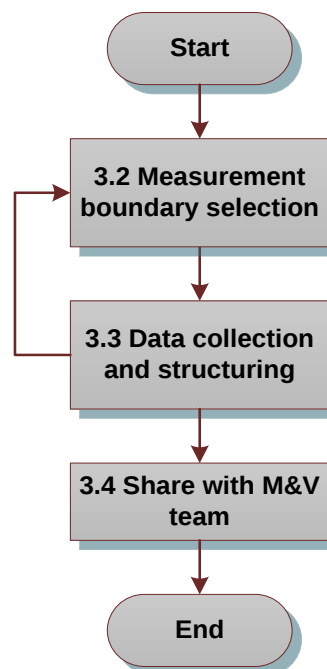


Figure 16: Overview of structured methodology

It can be seen from Figure 16 that a process approach together with a structural analysis principle will be used to develop the methodology. Mining operations have extensive components within its operations. The regional vastness and the complexity of the material handling between the operational facilities make it necessary to firstly identify Section 12L compliant boundaries before embarking on the data collection and structuring. After the final measurement boundary has been selected the necessary data and supporting documentation can be collected and structured in the database.

3.2 MEASUREMENT BOUNDARY SELECTION

The Six Sigma DMAIC and DFSS models use five words to describe the action that needs to take place with each step of the process. Figure 17 indicates the necessary actions to follow when in the process of selecting a measurement boundary. These steps are based on the Six Sigma DMAIC and DFSS model principles and will ensure that the measurement boundary conforms to the Standard requirements.

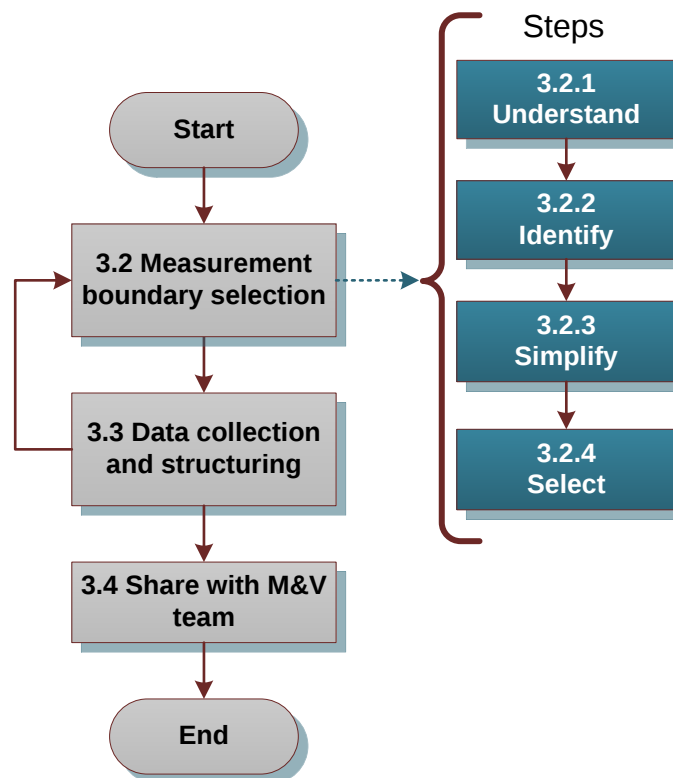


Figure 17: Measurement boundary selection framework

As is seen in the figure above, the measurement boundary selection process consist of four steps namely 3.2.1 Understand, 3.2.2 Identify, 3.2.3 Simplify and 3.2.4 Select. Each of the step's processes will be discussed in more detail below.

3.2.1 UNDERSTAND

The first step is to understand the operations of the mining company. The investigation includes a basic production flow of the mine. This diagram must indicate all the facilities involved in mining production. The facilities can be based in the same region or different regions. In South African gold and platinum mining industries, the mining facilities that are in the same region fall under one mining business unit. Each business unit's operational boundaries must be indicated on the diagram. Facilities should be indicated if external companies, for example joint ventures, are part of the mining production flow and/or share in the energy supply chain.

As explained in Chapter 2, each type of mining facility has a set energy driver and energy carrier. The energy drivers for each stage of production should be indicated after each operational facility. Each production stage facility will have specific associated energy carriers. These energy carriers can also be collectively indicated on the production flow. Figure 18 illustrates a simple example.

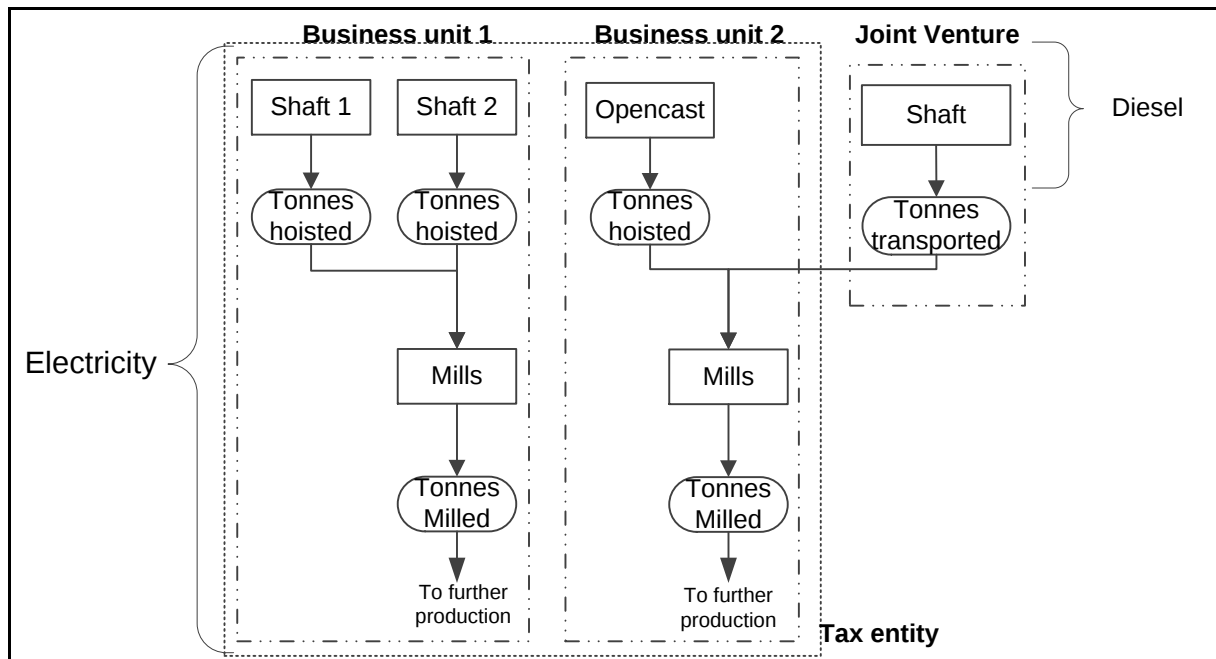


Figure 18: Understand - Mining operations production flow

3.2.2 IDENTIFY

As with the SADT approach, each production facility will be seen as a high-level activity box with input and outputs. The user is required to identify the incoming energy carriers and the outgoing energy drivers' measurement points. As specified in Chapter 2, an alternative to energy carrier metering equipment is supplier invoices. Energy suppliers can supply multiple Points of Deliveries (PoDs) to a mining business unit. These PoDs will not necessarily be dedicated to a specific mining facility. A mining facility can be supplied by several or more PoDs. Therefore it is necessary for the company to indicate all the facilities that are included in the supplier invoice. Figure 19 illustrates how the invoice boundaries and measurement instruments need to be indicated on the layout.

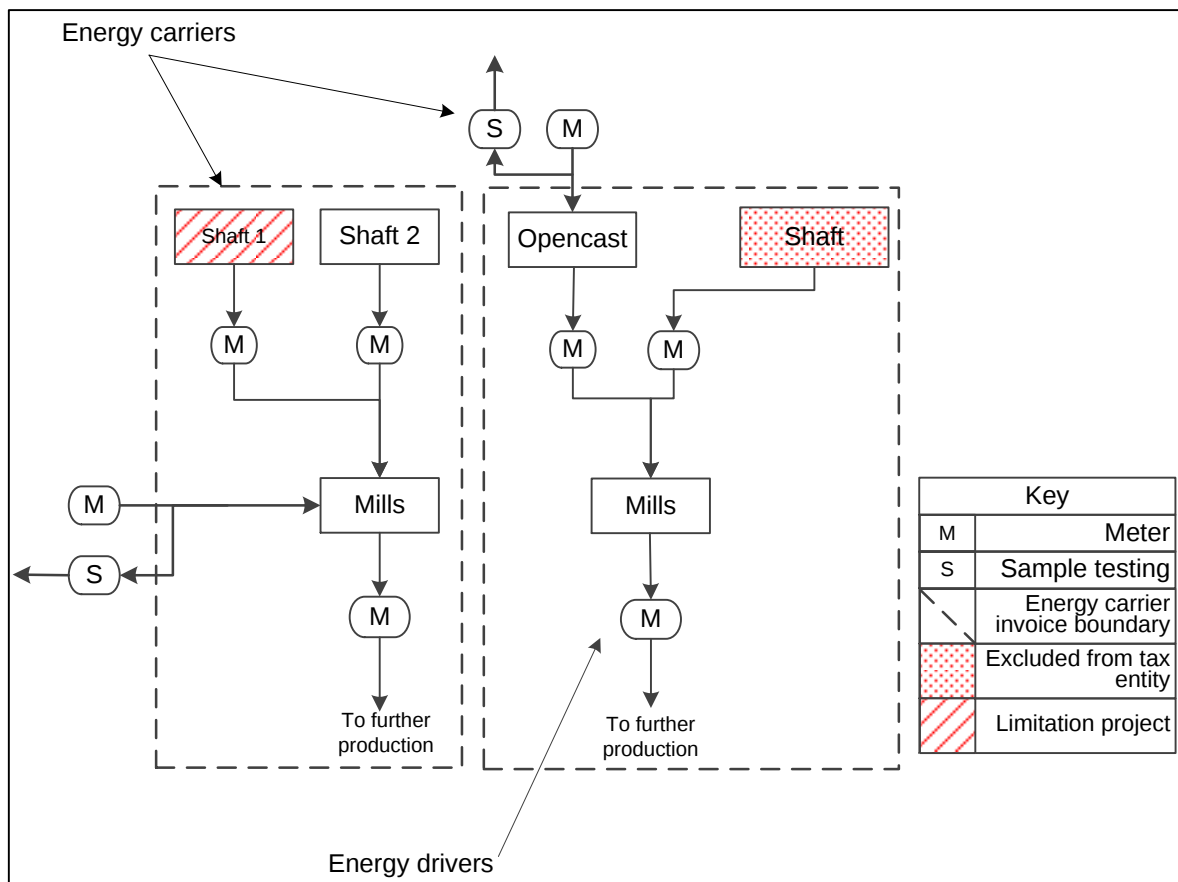


Figure 19: Identify - Measurement points identification

As can be seen in Figure 19, the limited EEI projects should be identified and indicated on the mine production flow because these projects can give a false indication of possible energy efficiency savings, especially when the measurement boundary is a whole facility approach. The sample testing measurement points shown in Figure 19 is to determine the energy content (CV) of the energy carriers.

3.2.3 SIMPLIFY

The key to this step is to simplify the complexity of the production flow, while not losing vital information. The Standard requires that the measurement of variables should be either calibrated measurement instrumentation or supplier invoices. Metering instrumentation compliance should be shown on the mining production flow. Compliance indication can be at three different levels namely;

1. **Not available** – There is not sufficient information available for the measurement point

2. **Available** – The measurement points indicate data available, but the data compliance is difficult or not known
3. **Compliant** – The data available has sufficient supporting documentation to ensure the data accuracy

A top-to-bottom approach should be followed with the compliance starting with the first objective of mining facilities (ore extraction). The compliance should be indicated until a compliant point is found in the individual business units. Figure 20 shows how compliance can be indicated on the production flow.

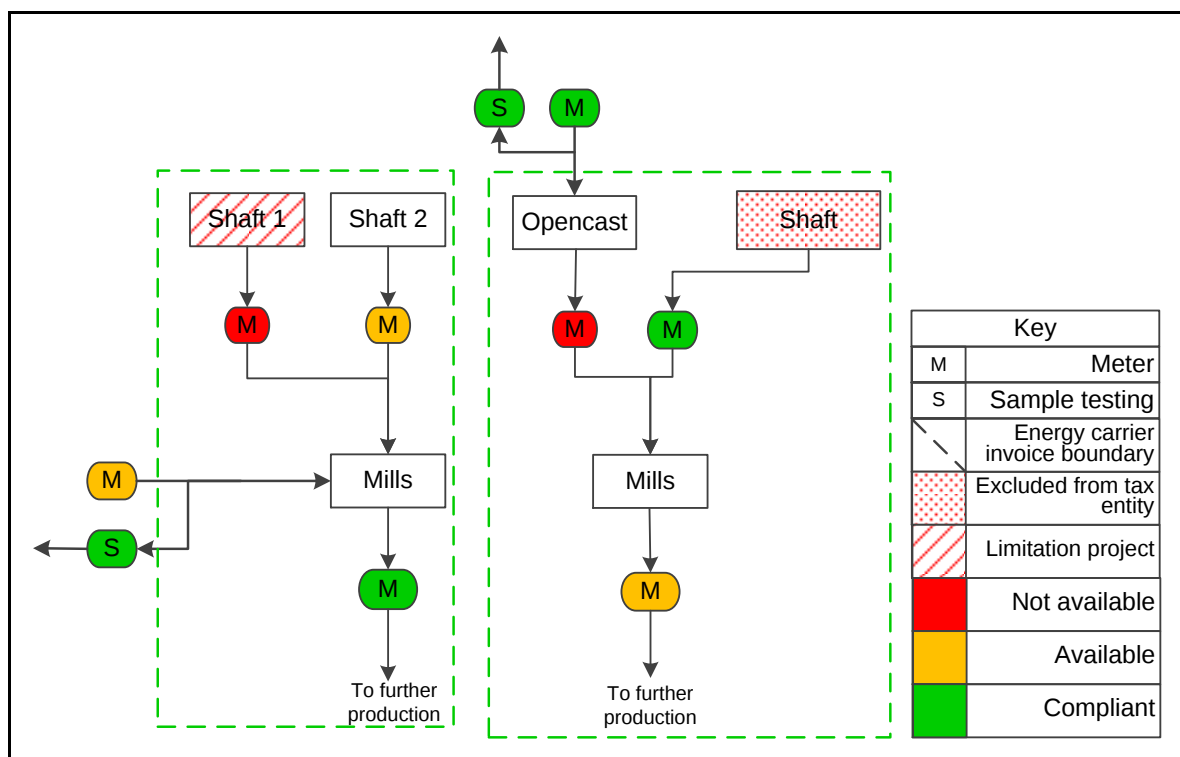


Figure 20: Simplify - Indicate measurement point compliance

3.2.4 SELECT

After the meter compliance is indicated, the user can start to identify possible measurement boundaries. Section 12L tax deduction can only be claimed for energy efficiency savings. It is therefore necessary to determine where EEI was implemented. There are many types of EEI that can be implemented on mining facilities. These interventions can range from major infrastructure projects to energy management programmes. These interventions can then be indicated on the mining layout diagram, seen in Figure 21. After all the necessary

information has been shown on the mining production flow, the user can decide on the final measurement boundary, see Section 2.4.3.

