Energy performance evaluation framework in South Africa

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Abstract

International performance evaluations on energy efficiency and demand side management (EEDSM) activities are usually conducted at three different levels, namely project level, program level, and policy level. In South Africa, M&V is largely done at project level, but there is more and more a need of evaluations on the program and policy levels. Currently, there is already a program evaluation guideline, but not consciously implemented. There is no policy evaluation guideline, and there is much confusion in the definition and differences of the three levels of performance evaluation. This paper aims to give clear definitions of the three levels of evaluations and share the South Africa experiences, which will further assist program managers, program evaluation panels, and M&V practitioners to prioritise important energy efficiency factors in design or evaluation of the programs and policies. Evaluations on EEDSM projects are usually based on the energy and power saving, with a brief emission reduction assessment. This is not enough for the evaluations at the program and policy levels since there are many other aspects need to be addressed. At the EEDSM program level, people are also interested in finding out the corresponding social and economic impact, which can be evaluated not only from conventional engineering point of view, but can also be evaluated from comprehensive environment, social, and economic aspects. Based on the information gathered from the project level and program level evaluations, the policy level evaluation is conducted by addressing the most important issues in terms of the key performance indicators from the engineering, environment, social, and economic aspects, in conjunction with the financial viability considerations.

1. Introduction

In response to the National Energy Efficiency Strategy [1] and National Climate Change Response Strategy [2], a number of energy efficiency and climate change mitigation programs have been developed and implemented in South Africa. The most well-known programs are Eskom energy efficiency and demand side management (EEDSM) program [3], DTI 12I [4] and SANEDI 12L tax incentive program [5], NBI private sector energy efficiency (PSEE) program [6], and the carbon tax program [7]. In the current energy efficiency space of South Africa, all these programs are actively operated under various energy regulatory institutions. For all of these energy programs, the impacts of energy/demand savings and relevant emission reductions are being monitored and evaluated through a measurement and verification (M&V) approach [8-11]. Such an M&V approach is widely used to quantify specific project level performance indicators under various energy programs, depending on the interests of the program participants. However, there is more and more a need of evaluations on the program and policy levels, which is interested to find out the corresponding social and economic impact, for instance, how many new jobs created each year, how is it aligned with the strategic positioning and restructuring of national economy, etc. The program and policy level evaluations aim to have a “bird’s eye view”, which is able to document the achievements, and identify further improvement opportunities in both energy policy and program developments.

International performance evaluations on various energy efficiency activities are usually conducted at three different levels, namely project level, program level, and policy level. In fact, most of existing energy efficiency program guidelines focus more on the project and program level of evaluation while pay less attention on the policy level evaluation. The project level evaluations usually quantify the project impact in terms of energy/demand savings and carbon emission reductions. For instance, the guideline [12] requires that physical evidence to evaluate an EEDSM program needs to be collected so that calculations based on measured quantitative data can give a rigorous evaluation on this EEDSM program, which is the so-called M&V process that consists of mainly the baselining, performance assessing and tracking procedures. A number of M&V guidelines [8-11] focus primarily on the evaluation of energy/power savings, with also, but relatively less, emphasis on emission reductions. These documents provide comprehensive M&V methodologies for the evaluation of engineering aspects of EEDSM programs, particularly [8] provides detailed M&V plans for different scenarios such as lighting systems, motors, chillers, geothermal heat pump, water, and renewable projects.

Besides the engineering aspects of energy and power consumptions, a full evaluation on environment, social, and economic aspects need also be evaluated for the EEDSM programs. Ref. [12] lists many protocols which includes not only the general energy/power saving impact, but also the market effects evaluation where the change of market structure or behaviour of market participants with respect to an increase in the adoption of energy efficient measures in the EEDSM program is evaluated. References [13] and [14] focus more on the economic analysis of DSM projects. Ref. [15] provides the monitoring and evaluation technique for forestry projects in carbon emission reduction. Environmental and socioeconomic impacts of an EEDSM project are also briefly discussed in [15], where the impacts on the following factors are mentioned: dams and reservoirs, hazardous and toxic materials, indoor air quality, industrial hazards, insurance claims, occupational health and safety, water quality, wildlife and habitat protection or enhancement, cultural properties (archaeological sites, historic monuments, and historic settlements), distribution of income and wealth, employment rights, gender equity, induced development and other sociocultural aspects (secondary growth of settlements and infrastructure), long-term income opportunities for local populations plants (jobs), public participation and capacity building, quality of life (local and regional). The European Union (EU) project in [16] focuses on the socio-economic impacts on renewable energies, for instance the impact of renewable energy on social welfare, migration flows, technology status, culture, security of energy supply, and environment are discussed. Ref. [17] discusses the socioeconomic measurement and validation for pilot building energy efficiency projects in several EU countries, where psychological model of human behaviour, human-machine interaction, and some socio-economic evaluation indicators are discussed. Ref. [18] summarises lessons learnt from Denmark practice on socio-economic assessment of wind power systems.