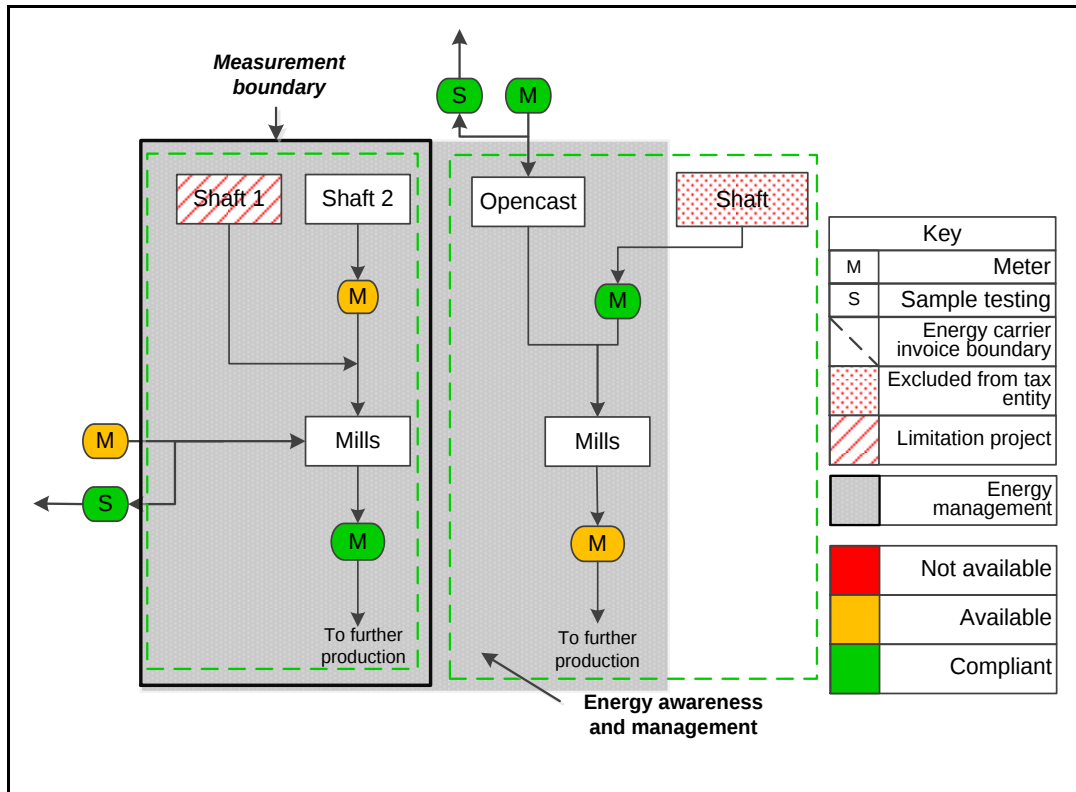


Figure 21: Select - Energy usage intervention indication

3.3 DATA COLLECTION AND STRUCTURING

When the measurement boundary is selected, each of the measurement point's relevant data and documentation must be collected. This data and documentation will then be shared with the M&V team. It is therefore necessary to develop a methodology to structure the data and documentation. The methodology should also ensure that the data and documentation is traceable and comprehensible for the M&V team.

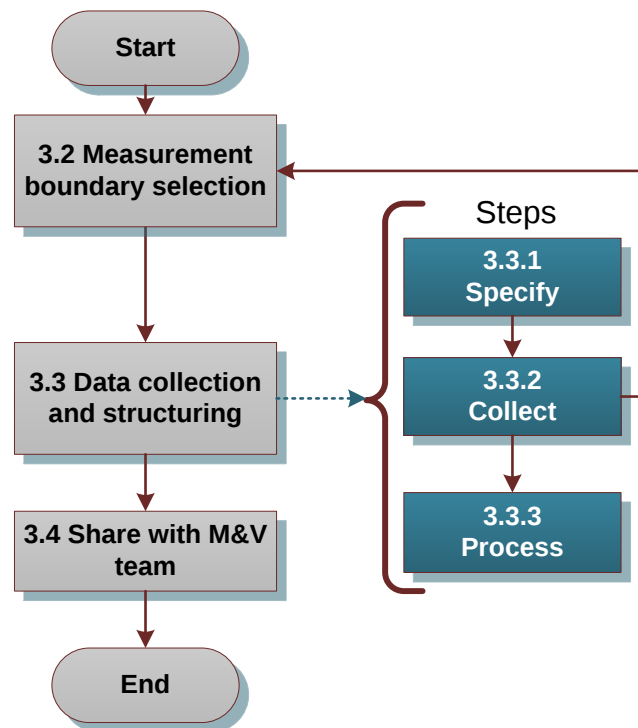


Figure 22: Data collection and structuring process

Figure 22 illustrates the three steps to be developed in the methodology. The first step is to specify the selected measurement boundary points of measurement. If there are limitation projects located within the boundary, the entire methodology will have to be applied on these projects individually. Within the collective steps, the specific summary will be used to only extract the necessary data and documentation.

This data and documentation will first undergo data testing and then structuring. This will ensure the integrity and traceability of the raw data and documentation. Some degree of processing will be required before the energy efficiency savings can be calculated. The final processed data will be structured in an equivalent energy table.

3.3.1 SPECIFY

Within the measurement boundary phase only high-level details regarding the measurement points and boundaries were indicated. A table summary should be constructed to specify the details that were obtained and indicated on the measurement boundary. This table can be used throughout the data collection process to ensure that all

the relevant data and supporting documentation has been collected. Figure 23 gives an illustration of a selected measurement boundary.

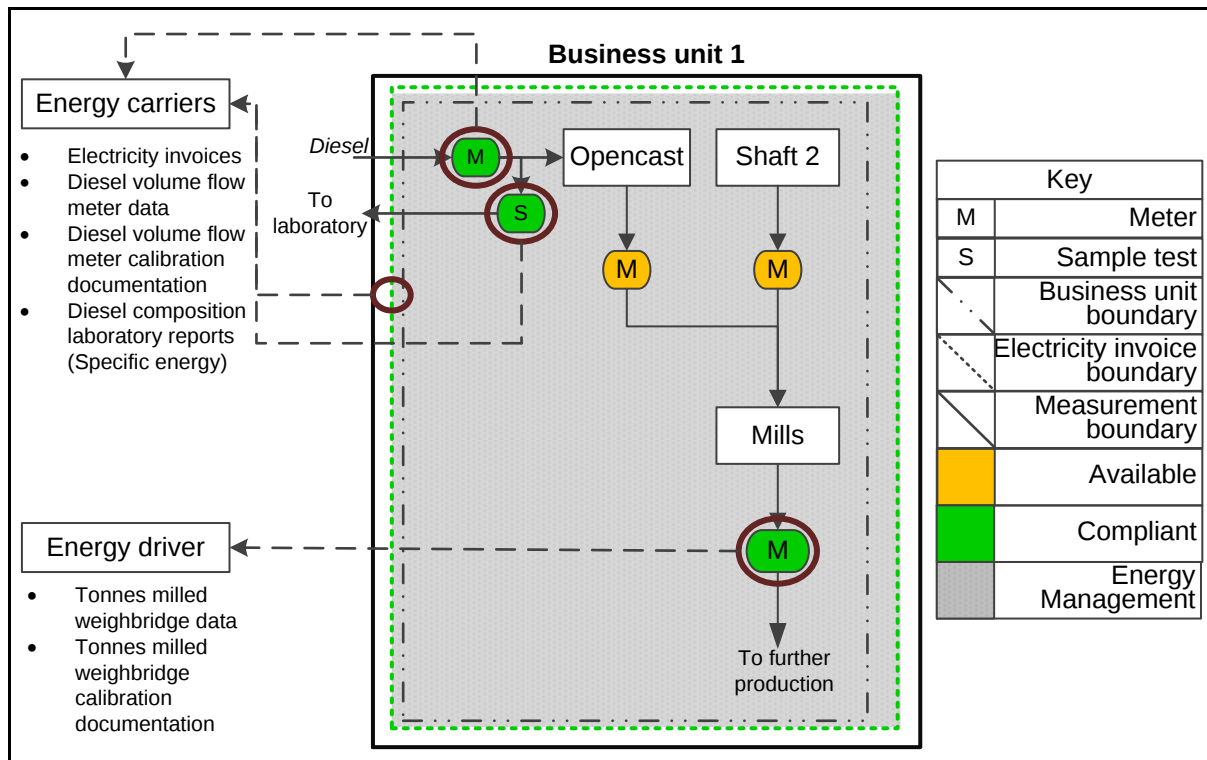


Figure 23: Specify - Measurement boundary summary

In terms of the figure above, the table should list the measurement point's energy group, meter type and necessary supporting documentation required. Energy supplier invoices which were relevant should also be specified. Only the energy driver measurement points chosen to represent the production process need to be summarised.

3.3.2 COLLECT

There can be numerous data sources where raw data and supporting documentation can be collected. The collection process will have to be done in a systematic fashion to ensure the traceability. Figure 24 shows the flow of the collection process. The relevant data and documentation is collected with the measurement boundary summary, before continuing to organising the information in a structure.

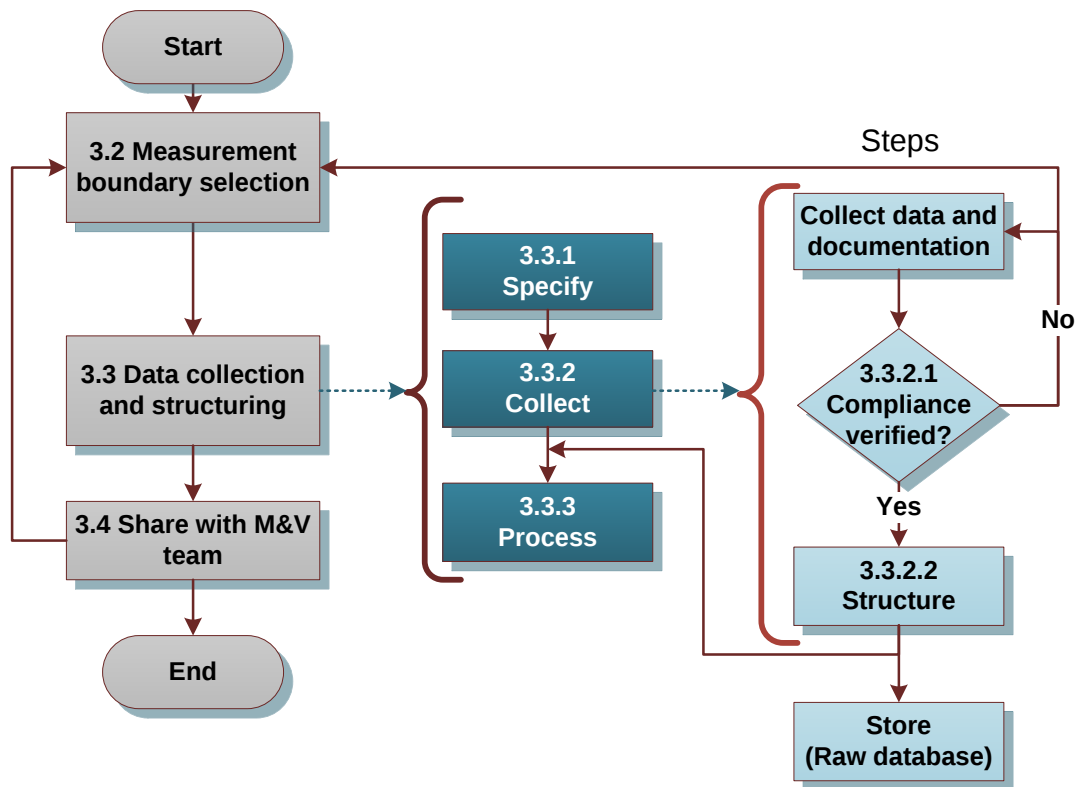


Figure 24: Collect - Data collection and structuring

Figure 24 shows that the data should first be tested for compliance and quality. The compliance testing should only ensure that all the supporting documentation was collected. However, if the data and documentation fails this testing, a new measurement point will have to be identified. This can lead to the selection of a new boundary.

If it is found that the data is compliant, quality³ testing can be done. This is done by comparing two independent data sources that contain the same relevant data. The data and documentation will then be added to a traceable structured database. There it will be used for processing and stored for the M&V team.

³ Data quality refers to if the data is “fit for use”. This will include ensuring that the data is relevant, complete, error-free and representative. [75]

Compliance verification

It is good practice to have a dataset of acceptable quality. After all the data and supporting documentation has been collected, data quality checks can be done. For the data, these checks should include error warnings identification, correct tag names, continuous period interval, etc. The supporting documentation validity should be ensured in the quality checks. This will include checking the expiration date, the error percentages, meter numbers, account numbers etc. Poor data accuracy, quality and integrity can have a significant impact on the energy efficiency savings calculations [75].

The SANS 50010 Standard emphasises data accuracy within its requirements. Consequently, if the data is compliant with the Standard, the data accuracy is assured. Data integrity⁴ however, will need to be verified within the context of the methodology. This can be done by comparing two independent data sources which contains the same relevant measurements. An example of this type of verification is comparing standard compliant Eskom bills with the company's internal electricity metering system.

Structure

When data confidence is assured, the data and documentation can be structured. It is important that the structure displays the data and documentation in a transparent and straightforward manner. A hierarchy folder structure will be used to develop the storage location. Figure 25 gives a breakdown of the structuring approach.

⁴ Data integrity is the prevention of unauthorised alterations to data. These alterations can occur when data is retrieved and stored or when the data is transferred from one format to another. [76][77]

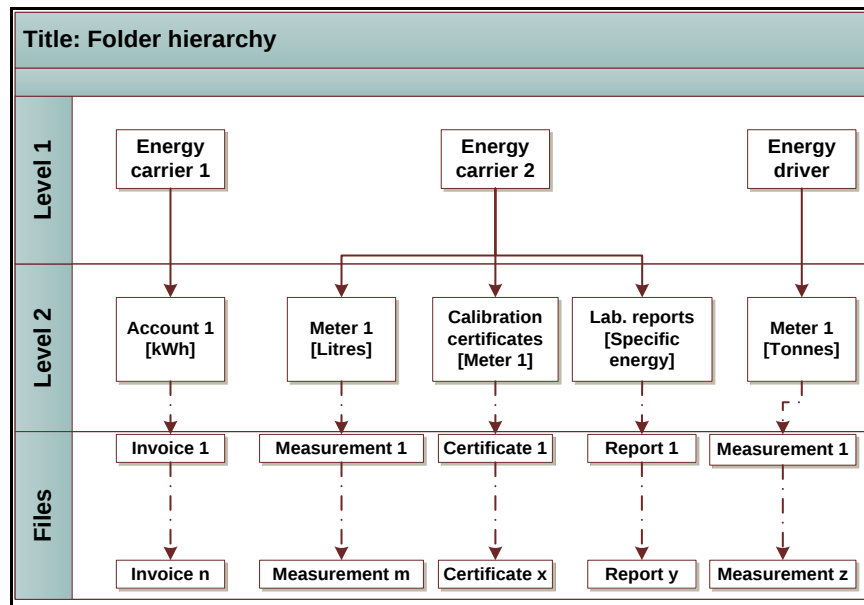


Figure 25: Structure - Raw data and documentation database structure

As is seen in the figure above, folder structure only has two levels before file entry. This is to assist that data is not obscure or the need for duplication. The first level should categorise the energy carry or energy driver. The data and documentation source should be identified in the second level. The unit of measurement can also be indicated in the second level. This will assist in the Process step of the methodology.

3.3.3 PROCESS

The data in the traceability folder structure will not always be in a format which can be used to do calculations on for example software packages similar to Excel. It is therefore necessary to process the data to deliver useful information. For the energy efficiency savings it is required that all the energy carriers have the same energy equivalent. This unit can either be in kWh or GJ.

For energy carriers that are not in the required unit, a transformation formula will be required. An example of this is a multiplication formula with the meter data and the energy carrier's CV value. Figure 26 shows the steps of this process.

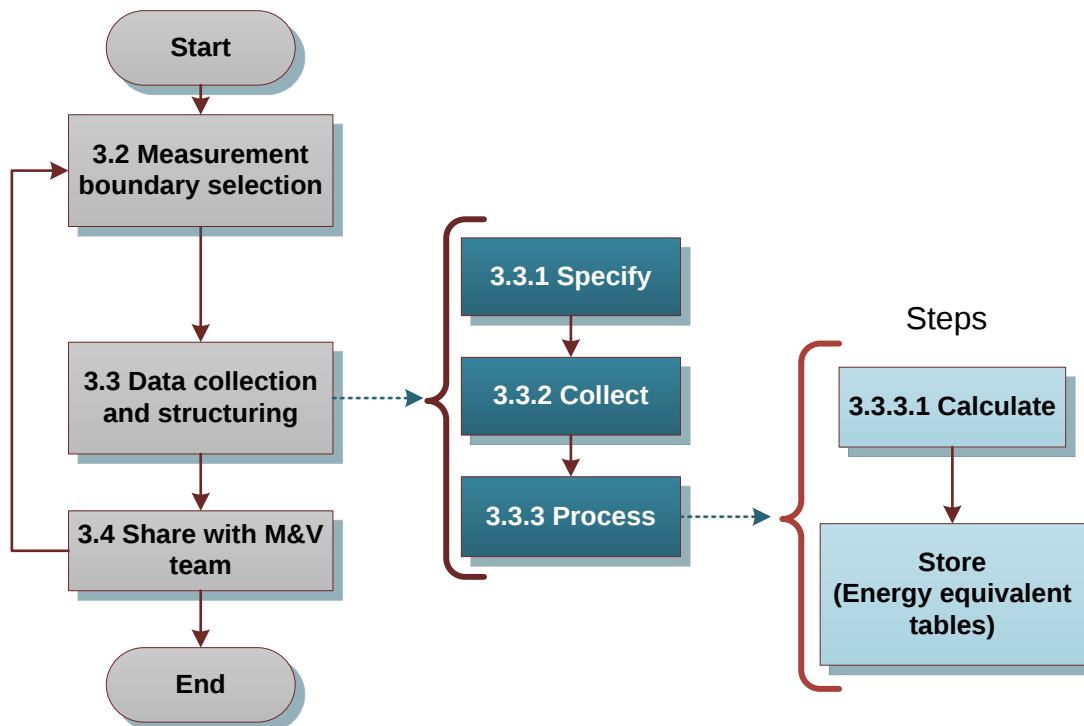


Figure 26: Process – Processing of raw database

Calculate

Using a flat-file database, an energy equivalent table can be used to process all the energy carriers into the same unit. The sample data within this table should also be normalised to the same period interval. This can be in days, weeks, months or even years.

Figure 27 shows a breakdown of this type of table.

The breakdown shows that the first label should identify the energy category. The next label should identify if the data input was a calculation, or a direct input from the folder structure. For practical reasons the selected energy driver data should also be normalised to the same period interval and entered into the tables. The third level will be the normalised records.

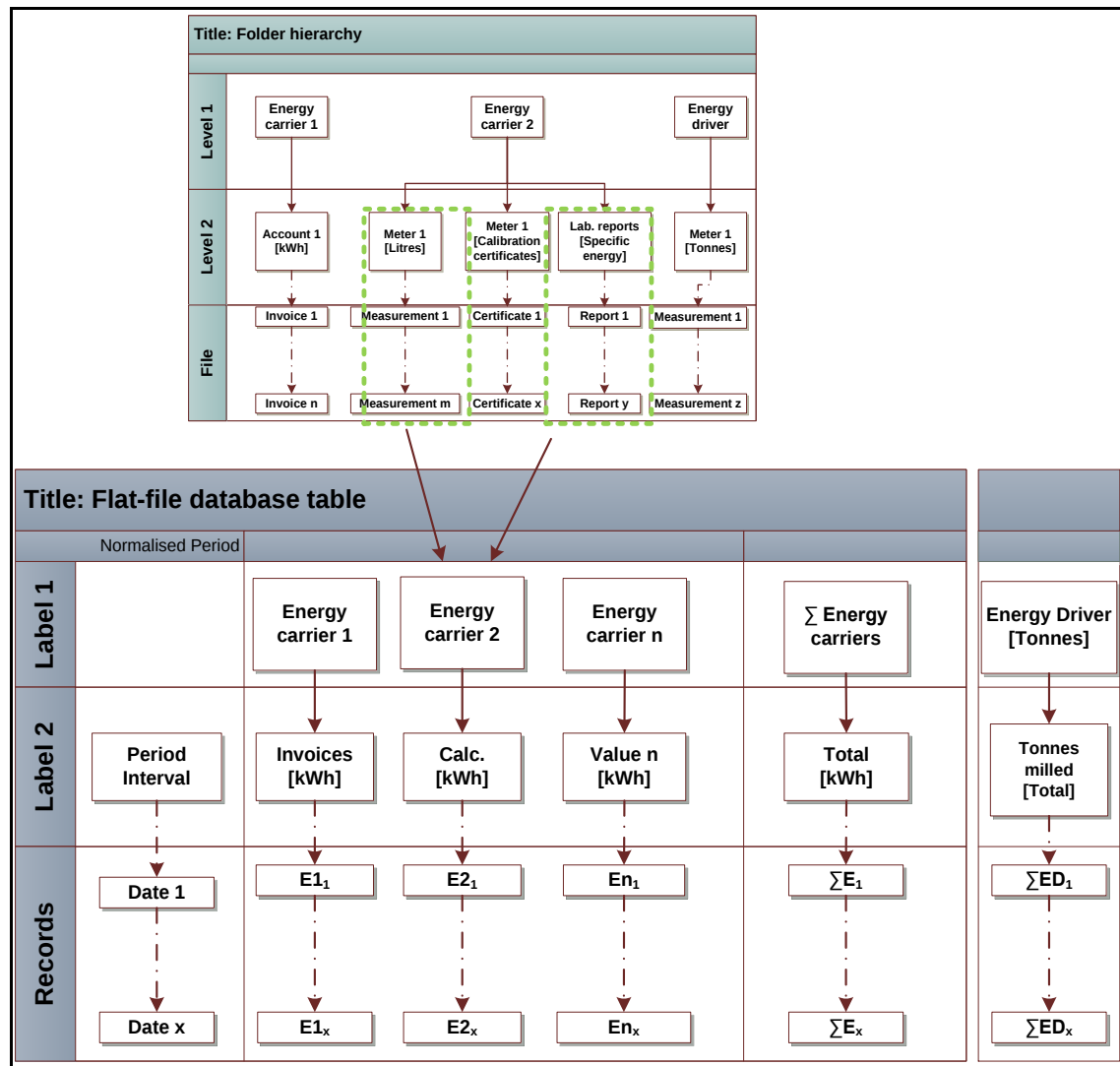


Figure 27: Energy equivalent Section 12L application tables

3.4 SHARE WITH M&V TEAM

The final step of the methodology will be to share all the layouts, data and documentation with the M&V team. This will enable the team to calculate the energy efficiency savings for the Section 12L application. Figure 28 show that there are three items to be shared with the team. These include the measurement boundary selection process, the folder hierarchy and the energy equivalent tables.

To assist the M&V team to understand the measurement boundary selection process, a report can be written. The structured folder hierarchy and flat-file databases as discussed

in the previous steps should be shared. The M&V team inspection can reveal compliance issues. This can lead to new boundary selection or the collection and structuring of data.

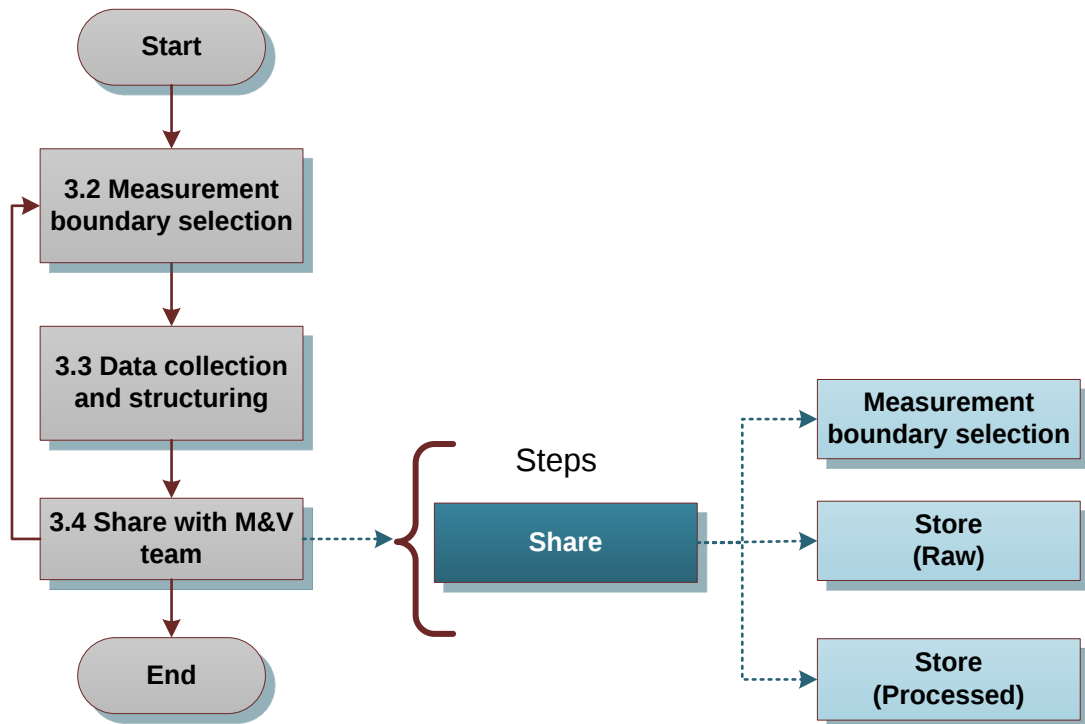


Figure 28: Share with M&V team

3.5 METHODOLOGY VERIFICATION

Verification of the methodology should ensure that the methodology implemented accurately representing the conceptual methodology design. It should also aim to identify if the problem statement was successfully solved. The flow diagram in Figure 29 shows the five verification points.

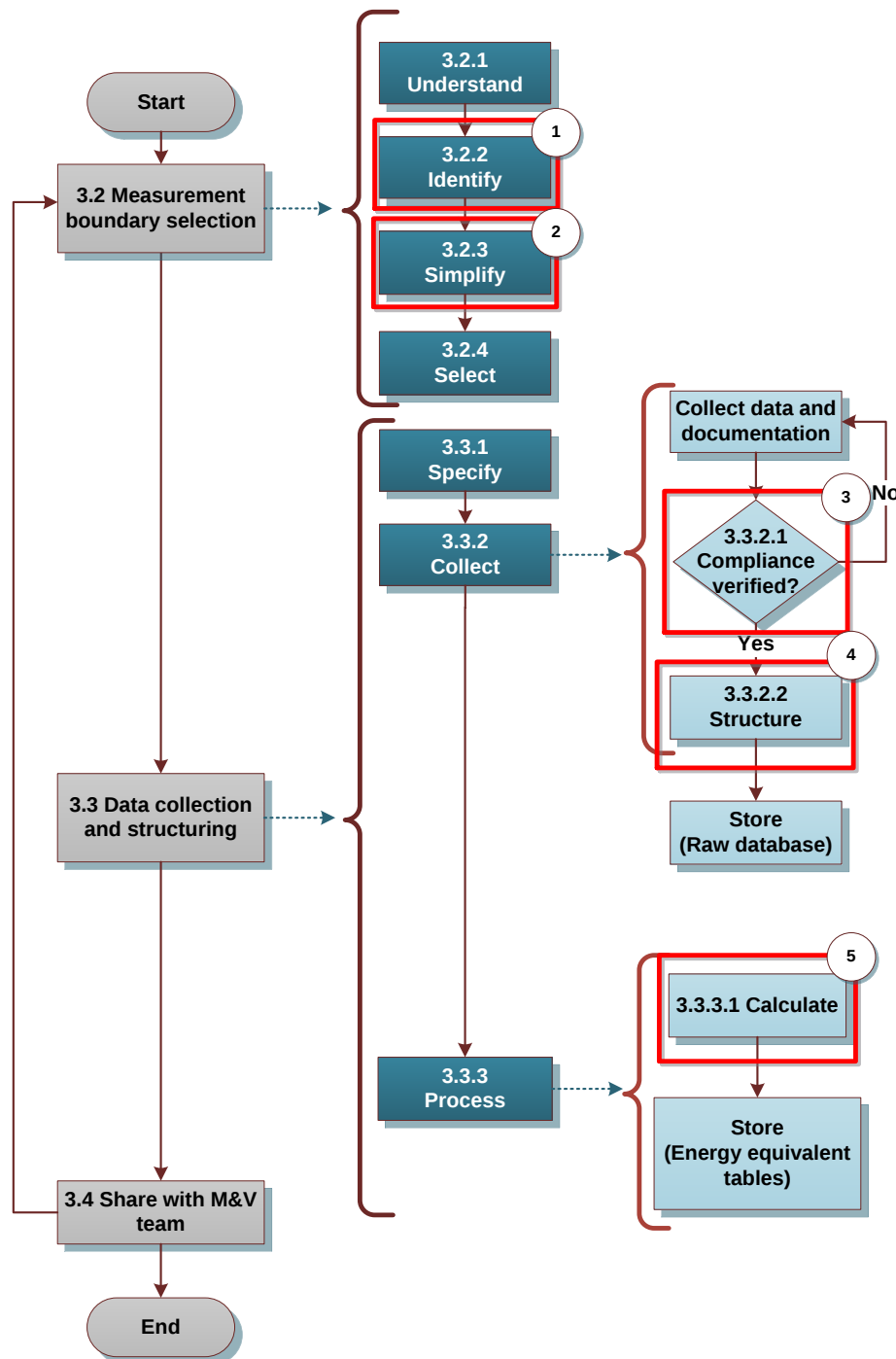


Figure 29: Methodology verification

A Standard compliant energy carrier and energy driver dataset should be supplied to the M&V team to calculate the EEI impacted. Each of these points, as identified in Figure 29, have a specific process that ensures that the methodology followed addresses this problem statement:

1. *Identify*: The Section 12L has limitations to the type of EEI that can be claimed. Within this step these EEI are identified and indicated. This step also identified operational facilities that will need to be excluded from the EEI calculations.
2. *Simplify*: The complexity of the mining industry is reduced by the SADT high-level approach. This step identifies high-level measurement points that are compliant with the Standard measuring requirements.
3. *Compliance verification*: To ensure that the final data and documentation stored and process is compliant. Final checks are done regarding the measurement point data and supporting documentation quality and integrity.
4. *Structure*: This storage structure is simple and traceable which will be easily comprehensible by the M&V team.
5. *Calculate*: All the energy data is normalised to the same unit of measurement and period interval. This will enable the M&V team to quantify the EEI impact.

3.6 CONCLUSION

The methodology developed in this chapter consists of two main phases. Firstly, a Section 12L Regulations and SANS 50010:2011 Standard compliant measurement boundary is identified. This is done in four steps.

The first step is to understand the main production flow between all the facilities. It is also necessary to investigate the energy carriers that are consumed by each facility. This identifies the system interdependency complexities. Secondly, the necessary facility energy drivers' measurement points, energy carriers' measurement points and Section 12L EEI limitations projects are identified and indicated on the production flow. The limited EEI projects energy efficiency saving should be excluded from the quantification process.

The third step is to simplify by indication. The compliance of the measurement points are investigated and indicated on the production flow measurement points. Finally, the noncompliant measurement point is removed and the EEI implantation scope is identified. After all the necessary information is available, a compliant boundary can be chosen.

The second phase of the methodology is to collect, organise and process the data and documentation from the selected measurement points. This phase has three steps namely Specify, Collect and Process. In the Specify step the selected measurement points' data and supporting documentation is specified for collection.

Thereafter, this data and documentation is collected in the Collect step. However, this step also has a data quality and integrity verification process. After the quality and integrity has been verified, the data and supporting documentation is organised in a folder hierarchy. The data necessary for the quantification of the EEI will need to be in the same format and unit of measurement. Therefore, the data is converted into an energy equivalent table. A flat-file database is used for this purpose.

The final step is to share all the data and documentation with the M&V team. This will include the measurement boundary selection process, the folder hierarchy and the flat-file database. The methodology design is verified by comparing the outcomes of the different steps to the statutory document namely the Section 12L Regulations and SANS 50010:2011 documents.

Chapter 4

CASE STUDIES

4 CASE STUDIES

4.1 INTRODUCTION

The following chapter applies the methodology developed to actual case studies. The case studies present operational production flow, measurement points, energy drivers and energy carriers which are based on actual mining operations. This information was collected from interviews with mining personnel, operational layouts and the mining company's public published reports. Due to strict confidentiality agreements, the companies presented within this chapter will be referred to as gold mining company and platinum mining company. The energy drivers will only be explained and no measured data can be presented due to this confidentiality. Figure 30 shows the methodology breakdown that will be applied to the case studies.

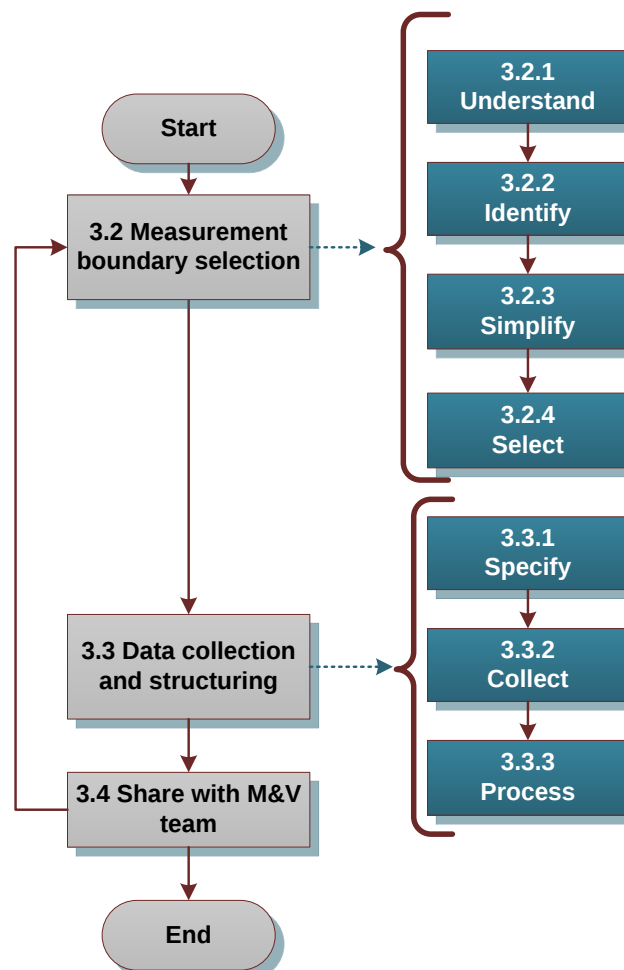


Figure 30: Methodology framework

4.2 CASE STUDY 1: PLATINUM MINING COMPANY

A platinum mining company that mainly operates within the South African Bushveld complex is discussed. This company's operations consist of five regional business units. The company also has an independent smelter complex. The operations mine both Upper Group 2 (UG2) and Merensky reefs that are rich in PGM. These reefs also contain base metals like nickel, copper and cobalt. In addition, the company's taxable entity has associates and joint-venture agreements with external companies. These external companies form part of the production flow, as well as operates on the same premises as the mining company.