These international guidelines and practices provide very helpful discussions on the general energy performance evaluations. However, none of them provides a full discussion on the evaluation of all the engineering, environment, social, and economic evaluation of the energy programs at an operational level. In addition, there is much confusion in the definition and differences of the project, program, and policy levels of energy performance evaluation. In this paper, existing energy performance evaluation activities in South Africa are reviewed and summarised according to the summary reports on the key EEDSM projects and programmes, such as the reports on the Eskom EEDSM programme [3], 12I programme [4], the clean development mechanism (CDM) programme [23-24], etc. Based on the review, a systematic energy performance evaluation framework is proposed, with the adoption of a new energy efficiency classification approach which classifies general energy efficiency in terms of the efficiencies of performance, operation, equipment and technology (POET) [19-21]. With the POET framework, M&V professionals with strong engineering background are still able to evaluate EEDSM programs not only from the engineering and environment point of view, but also the social and economic point of view. In the proposed POET based energy performance evaluation framework, the project level evaluation is to quantify performance indicators within the project boundary, but covers at least one of the fours aspects, namely engineering aspects, environment aspects, social aspects, and economic aspects, as a result of an EEDSM program. For instance, to identify the energy/demand savings, CO_2 emission reduction, or annual job creations by an M&V approach is a project level evaluation. The program evaluation is to collect all relevant information and performance indicators at the project level, and then compare the performance indicators, in order to analyse whether the project is cost-effectively implemented and to determine whether each project has positive contributions to the target of the programmes. The policy level evaluation is to guide national policy making, to prioritise EE programs and projects to achieve certain social welfare, or national targets or international commitment and obligations. The policy level evaluation monitors the cost, efficiency, and effectiveness over a number of energy efficiency programs. With the designed comparison matrix and decision matrix, the decision makes are able to choose the most effective and powerful program to be implemented for the desired policy targets, such as to save energy and environment, to promote economic growth and/or job creation.

In South Africa, majority energy performance evaluations are done at the project level by M&V. Currently, there is already a program evaluation guideline, but not consciously implemented. There is no policy evaluation guideline, but with the definitions and methodologies proposed in this paper, it is expected that program managers, program evaluation panels, and M&V practitioners are able to prioritise important energy efficiency factors in design or evaluation of the programs and policies.

2. Current energy performance evaluation status in South Africa

A simplified South African energy efficiency high level policy map is shown in Figure 1, where a more comprehensive one is given in [25]. In addition to the policy map, detailed reviews on all the South African energy policies and are also summarized in [26]. In Figure 1, the energy policy and regulations at the top three levels provide orientation and guidance to the energy efficiency activities at the national level, while the EE incentives and initiative at the two bottom layers focus more on implementation of the energy regulations, which aim to support the national policy. In practice, for various energy programmes, the fundamental manageable and implementable units are the energy efficiency projects. In this section, selected case studies are presented to reflect the current status of the South Africa energy performance evaluation framework at project level, programme level, and policy level. From the case studies, experiences on the energy performance evaluations are summarised while problems on the performance evaluation framework are identified, which need to be properly addressed for the future developments on South Africa's programme evaluation and policy making.

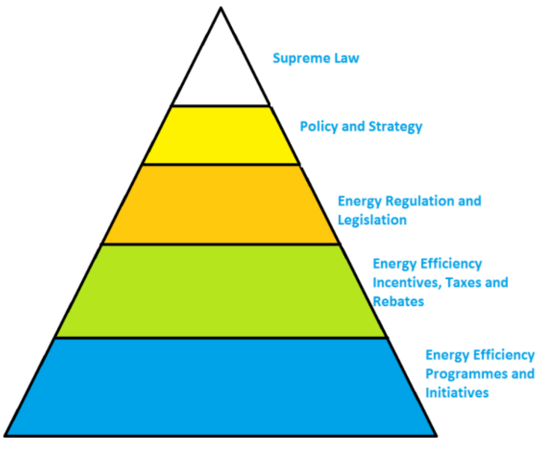

Figure 1. South African energy efficiency high level policy map (simplified).