4.2.1 CASE STUDY 1: MEASUREMENT BOUNDARY SELECTION

i. Measurement boundary selection: Understand

Figure 31 illustrates the operational production flow of the mining company. The flow consists of mining, concentrating, metal extraction and refining. The production facility of each production flow phase is also indicated on the figure. The company makes use of both deep-level and opencast mining techniques. The deep-level mining techniques consist out of conventional and trackless mechanised operations. The mining facilities that operate in the same region are indicated by the five different business unit boundaries.

The extracted ore from four of the business units are concentrated on-site. The fifth business unit has an agreement with an external company to concentrate the ore. Business unit four also has an agreement with an external concentrator where mined ore is concentrated. The waste material generated in the concentration process, usually called tailings, is reprocessed by third party operations on-site, except for one business unit that also reprocesses old tailings dams (surface operations).

With this investigation the mining stages main energy drives were identified as tonnes ore extracted, - concentrate, - furnace matte, and - converted matte. The ounces PGM and tonnes of base metals are the final product of the production flow. Tonnes of concentrate are transported between facilities due to processing and metallurgical reasons.

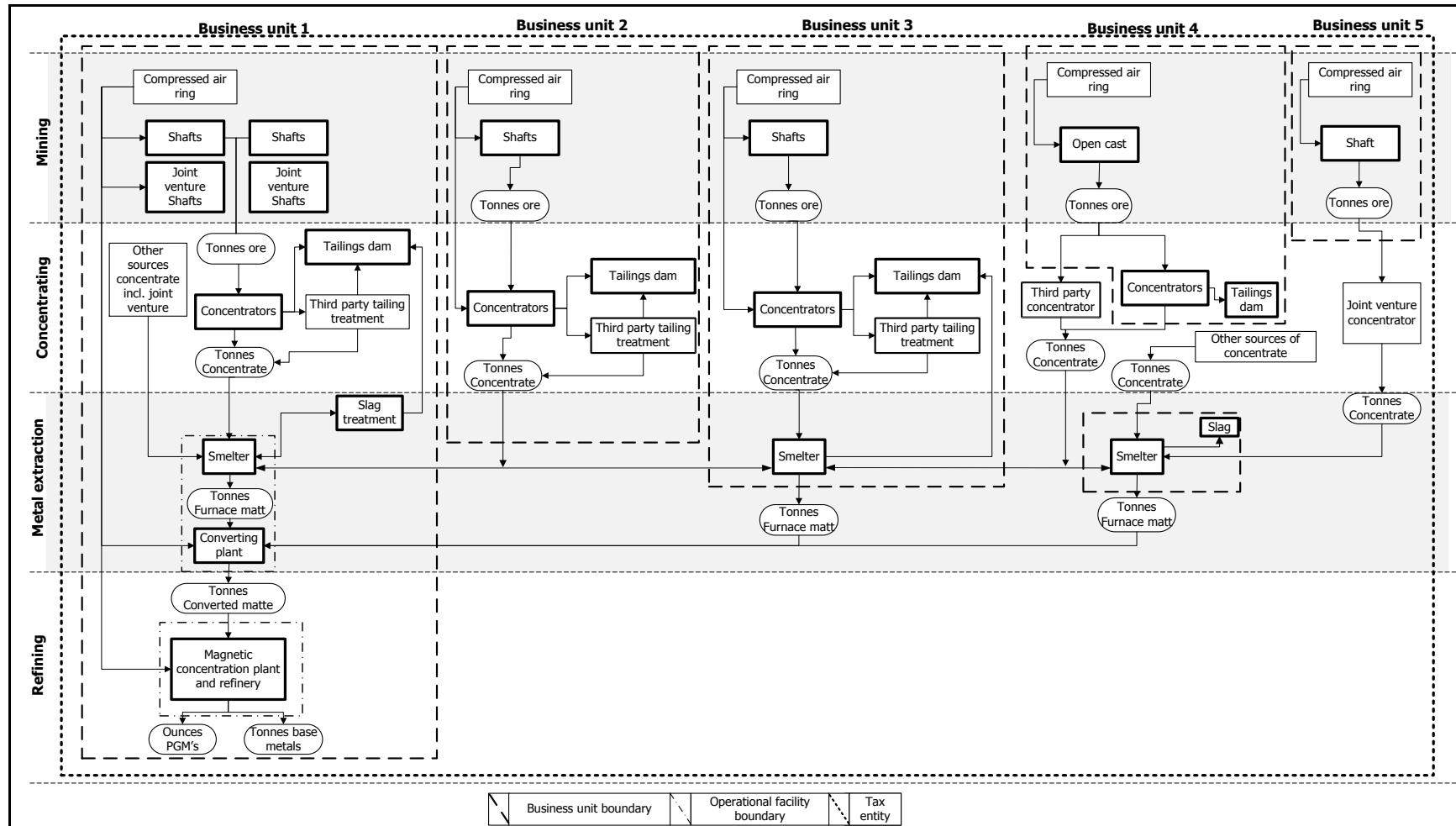


Figure 31: Case study 1 - Understand

Additionally, instead of the converted matte going directly to the base metal refinery and then the precious metal refinery, this company has a magnetic separation plant within the base metal refinery. In one step the converted matte is magnetically separated into base metals and precious metals. Thus, making the final step of production a parallel flow between the base metal refinery and the precious metal refinery instead of a series flow.

In Figure 32 all the energy carriers as published by the company's annual sustainability reports are summarised. The figure portrays the average percentages for the values as published for the years 2012-2014.

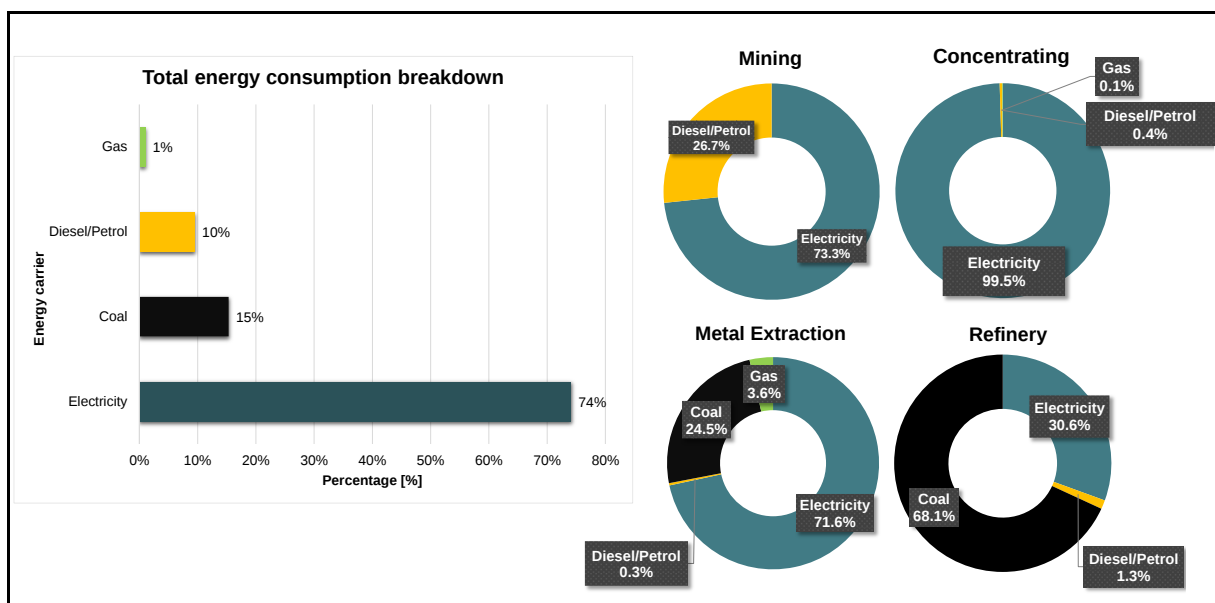


Figure 32: Case study 1 – Total energy consumption breakdown

As seen in Figure 32 from 2012 – 2014 electricity, coal and diesel are the main energy carriers for this company. Electricity is the largest due to the fact that it is used throughout the production flow. The opencast and trackless mechanised mining techniques are associated with large diesel and petrol consumption, see Figure 32. For thermal reasons coal is consumed by the smelters, the converting plant and the base metal refinery. Each business unit has a compressed air ring for mining operations

ii. Measurement boundary selection: Identify

In this stage of the case study the energy carriers and energy driver metering systems will be identified. Figure 33 gives an illustration of the metering systems at each of the business units and the independent smelter complex. The energy carriers and drivers are discussed below.

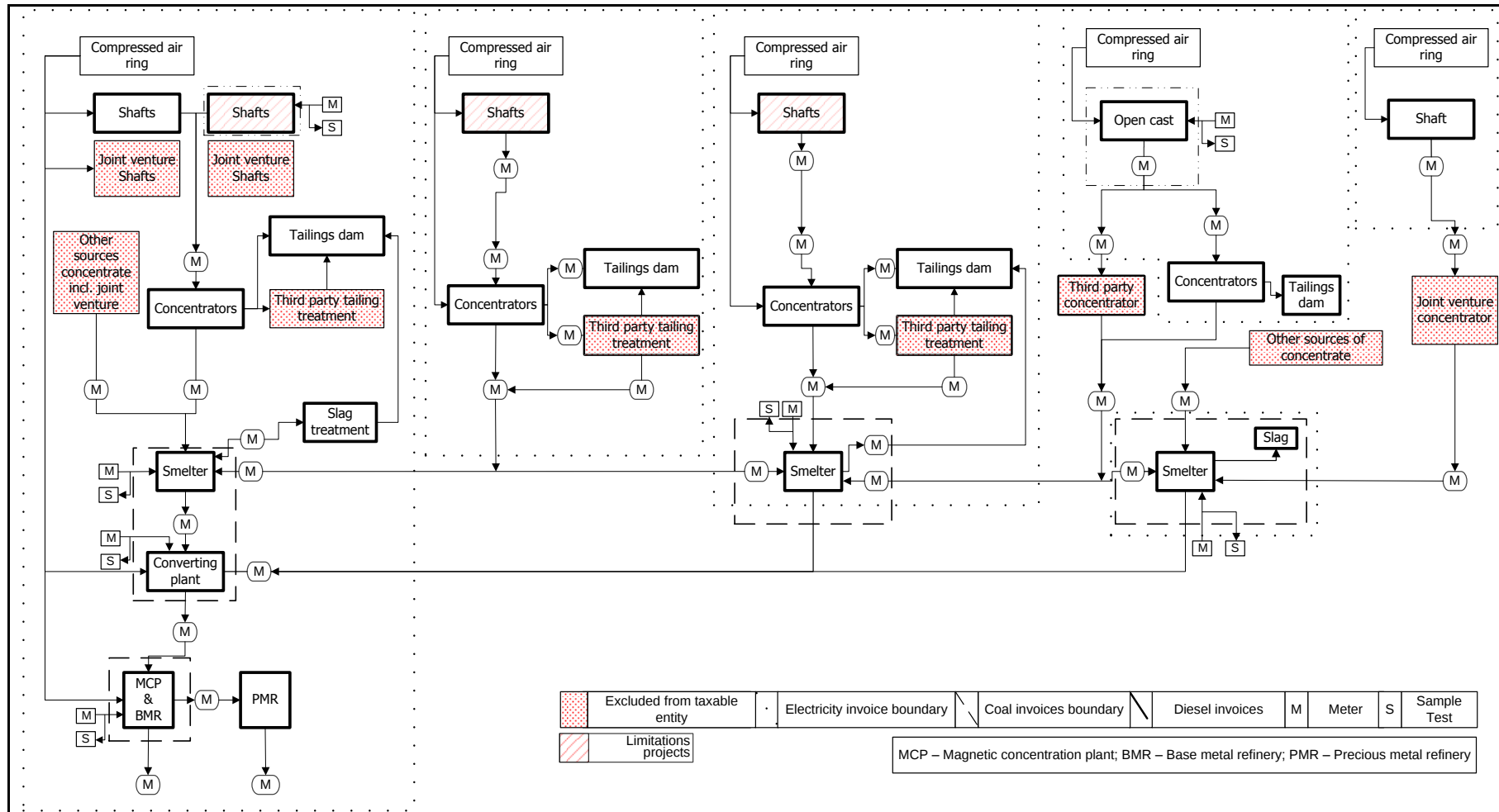


Figure 33: Case study 1 – Identify

Electricity

Figure 33 shows each of the business units and the independent smelter complex as a regional electricity supplier invoice. Table 3 summarises the amount of PoDs at each of the business units.

Table 3: Case study 1 – Amount of PoDs per business unit

<i>Business unit</i>	<i>Electricity supplier [PoDs]</i>
1	13
2	4
3	3
4	2
5	1
<i>Independent smelter complex</i>	1

As is seen from Table 3 business unit one has the most PoDs. This is due to the last stages of the production processes being located on the business unit's operational region. The smelter, converting plant and base metal refinery have their own dedicated invoiced PoDs. The precious metal refinery, shafts, third parties and concentrators are distributed between the remaining PoDs.

The business unit has an internal electricity monitoring system. By using this system the business unit will internally bill each of the operational facilities for electricity consumed. The rest of the business units also have internal electricity monitoring systems. Furthermore, these business units and the independent smelter complex similarly have distribution networks from the PoDs to the operational facilities.

Coal

The coal is transported from the coal supplier depot to the facilities by trucks. These trucks are weighed on arrival by a weighbridge. The trucks will then unload the coal onto a stockpile. The stockpiles are less than a month's worth of production coal. From the stockpile the coal is transported via conveyor belts into the facilities. The mining company only has one supplier of coal. The coal received is from one source. The coal supplier does daily composition analysis sample tests on the outgoing product.

Diesel

Business unit one and business unit four are the two largest consumers of diesel. In opencast mines, diesel and petrol are consumed on a 24-hour basis. Consequently, the filling stations have to maintain their stockpiles continuously. Diesel bunkers are located underground for the trackless mechanised operations equipment filling. In both, the operation volume meters are used to measure the diesel and petrol consumption. The diesel suppliers have a standardised laboratory tested composition analysis for their petrol and diesel products.

Compressed air

The regional business units make use of compressed air rings. Some of the production facilities have their own compressed air systems on-site. Volume meters are installed to measure the amount of air produced by the compressed air-ring compressors. It is not always the case that there are volume meters located at each of the consuming facilities. These meters will monitor the consumption of each individual facility. However, an air usage balance is used to justify the air consumption. This balance is based on installed volume meters, historical and statistical data.

Energy drivers measurement

The energy driver meters mostly measure the weight of the driver. The tonnes of ore will either be measured by a train weighbridge or belt scales on the conveyor belts. The tonnes concentrate can either be in a dry or wet state. The dry tonnes concentrate is transported by trucks to and between the smelter complexes. These trucks are measured by a weighbridge on arrival. The wet state concentrate is measured by gravity feed meters.

The tonnes of furnace matte transported from business unit four smelter and the independent smelter complex are similarly weighed on arrival. Business unit one smelter and the converting plant are located on the same facility. Therefore, the furnace matte is only transported from the one plant to the next. The converted matte is then transported to the magnetic concentration plant. From here the base metals and PGMs are sent to their respective refineries. The PGMs and the base metals produced are weighed on scales.

iii. Measurement boundary selection: Simplify

The compliance of the meters are indicated on Figure 34. In the figure, the three levels of data accuracy and compliance is indicated. The joint ventures and third party operations within the production flow add to the complexity.

Energy carriers

The electricity internal metering systems do not have adequate supporting documentation to ensure data accuracy. The electricity supplier invoices are regarded as a compliant source of electricity data. Thus, if the internal electricity metering system is to be used, these meters in question will have to be calibrated by an independent company according to international and national standards.