2.1 Measurement and Verification for Project Level Evaluation

Usually an energy programme is implemented through a series of EE projects that are developed by the energy service companies (ESCos) for the clients. On completion of an EE project, both the clients and the programme administrators want to know the performance of a project. More precisely, the clients are more interested in the energy and cost savings, while the programme administrators want to have a holistic view at the programme level of the relevant engineering, environment, social, and economic impacts. These impacts can be measured and verified by independent third party M&V companies in the M&V process illustrated in Figure 2.

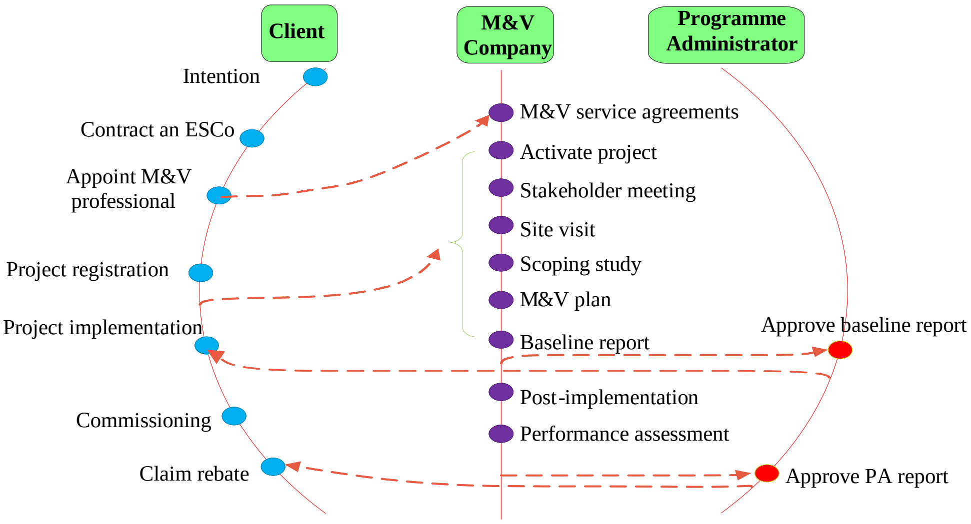

Figure 2. General M&V process in South Africa.

In Figure 2, four parties are involved interactively in the M&V process, namely client, ESCo, M&V Company, and the programme administrators. Usually the energy programmes are designed for the positive impacts from all the engineering, environment, social, and economic aspects, where the impact of each evaluating factor is claimed in either a quantitative way or a qualitative way. Examples for quantitative achievements include the exact amount of energy saving to be achieved, the number of jobs created each year, the reduced amount greenhouse gas emission, etc. Examples for qualitative achievements can be statements on how the program is aligned with national economic strategic positioning, why the program is compatible with local participation, etc. On completion of the M&V process, the performance assessment report will be compiled to evaluate if the expected impact has been achieved. In South Africa, intensive M&V practices have been performed to project level performance evaluation in various programmes as listed in Table 1. As can be seen in Figure 2, the M&V processes are compulsorily required to the performance evaluations on the energy savings and carbon emission reduction impact evaluations.

Table 1. Project evaluation for various EE programmes in South Africa.

Programme	Administrator	Evaluation Approach	Performance indicators
Eskom IDM [26]	Eskom	M&V	Demand and energy savings
National SWH [26]	DoE, Eskom	M&V	Demand and energy savings
Municipal EEDSM [26]	DoE, municipalities	M&V	Demand and energy savings
PSEE [6]	NBI	M&V	Energy savings in kWh per annum
12L & 12I [4-5]	SANEDI	M&V	Energy savings in kWh per annum

CDM [22-23]	Designated National Authority (DNA)	M&V	Carbon emission reduction
Department of public works (DPW) [27]	DPW, DoE, SANEDI	M&V	Demand and energy savings

2.2 Best Practice on Energy Programme Evaluation in South Africa

South Africa is lack of a systematic approach to conduct energy programme performance evaluation. There is a programme evaluation guideline available in [28], but not consciously implemented. Due to lack of a consistent programme evaluation framework, the current programme evaluations have a diverse focus on different performance indicators of different programmes. In addition, the captured performance indicators are not obtained by the same approach. For instance, a programme level evaluation for the period of 01 April 2011 to 31 March 2015 is provided on the 12I Tax Allowance Incentive (TAI) programme [29]. For each project of the TAI programme, the following impact factors are monitored:

- Annual energy savings in terms of kWh;
- Skill development based on training support;
- Attracted local and foreign investment;
- Job creation: new job count at province level;
- Project progress: project distributions in terms of geographic footprint and subsectors.