Diesel, petrol and coal have on-site storage facilities. The Standard does require that there are on-site storage facilities. Calibrated measurement equipment should be used. It will be difficult to prove data accuracy for the diesel, petrol and coal facility measurement equipment. However, the facilities have a high volume consumption of these energy carriers. It is less than a month's worth of production. Thus, energy supplier tax invoices will be presented to the M&V team for consideration for the data source, as well as the supporting documentation. If the M&V decides this is not sufficient, the measurement equipment needs to be calibrated.

Energy drivers

Figure 34 indicates that there was a lack of supporting information in the mining and concentration phases of the production flow. In the metal extraction and refining process more information was available. The weighbridge at business unit one smelter and converting plant complex has adequate supporting documentation.

Business unit three's smelter complex weighbridge has supporting documentation. This documentation however, only verifies the measurements taken by the bridge; the documents do not indicate if an error correction was made to the measurement equipment. Therefore the documents are not sufficient to ensure data accuracy. The PGMs and base metals weight scales have sufficient documentation to support data accuracy.

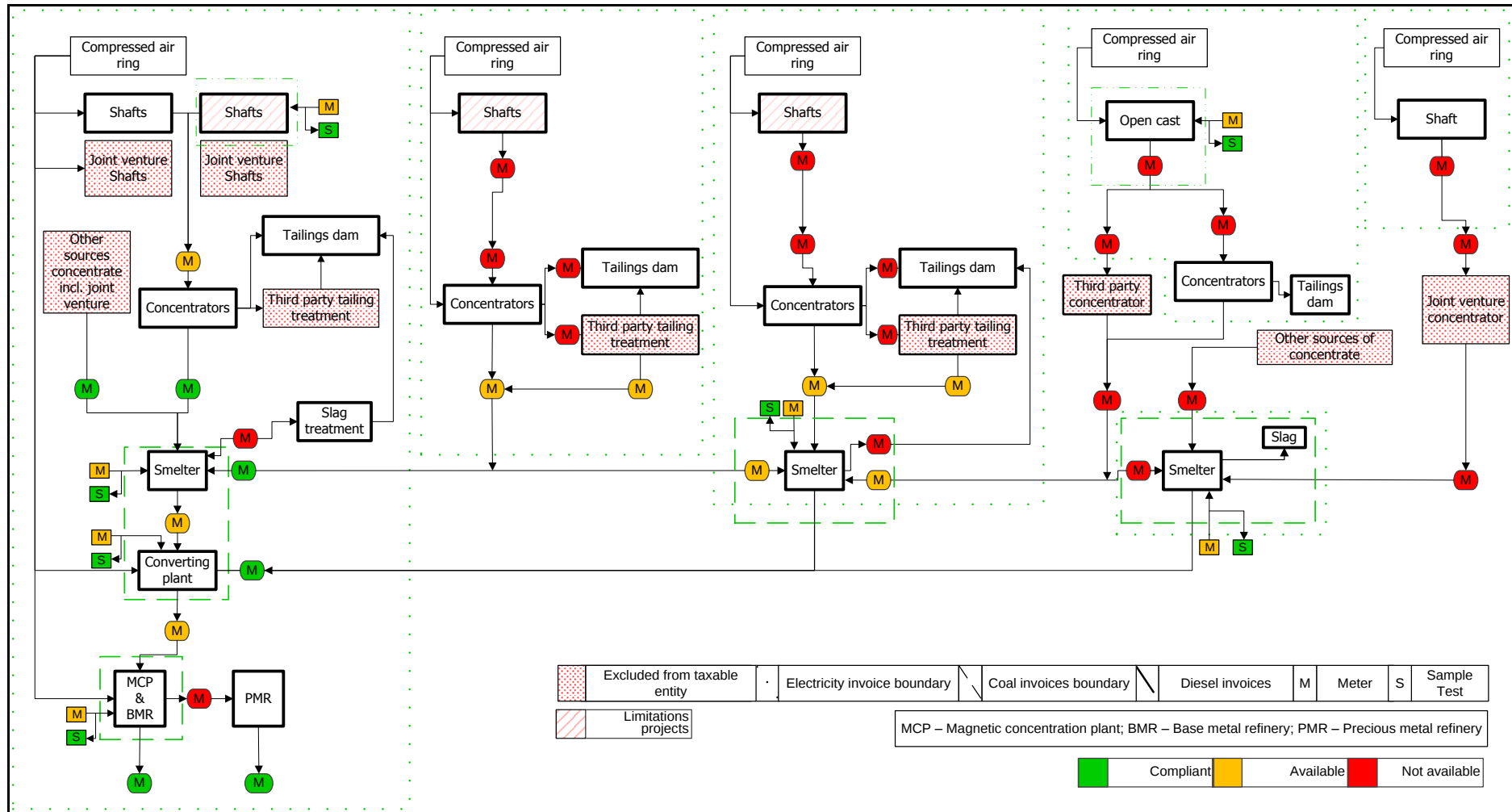


Figure 34: Case study 1 - Simplify

iv. Measurement boundary selection: Select

The mining company had an energy awareness campaign. The effect of the energy awareness is broad and will be difficult to separate individually. In addition, there were concurrent projects implemented on the shafts at business unit one, two and three. With the selection phase five different options are identified.

Option A

The independent smelter complex can be isolated as is indicated in Figure 35. The smelter has its own electricity supplier invoice. Coal invoices will be used to determine the coal consumption. The energy driver will be furnace matte that is weighed at the complex 1 smelter weighbridge. The advantage of this boundary is that there are no third parties involved. The disadvantage is that all the energy savings achieved on the other facilities will be lost.

Option B

A measurement boundary can be drawn around business unit three. This measurement boundary will include a third party operation, as well as concurrent projects. These operations and projects will have to be isolated and the methodology should be applied. The business unit's regional electricity account will be used. The coal will be quantified with coal invoices. Furnace matte will be the business unit's energy driver which will be measured at smelter 1 weighbridge.

Option C

With this boundary, the metal extraction and refinery operation will be isolated. This option will exclude all the third party operations and concurrent projects. The disadvantage of this option is that the internal electricity power meters will have to be calibrated where needed. Also, the compressed air is consumed by the smelter complex and base metal refinery. It is therefore necessary to calculate this energy carrier. The base metals and PGMs are compliant and will be used as the energy drivers

Option D

This measurement boundary isolates the refinery operations. The base metals and PGMs will be the energy drivers. Coal and electricity will be the energy carriers.

Option E

With this option all the business units and the energy savings will be quantified. It will however, be necessary to isolate all the third party operations and concurrent projects. Furthermore the impact of the concentrate bought by the mining company will need to be determined.

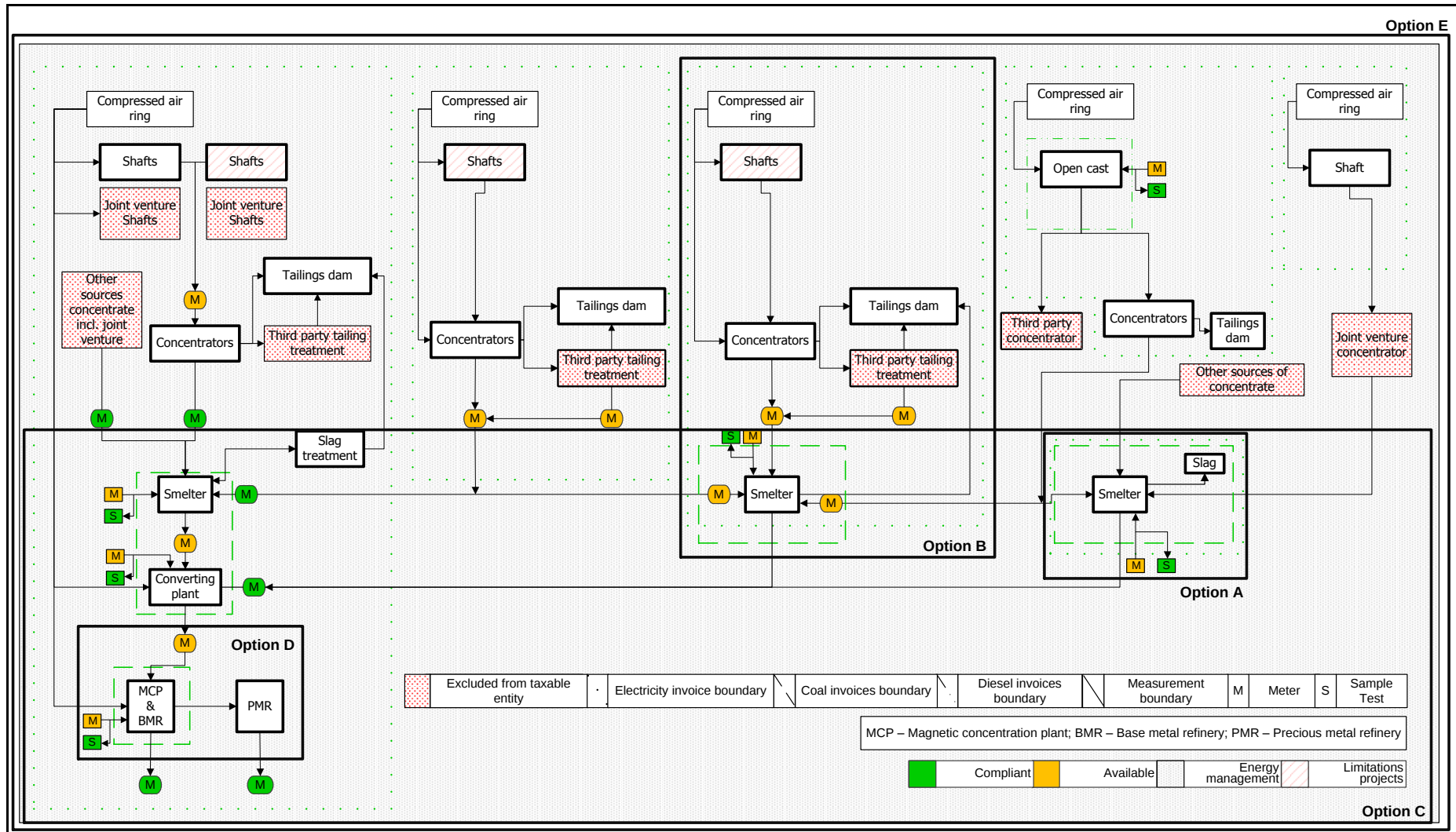


Figure 35: Case study 1 - Select

4.2.2 CASE STUDY 1: DATA COLLECTION AND STRUCTURING

The measurement boundary Option C within an M&V whole facility option in Figure 35 will be demonstrated in this part of the methodology. All the required data and supporting documentation will be specified. This data will be required for the M&V team to compile a successful Section 12L inspection and calculate the savings.

i. Data collection and structuring: Specify

The selected measurement boundary is drawn in more detail in Figure 36. The figure indicates that electricity, coal and compressed air measurements will have to be specified, collected and structured. The energy drivers will measure precious metals together with the measured base metals. Table 4 summarises Figure 36's requirements.

Table 4: Case study 1 – Energy carrier and driver specifications

Energy carriers	Supporting documentation
<i>Business unit 1 electricity invoice</i>	Invoices
<i>PMR internal electricity metering data</i>	Calibration certificate
<i>Smelter 2 internal electricity metering data</i>	Calibration certificate
<i>Independent complex electricity invoices</i>	Invoices
<i>Smelter 1 and converting plant coal invoices</i>	Invoices
<i>Smelter 2 coal invoices</i>	Invoices
<i>Smelter 3 coal invoices</i>	Invoices
<i>Coal analysis laboratory reports</i>	Reports/Laboratory standards
<i>MCP & BMR coal invoices</i>	Invoices
<i>MCP & BMR compressed air consumption</i>	Calibration certificate
<i>Business unit 1 compressors energy equivalent</i>	Conversion calculations
Energy drivers	
<i>PGM's measurement data</i>	Calibration certificates
<i>Base metal measurement data</i>	Calibration certificates

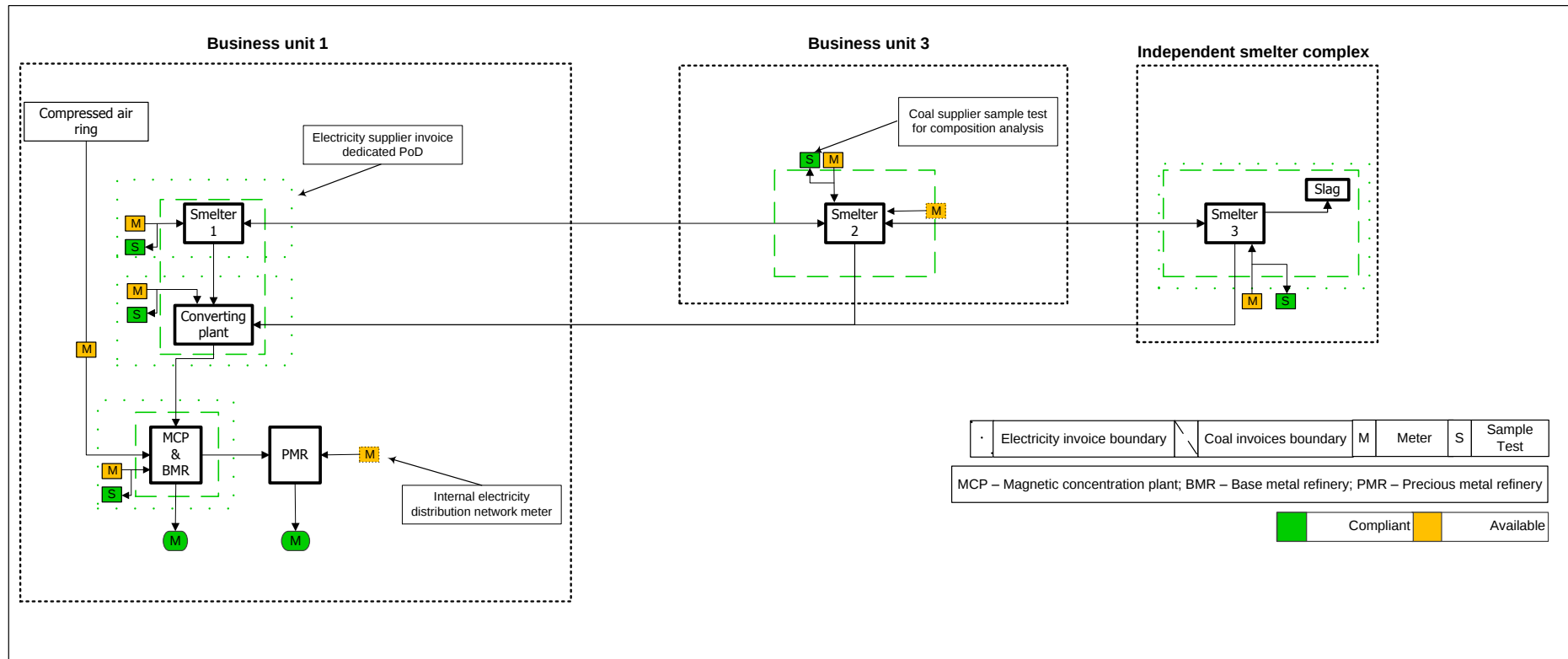


Figure 36: Case study 1 – Specify

ii. Data collection and structuring: Collect

Compliance verification

Data quality checks were done on the data collected. These checks indicated that the data is of sufficient quality. The supporting documentation quality checks indicated no major issues, except for the base metal refinery that supplied verification reports for their scales calibrations. These reports did not ensure the measurement equipment accuracy. With further inquiry, the equipment calibration certificates were supplied. Appendix A shows an example of one of the scales that measures the PGM's calibration certificates. The important areas are highlighted in red.

The calibration certificate was issued by a SANAS accredited calibration laboratory. This supports that the meter equipment calibration adhere to international and national standards. Furthermore, the scale number and unit of measurement are indicated on the certificate. The data collected has ounces as its unit of measurement. Mining companies report to their stakeholders on an ounce unit instead of a gram unit. Therefore, the data is converted from a gram unit to an ounce unit. This converted data is audited by an external auditing company on an annual basis.

When the data is collected and extracted, the integrity of the data should be ensured. This means that the data was not altered or not included due to the transfer from one source to another. The electricity invoice data was checked against the company's internal electricity data. Figure 37 illustrates an example of this data integrity checking. The electricity internal metering data was compared to the company's safety, health and environment database data. The production sheets data for both the PGMs and base metals were also compared to this database.

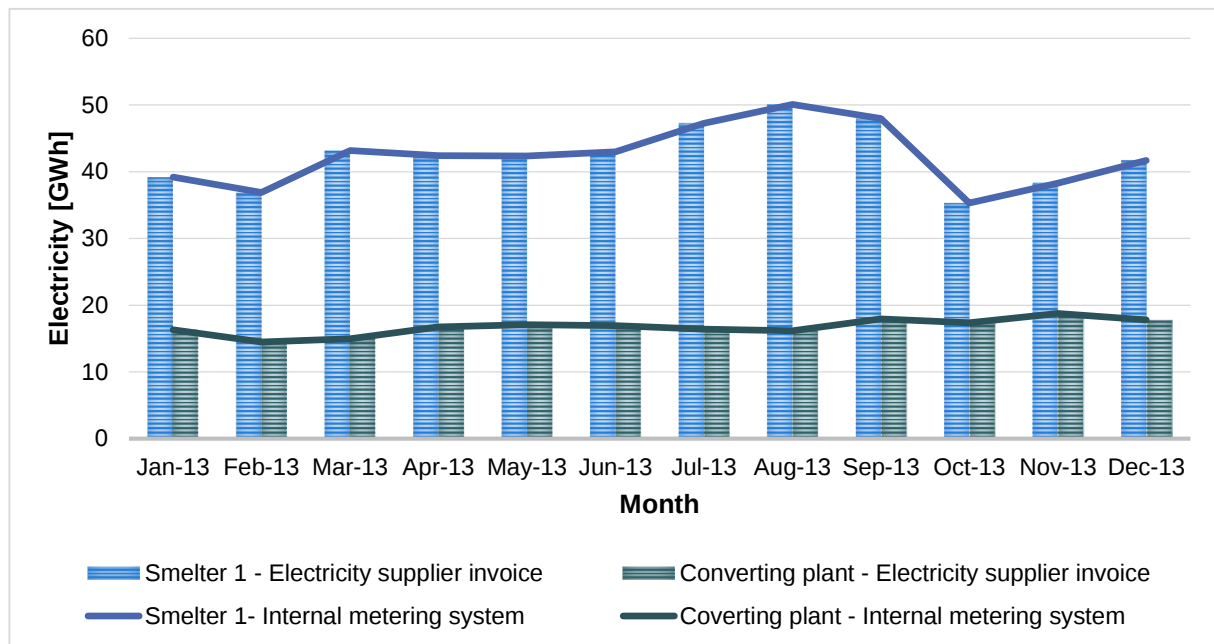


Figure 37: Case study 1 – Smelter 1 and converting plant data collected data integrity check

On the coal supplier invoices, the amount of coal tonnes delivered is indicated. These data values are captured by the company's supply chain personnel into an internal database. The coal quantities for the period interval were extracted from the database. The data integrity was ensured by comparing the captured data with the actual invoices. Because of the large quantity of invoices received in a financial year, only a group sample was done to ensure the data integrity. The sample test results for the coal composition analysis were supplied by the coal supplier. Data integrity could not be performed on this set of data due to the lack of data source access. However, the supplier laboratory adheres to national and international standards. The laboratory is in the process of SANS accreditation.

The compressed air supplied to the magnetic concentration plant and the base metal refinery was captured from the accounts sent to the facility. These accounts are compiled by business unit one's central services. Their calculation sheets were later provided and a comparison was made.

Structured folder hierarchy

The verified datasets and supporting documentations can be structured in a folder hierarchy. The structured framework is shown in Figure 38. Level 1 categorises the energy carriers and energy drivers. Level 2 is a more detailed breakdown of the data and documentation collected. This level should align with Table 4's specification for the collection phase.

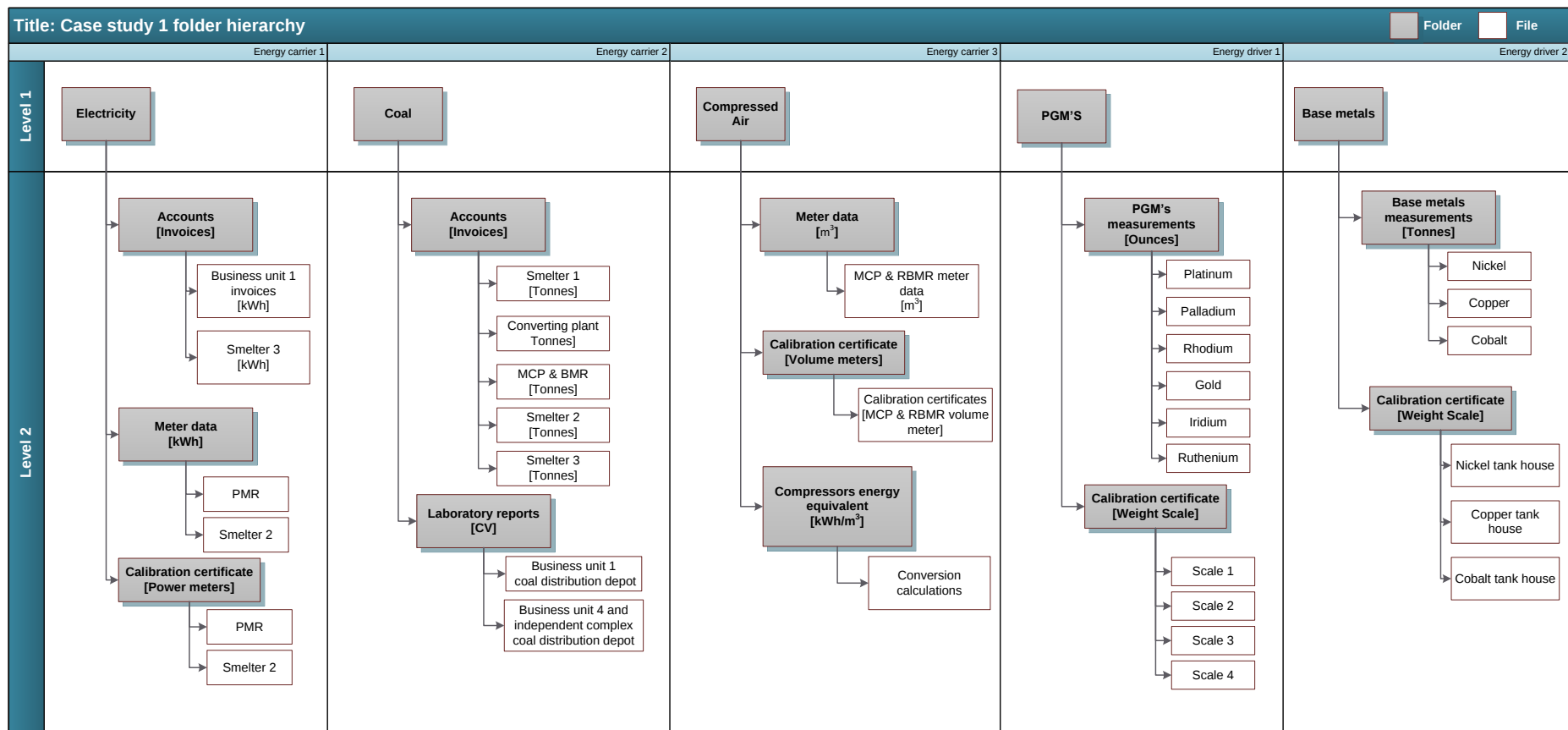


Figure 38: Case study 1 folder hierarchy

iii. Data collection and structuring: Process

The energy savings calculations will require a normalised dataset. This dataset should be in the same unit of measurement and all data points must be aligned with a period interval. The energy carriers unit of measurement chosen for this case study is kWh. The period interval will be on a monthly basis. This means that all the energy consumed in a specific month must be normalised to a single monthly data entry.

The processed flat-file database structure consists of a period interval, the normalised data for each energy carrier and total energy consumption of the measurement boundary, see Figure 39. The energy drivers can also be normalised to monthly values. The electricity accounts' invoices raw dataset requires no processing. The power meter data will need to be normalised to specific monthly entries.

The coal raw datasets for the account invoices are in tonnes. These ton values must be multiplied by an average CV. The CVs are calculated by averaging the sample tests CVs for a month. The multiplied value will be in a gigajoule unit. Consequently this value should be divided by 0.0036 to convert the value to kWh.

The monthly compressed air consumption is in cubic meters. The ratio of cubic meter of compressed air to kWh for each of the compressors was calculated. This calculation is done using the companies specified energy consumption energy equivalent value (kWh/m³).

4.2.3 CASE STUDY 1: SUBMIT TO M&V TEAM

The final step is to send all the information to the M&V team. This will include the measurement boundary selection process, followed by the folder hierarchy and processed flat-file databases. A report can be compiled to explain all the boundary selection processes and all the data collected and processed. Uncertainties that were encountered in this process can also be noted in the report.

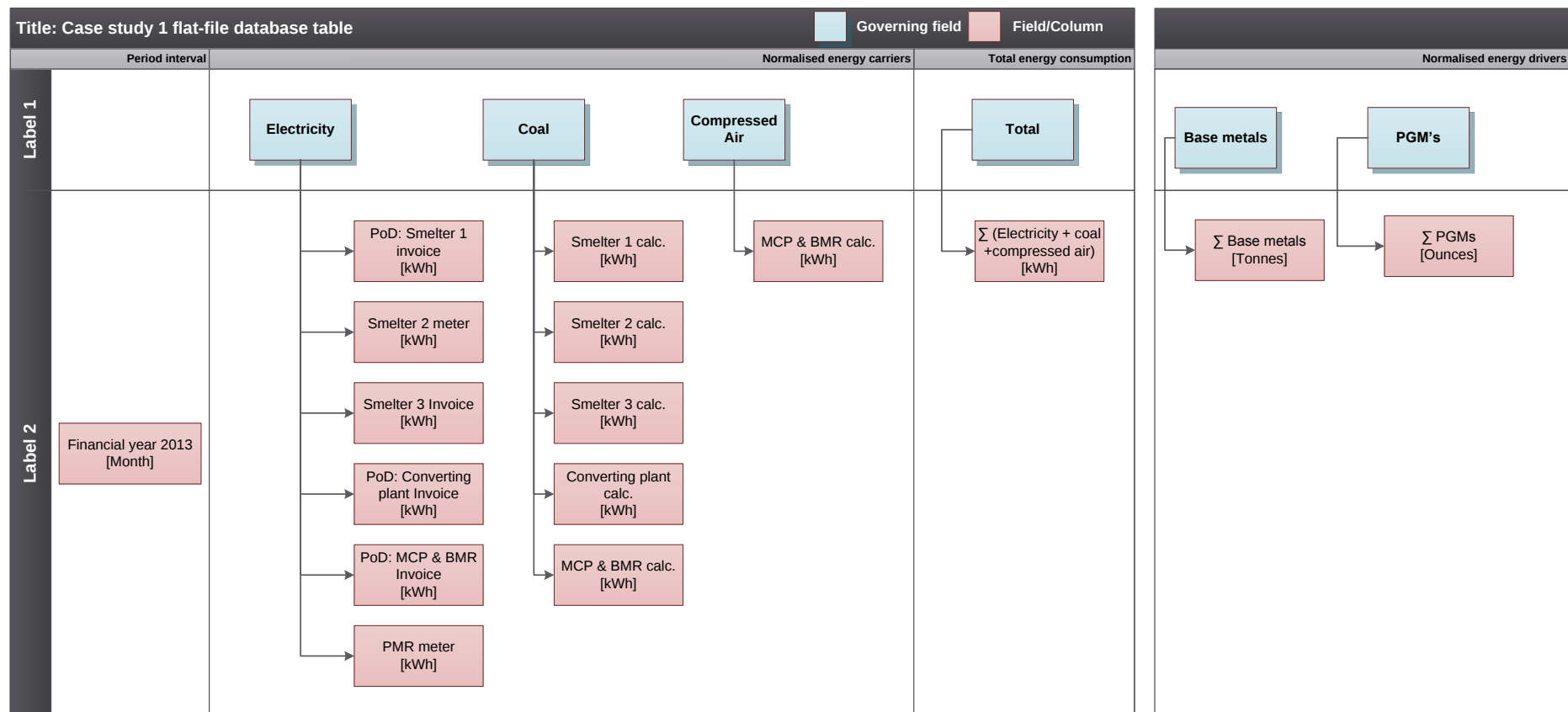


Figure 39: Case study 1 flat-file database table

4.3 CASE STUDY 2: GOLD MINING COMPANY

The following case study is of a gold mining company. This company's operations are based in the North-West province. There are two separate mining business units that operate in two different regions. All the facilities in both the business units fall within one taxable entity. There are no external companies operating on the mining company's operations. The company mainly mines gold bearing reefs. These reefs of ore have sufficient quantities of uranium that can also be extracted.

4.3.1 CASE STUDY 2: MEASUREMENT BOUNDARY SELECTION

i. Measurement boundary selection: Understand

There are three deep-level production shafts in each of the mining business units. From the production shafts the mined ore is transported via conveyor belts to gold plants. Business unit one has four gold plants and business unit two has two gold plants. In both the business units, waste material is also reprocessed called surface operations. The gold plants in both regions have similar gold extraction processes except for three of the plants. These similar processes include milling, thickeners, leaching, carbon in pulp (CIP) and elution together with refining.

The first exception is in business unit one: gold plant one. In this plant's production flow, there is a uranium recovery plant. The second exception is also in business unit one, but in gold plant four. This plant uses a carbon in leach process instead of a CIP process. The last exception is in business unit two: plant two, which does not have an elution and refinery facility. The tonnes processed are pumped from gold plant two to gold plant one for final processing. More detail of the process is given in Chapter Two. The complete operational layout is given in Figure 40.

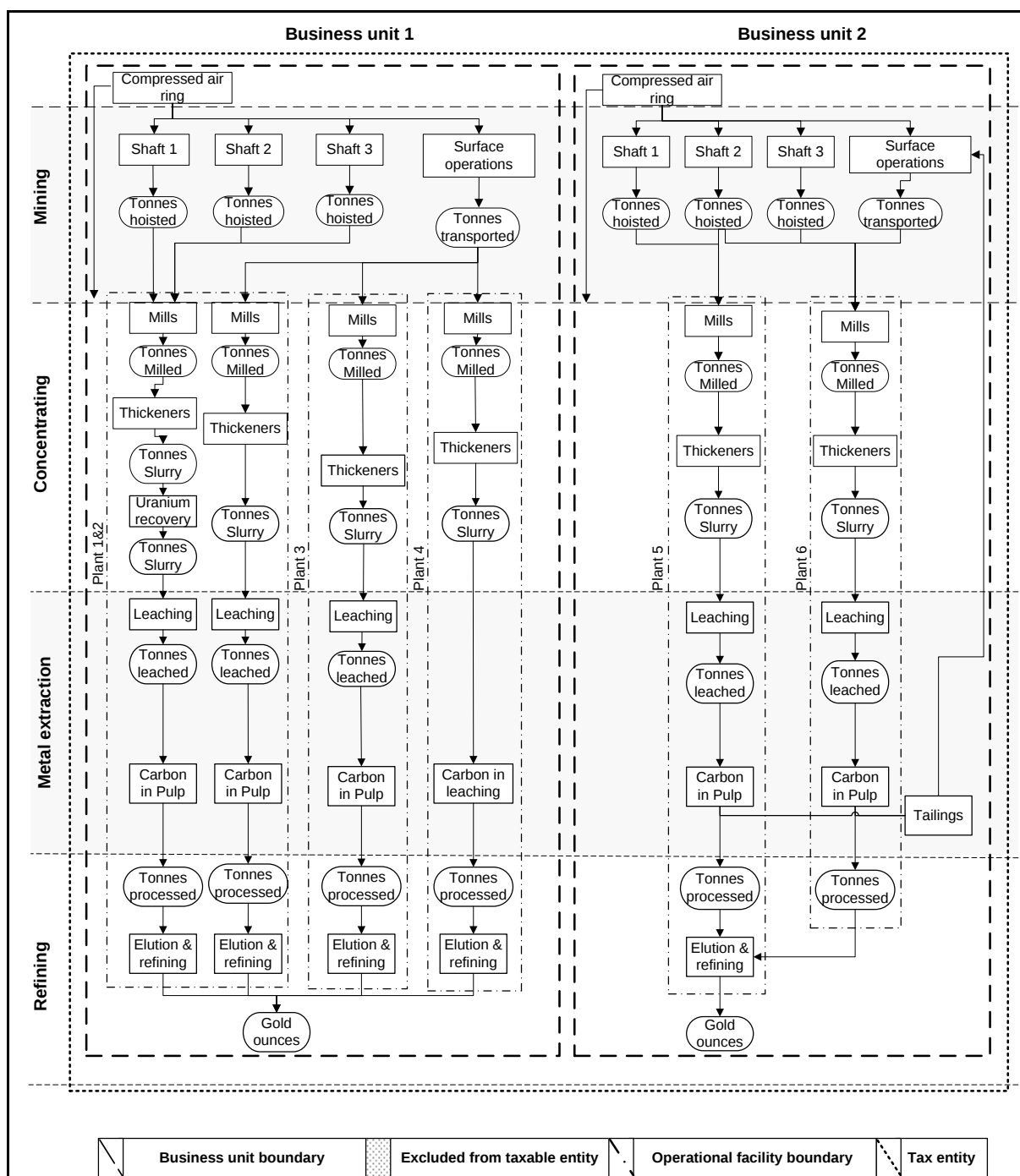


Figure 40: Case study 2 - Understand

In the above figure the energy drivers of each of the production facilities and processes are indicated. The energy carriers used to drive the production is mainly electricity. A breakdown of all the energy carriers as reported by the mining company is given in Figure 41.

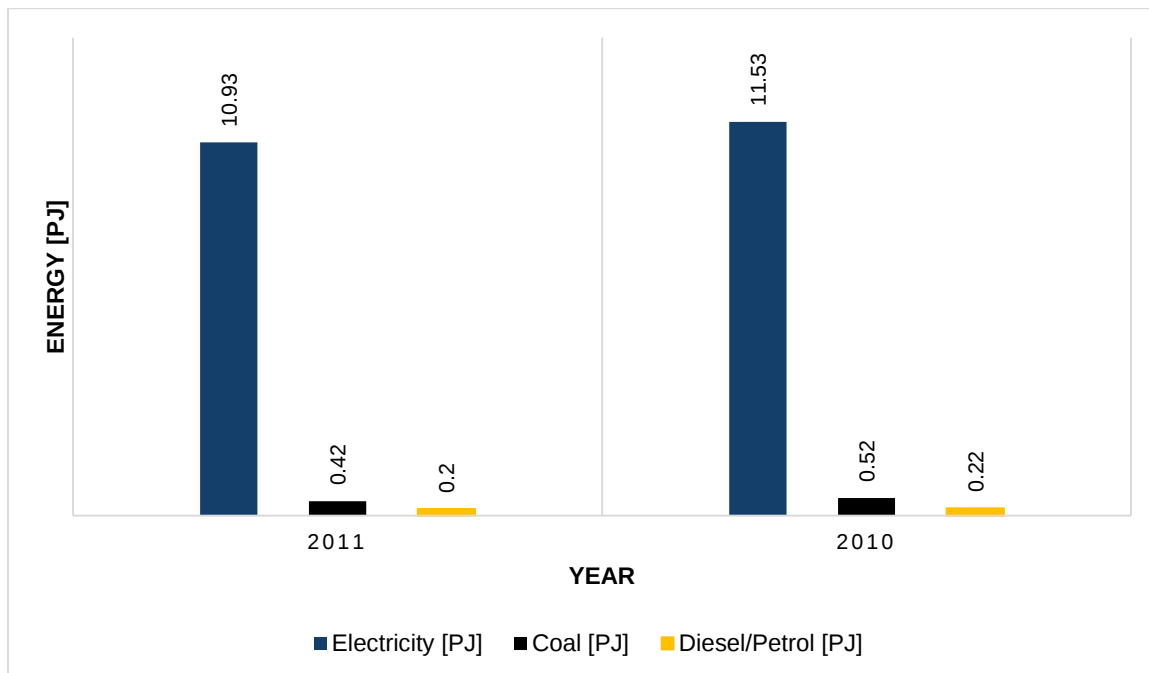


Figure 41: Case study 2 - Total Energy Usage (2010-2011)

The above figure illustrates that the gold mining company reports on electricity, coal and diesel. The entire production flow uses electricity to drive the operations. Coal is mainly used in the uranium plant for steam generation. Diesel is used for general transportation and surface operations.

Since electricity is the largest consumed energy carrier and is mainly used for production reasons, electricity will be the only energy carrier considered for this case study. Furthermore, there is not a “fuel swap” between the electricity, coal and diesel. For example the steam can be generated by coal-fired boilers, as well as electricity boilers.

ii. Measurement boundary selection: Identify

Both the business units have their own regional electricity supplier invoices. The internal electricity metering is complex and difficult to isolate to each individual shaft and gold plant. As previously discussed, in the gold mining process there are only two operational facilities, namely the shafts and the gold plants. In the gold plants, multiple production operations take place. Each of these operations have their own production drivers.

The shafts and milling operations will have a solid material that will have to be weighed usually by belt scales. From the thickeners onwards, liquids are handled. In the elution and refinery

operational phase, solid material will be weighted. Concurrent projects were implemented on business unit one: shaft one and two and business unit two: shaft one. Figure 42 shows the location the energy drivers' meters. The regional electricity invoice boundaries are also indicated in the figure.

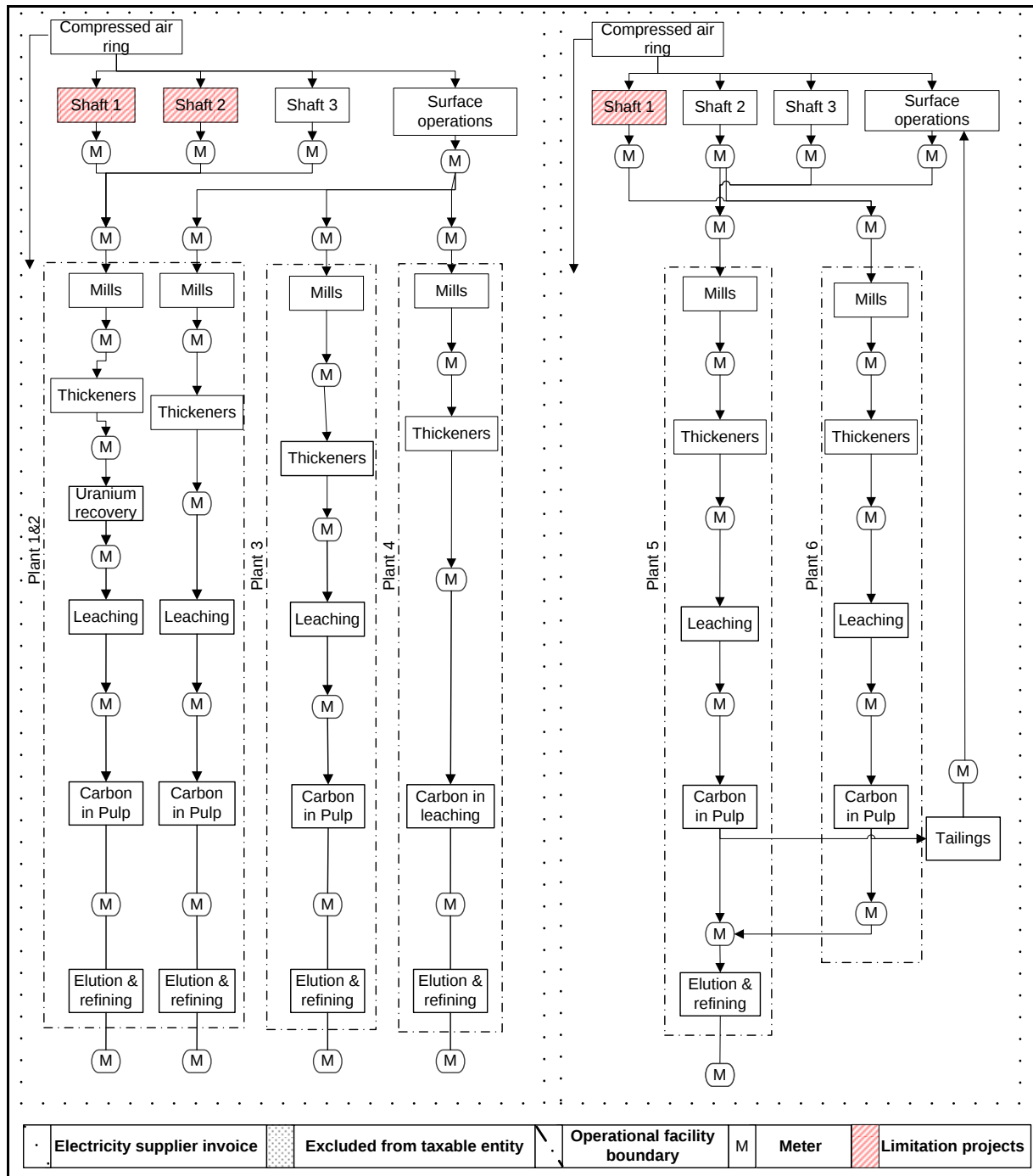


Figure 42: Case study 2 – Identify

iii. Measurement boundary selection: Simplify

Figure 43 shows the energy driver meters compliance. The belt scales that enter the gold plant facility are calibrated. Only gold plant three mills to thickeners belt scale are compliant. The mass flow meters between the thickeners and the leaching process are internally calibrated according to the company's standards. This calibration standard is in accordance with the equipment manufacturing processes and specifications. The electricity supplier invoice as previously discussed is a compliant data source.

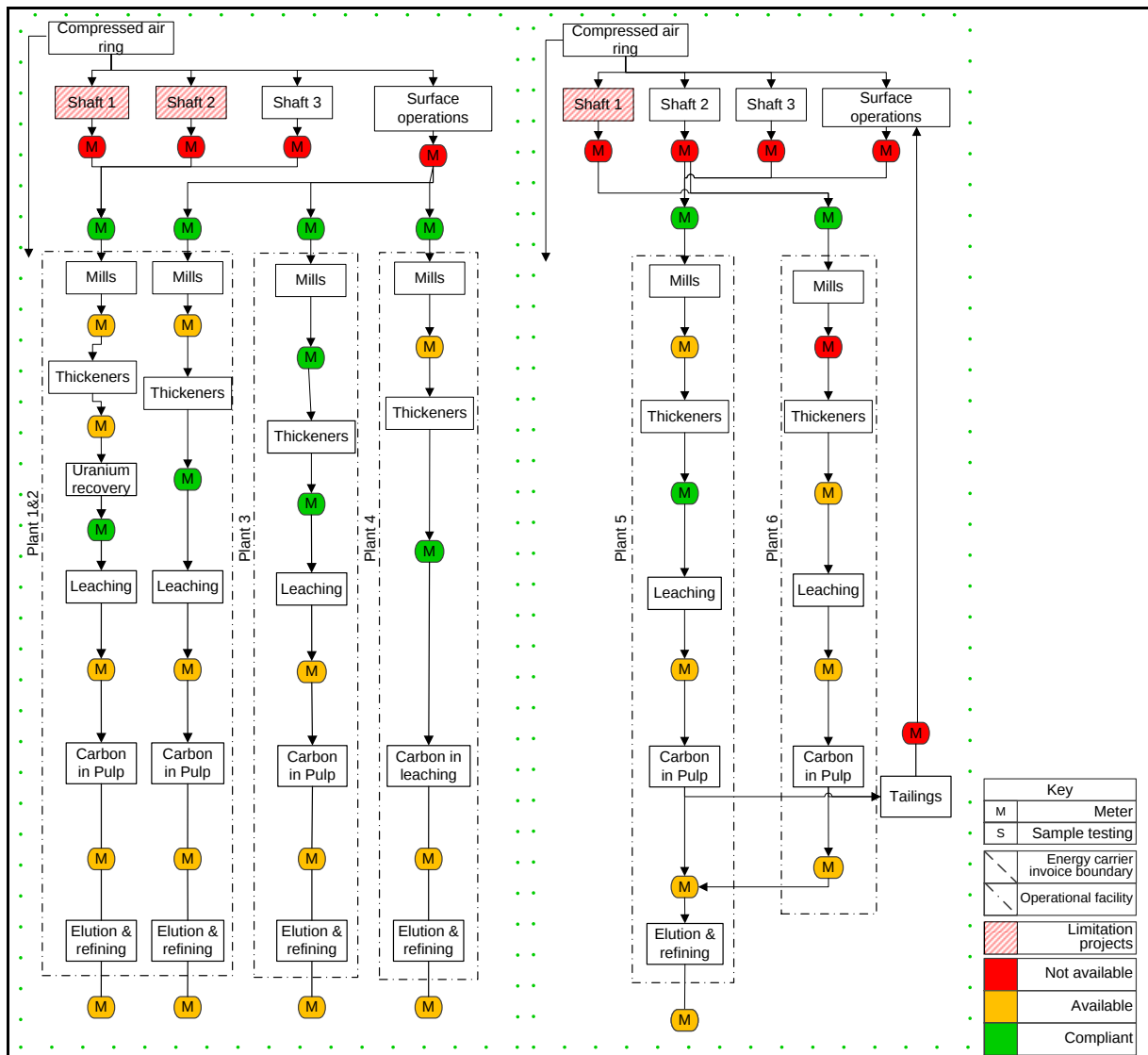


Figure 43: Case study 2 – Simplify

iv. Measurement boundary selection: Select

The mining company continually invests in electricity efficiency initiatives through the implementation of an ISO 50001 energy management system. These initiatives lead to electricity savings that can be claimed for Section 12L. The electricity savings achieved by a number of implemented limitations projects were achieved before this case study's Section 12L baseline. Consequently, the baseline will already be based on the new electricity consumption profile. However, there are limitations to projects that need to be considered, see Figure 44. There are three possible options that can be selected for the measurement boundary.

Both Option A and B isolate each regional business unit. Due to the complexity of the internal electricity, sub-metering of the individual regional electricity invoices can be used. The compressed air system for the business units are also complex to isolate. Therefore it will be the best option to include both the shafts and gold plants in each of the regions. The tonnes of ore transported from the shafts to the gold plant will be the energy driver. The choice between the two options will mostly rely on which business unit has the greatest potential for savings.

Option C will include both Option A and B. This option will require that both the regional electricity accounts be collected for the selected period interval. In addition, the belt scales calibration of gold plant one to six needs to be collected. This option will be the most time consuming, but the highest possible saving can be achieved with this option.

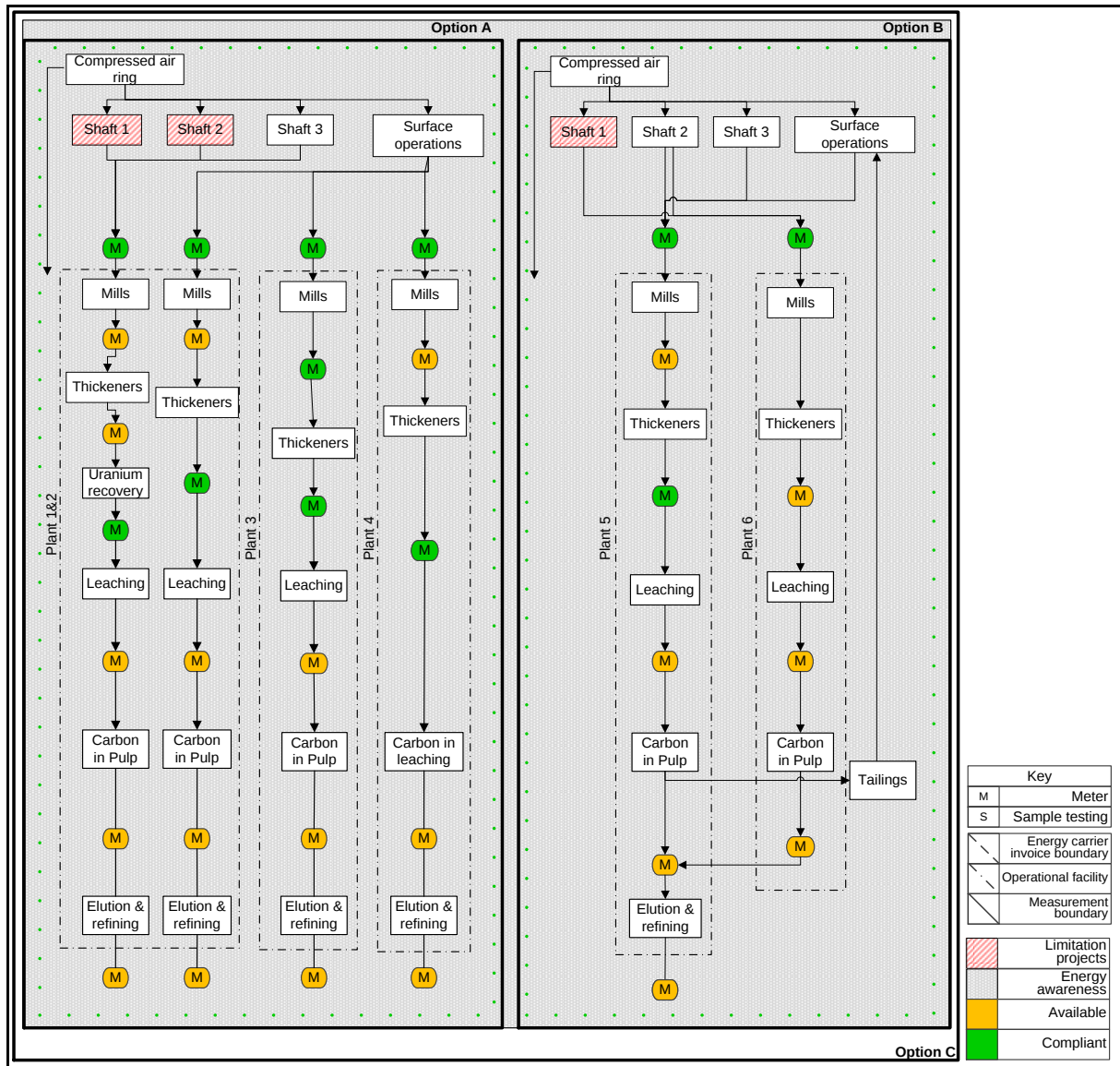


Figure 44: Case study 2 – Select

4.3.2 CASE STUDY 2: DATA COLLECTION AND STRUCTURING

For this part of the case study Option A will be discussed. A whole facility approach was chosen. The methodology will have to be implemented on each of the facilities where a limitation project was implemented.

i. Data collection and structuring: Specify

Table 5 summarises the data and documentation requirements for selected measurement boundary. Only the business unit's electricity supplier invoices will need to be collected for the energy carriers. The belt scales that measure the tonnes of ore from the mining shafts to the

milling plant data will need to be extracted. The calibration certificates for these belt scales are also needed.

Table 5: Case study 2 – Energy carrier and energy driver specifications

Energy carriers

<i>Business unit 1 electricity supplier invoices</i>	Invoices
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Energy drivers

<i>Gold plant 1 mills feeders (belt scales)</i>	Calibration certificate
<i>Gold plant 2 mills feeders (belt scales)</i>	Calibration certificate
<i>Gold plant 3 mills feeders (belt scales)</i>	Calibration certificate
<i>Gold plant 4 mills feeders (belt scales)</i>	Calibration certificate

ii. Data collection and structuring: Collect

Compliance verification

The internal electricity power meters located on the electricity suppliers PoD's incomers was used for the electricity data integrity checks. The gold plants mill feeders' belt scales measured data was compared with the daily production reports.

Folder hierarchy

The folder hierarchy will consist of the collected electricity supplier invoices. For the energy drivers, the belt scales data and calibration documentation are necessary, see Figure 45.

iii. Data collection and structuring: Process

The processing required to make the dataset useable will normalise the belt scale data to a monthly interval. It will also be necessary to input the data from the electricity supplier invoices into the flat-file database. With this dataset normalising, monthly intervals will not be necessary. Figure 46 illustrates the outline of the flat-file database.

4.3.3 CASE STUDY 2: SUBMIT TO M&V TEAM

The measurement boundary selection process, folder hierarchy and flat-file databases are shared with the M&V team. A report can be compiled which included the uncertainties encountered within the process.

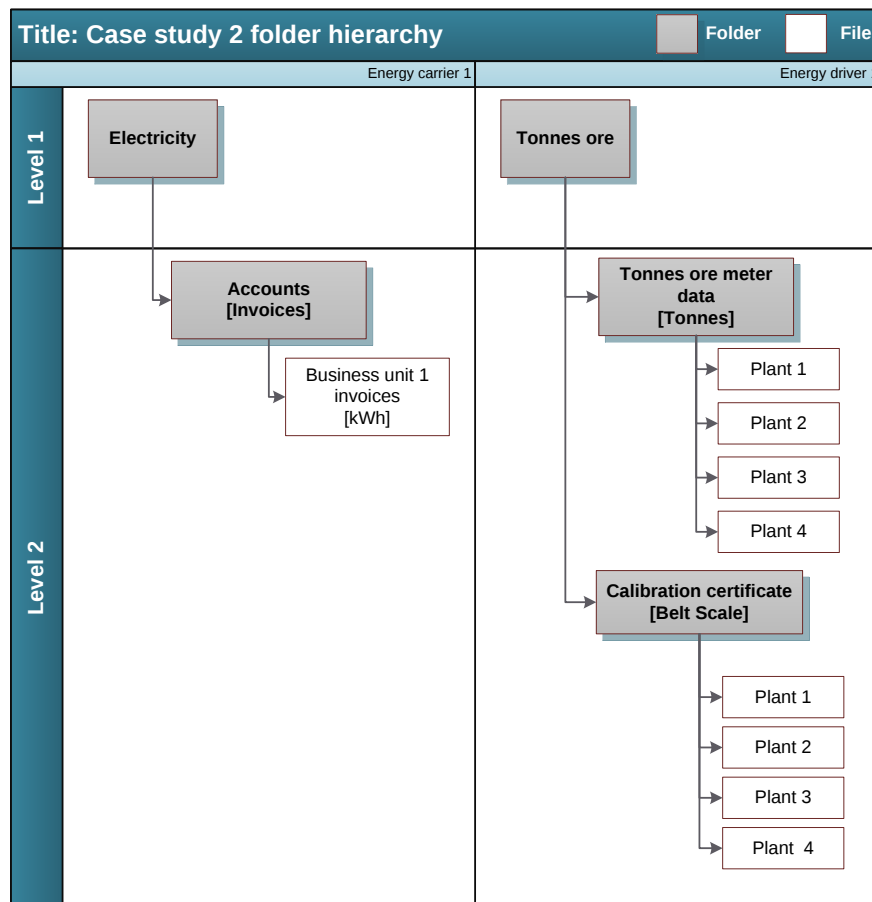


Figure 45: Case study 2 folder hierarchy

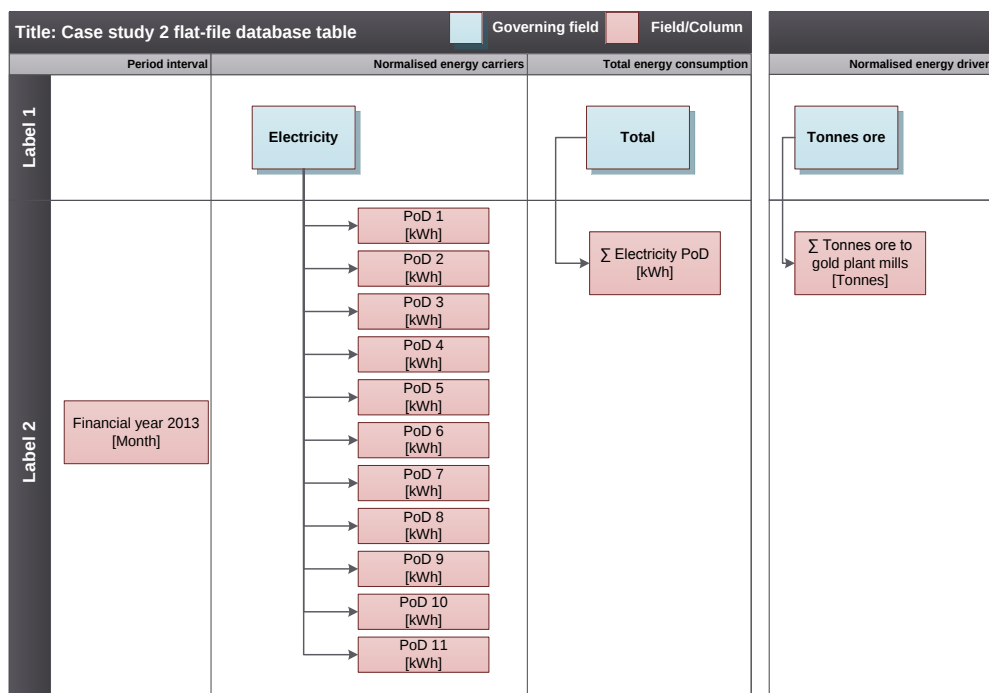


Figure 46: Case study 2 flat-file database table

4.4 CONCLUSION

The methodology was implemented on two complex case studies. In both cases, multiple feasible Section 12L compliant boundaries could be generated. The Section 12L measurement boundary option chosen for both the case studies were a whole facility approach. This was because both the mining companies' energy savings were achieved through improved holistic energy management systems, rather than major infrastructure projects.

For both the case studies limitation and concurrent projects were implemented in the mining phase of the production flow. The selected measurement boundary option in the first case study excluded these projects. However, the second case study had multiple concurrent benefit projects implemented. These projects need to be ring-fenced and excluded from the EEI impact quantification.

The next phase of the methodology implemented produced all the required data and supporting documentation necessary to quantify the EEI impact in accordance with the M&V methodology data assurance principles and the SANS 50010:2011 framework. The auditability of results was illustrated in the transparent and traceable outputs of the folder hierarchies and flat-file databases. All the main objectives of the problem statement were addressed in the practical application and validation of these case studies.

Chapter 5

CONCLUSION

5 CONCLUSION

5.1 DISSERTATION CONCLUSION

The Section 12L application is complex for the gold and platinum mining industries, especially when holistic EEIs are implemented. The main contributor to the complexity is selecting a measurement boundary with EEI impact measuring points that are compliant with all the Section 12L requirements. This step is additionally made overly complex by the mining company's organisational structures and operational energy supply. The SANS accredited M&V team assigned to quantify the EEI impact requires assistance from industry. However, the industry professionals do not necessarily have the required knowledge of the Section 12L EEI quantification process and requirements. A new methodology is therefore required to facilitate the measurement boundary selection process and avoid an inefficient trial and error approach.

The literature study focused on understanding several key drivers affecting the Section 12L application process. An investigation into mining interdependence highlighted the complexity of the production flow facilities, energy supply chain and data management. The M&V requirements in relation to the Section 12L Law, this Section's promulgated Regulations and the SANS 50010:2011 Standard energy efficiency quantification requirements were also studied. Together with these main focus areas, the SADT and the quality assurance principles of Six Sigma was investigated. This study identified the need to firstly simplify the mining complexity and identify measurement boundary. With the high volume of data generated by the mining company and the application a transparent and traceable data storage structure is required.

The study objective was to develop a methodology to facilitate industry to identify Section 12L compliant measurement points for the energy carriers and energy drivers. Thereafter a suitable measurement boundary could be selected. This is followed by industry having to collect, organise and process the data and supporting documentation for the M&V team EEI impact quantification process. This objective was met by firstly simplifying the mining operations complexity, using the activity box principle of SADT, and then identifying

measurement points that are Section 12L compliant. This enables industry to select compliant measurement boundaries.

The boundary selection process indicated the data and supporting documentation requirements for a successful EEI impact quantification and Section 12L application. The data and supporting documentation was stored in a folder hierarchy to ensure a compliant and traceable process. The energy carrier data was normalised to the same measurement period and unit in a flat-file database. The measurement boundary selection process, the folder hierarchy and the flat-file energy equivalent table database were shared with the M&V team.

With this information the M&V team can quantify the EEI impact. The methodology was verified by comparing the outcome of key processes to the mandatory Section 12L Regulations and SANS 50010:2011 documents. In both the case studies presented, the best methodology for the Section 12L measurement boundary was a whole facility approach. This was because the energy savings were achieved through improved energy management system, rather than infrastructure projects. Eight Section 12L compliant boundaries were generated between the two case studies. The most suitable boundary was selected. The collected data and supporting documentation were presented in a transparent and traceable manner, therefore validating that the developed methodology could be implemented to assist industry to select Section 12L measuring boundaries and allow the M&V team to quantify the impact of the EEI.

In conclusion, the Section 12L tax incentive rewards companies for quantifiable energy efficiency savings. However, to claim the tax incentive a strict application process and requirements must be followed to ensure the quality, traceability and integrity of the quantified energy efficiency savings. These strict requirements together with mining interdependence complexity requires effective collaboration between the M&V team and industry, that will need to collect, organise and process the data and supporting documentation for the M&V team.

To facilitate this process a clear methodology was developed to reduce mining complexity, identify Section 12L compliant measurement points and select an appropriate measurement boundary. Thereafter, the specified measuring point's data and supporting documentation was collected and organised in a folder hierarchy to ensure transparency. To further assist the

M&V team, the energy carrier data was processed to the same measurement period and unit. The holistic approach of energy management systems implemented on mining facilities, will require a whole facility measurement boundary approach when applying for the Section 12L tax incentive.

5.2 RECOMMENDATIONS FOR FURTHER STUDY

This dissertation developed a methodology to assist both industry and M&V teams with the need identified in the problem statement. However, the verification and validation of the methodology identified a number of potential subjects for additional investigation.

Firstly, it is recommended that the methodology be adapted for implementation on other industries. This will broaden the scope of the developed methodology and possibly universalise its application.

Secondly, the Section 12L tax incentive application requirements was the main focus of this dissertation. However, there is a number of additional financial incentives and disincentives (for example Section 12I, MCEP, Carbon Tax, etc.) currently in operation. These programmes may also have similar requirements for M&V. Application of the methodology on these programmes should therefore be investigated. This recommendation is also extended to international programmes.

Developing a Section 12L application is resource intensive and therefore has a financial impact. The final recommendation is to develop a model to determine the financial feasibility of Section 12L applications.

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APPENDIX A

CALIBRATION CERTIFICATE



SARTO MASS SERVICES CC
Balance Services and Calibration

Reg No. CK 2001/049589/2
363 Oak Avenue, Ferndale, Randburg, 2194
P.O. Box 15, Randburg 2125
Tel: (011) 787-9179
Fax: (011) 787-9180
e-mail: sartoservice@sarto.co.za

See next page for
certificate of accreditation



Name of client: [REDACTED] Address of client: [REDACTED]		Location: Level 3 Environment: Clean Next Due: Nov-13 Calibration date: 16-May-13 Certificate issue date: 21-May-13	Supplementary Cert.: [REDACTED] Original Cert No.: [REDACTED] Job card no: [REDACTED]
Contact Person: [REDACTED]		Metrologist: [REDACTED] Checked by: [REDACTED]	Procedure(s) Used: SMS001/CP

Standards Used		Description of UNIT	
Description 1	Standard Set of Masspieces	Make / Model :	[REDACTED]
Serial No.		Serial No. :	[REDACTED]
Certificate no.	MVM-5565 d/d May-2012	Unit of Measurement:	g
Description 2		Capacity:	32100
Serial No.		Resolution:	0.1
Certificate no.		Sensitivity test required:	Multi-interval Balance:

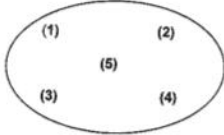
CALIBRATION CERTIFICATE: This calibration certificate is issued under the authority and conditions granted by SANAS. It may not be reproduced except, in full, without the written approval of the laboratory.

CALIBRATION PROCEDURE: The instrument has been calibrated with standard weights of known value, traceable to the national standard, in accordance with Procedure No. SMS001/CP.

REMARKS: SETTLING TIME 5 SECONDS. EXTERNAL CALIBRATION DONE

REPEATABILITY (g)					ACCURACY AND LINEARITY				
LOAD APPLIED (g)	BEFORE (g)	AFTER (g)	AFTER ADJ. DEV. (g)		LOAD APPLIED (g)	BEFORE (g)	AFTER (g)	AFTER ADJ. DEV. (g)	
15000.0	1000.0	1000.0	0.0		15000.0	1000.0	1000.0	0.0	
15000.0	2000.0	2000.0	0.0		15000.0	2000.0	2000.0	0.0	
15000.0	5000.0	5000.0	0.0		15000.0	5000.0	5000.0	0.0	
15000.0	10000.1	10000.0	-0.1		15000.0	10000.0	10000.0	-0.1	
15000.0	20000.0	19999.9	0.0		15000.0	20000.0	20000.0	0.0	
15000.0	30000.1	29999.8	-0.1		15000.0	30000.0	30000.0	-0.1	
Std. Deviation: ±0.0g									

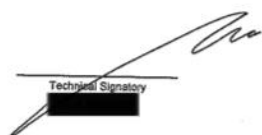
ECCENTRIC ERROR	
Load Applied: 10000 (g)	Error: 0.0 (g)
(1) 10000.0	(2) 10000.0
(3) 10000.0	(4) 10000.0
(5) 10000.0	



EXPANDED UNCERTAINTY: 0.1 g

EXPANDED UNCERTAINTY: The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95%, the uncertainty of measurement has been estimated in accordance with the principles defined in the GUM, Guide to Uncertainty of Measurement, ISO, Geneva, 1995.

VALIDITY OF CALIBRATION: The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling and frequency of use. It is recommended that the recalibration be undertaken at an interval that will ensure that the instrument remains within the desired limits.



Technician Signature

End of Calibration Certificate

CERTIFICATE OF ACCREDITATION

In terms of section 22(2) (b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that:-

SARTO MASS SERVICES CC
Co. Reg. No.: 2001/049589/23

Facility Accreditation Number: **1415**

is a South African National Accreditation System accredited Calibration laboratory
provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying schedule of accreditation
Annexure "A", bearing the above accreditation number for

MASS METROLOGY

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17025:2005

The accreditation demonstrates technical competency for a defined scope and the operation of a
laboratory quality management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the
relevant SANAS accreditation symbol to issue facility reports and/or certificates