Among the above performance indicators, only the annual energy savings is quantified by the M&V approach.

In the South African CDM project portfolio [23], there are 347 CDM projects submitted to the DNA. The M&V approach are required to verify the energy savings, and corresponding carbon emission reductions. In the PDD of each CDM project, gold standard assessments are conducted to evaluate the environment indicators, social sustainability and development, and economic and technology development impact of each project. However, detailed evaluation approach on the social and economic aspects is not given in the PDD. A high-level overview on the national EEDSM programme operated by Eskom is given in [22]. The programme performance of the EEDSM programme is solely represented by the achieved MW savings verified by independent M&V teams. A comprehensive review on the energy efficiency activities in the South African public buildings is given in [27]. The report aims to identify a feasible approach to develop energy baseline for the national public buildings, and to further develop an energy savings proposals. Information provided in the report can also be used to conduct energy performance evaluations on project level, programme level, and policy level. Limitation of this report is that all the analysis are focus on the engineering aspects of the energy efficiency programmes, and lack of evaluations on the environment, social, and economic aspects.

2.3 Energy Policy Evaluation in South Africa

There is lack of a clear definition of the energy policy evaluation in South Africa. The policy level evaluation is to guide national policy making, to prioritise EE programs and projects to achieve certain social welfare, or national targets or international commitment and obligations. However, due to poor programme evaluation practice, the programme evaluation reports easily fall into a narrow insight on the energy perspectives, instead of a broader view at all areas across the engineering, environment, social and economic aspects. This situation adds great difficulties to policy makers to compare the performance of among various energy efficiency programmes.

The South Africa DoE has made efforts to review the existing energy policy frameworks, which aims to find most effective solutions to improve the performance of existing energy polices, programmes, and projects. Currently, energy policy reviews rely on regular policy reviews and expert opinions. For instance, an overview and assessment on the national energy efficiency and energy conservation policies and initiatives have been conducted, in order to provide a comprehensive legislative and policy context for the development of the National Energy Efficiency Action Plan (NEEAP). Details on the energy policy and initiative review can be found in [26]. On the other hand, expert opinions suggest the following five policy supports for national energy efficiency development

- to set up a national EEDSM roadmap;
- to strengthen the R&D research and training facilities in EEDSM;
- to mandate SANEDI as an EEDSM implementation agent;
- a ring-fenced overhead to support the implementation of national programmes; and
- to establish a national monitoring, evaluation and reporting framework.

The expert opinions are raised based on an in-depth analysis and comparisons on a number of EEDSM options in terms of programme affordability, implementation and applicable timeframe, and potential savings [30].

2.4 Summary and comments

According to the brief review on the energy performance evaluation activities on the project, programme, and policy levels in South Africa, the following viewpoints are observed:

- Majority of the project level evaluations are performed by an M&V approach, which focus on the engineering aspect indictors such as the energy and demand savings, or the environment aspect such as the carbon emission reductions;
- Lack of clear definitions of performance evaluation at different levels;
- Lack of a consistent programme evaluation framework;
- No policy level evaluation.

In the following, a systematic energy performance evaluation framework is proposed, which takes advantage of the intensive M&V experiences in South Africa, in order to improve the energy performance evaluation framework in South Africa.

3. Proposed energy performance evaluation framework in South Africa

3.1 Definitions and Clarifications

It is proposed to conduct energy performance evaluations in South Africa at three levels, namely project level, programme level, and policy level evaluations. Definitions of the three levels of energy performance evaluations are introduced, and relationships between the three levels of evaluations are also illustrated by Figure 3 to clarify the differences among the three levels of evaluations. Let the round, rectangle, and pentagonal shapes marked with A_i, B_i, and C_i, $i = 1, 2, 3$ in Figure 3 represent various EE project of an energy programme. The projects in the same EE programme may have different EE interventions, different sizes and boundaries. In addition, the projects may be implemented at different time instances or different geographical locations. For instance, an EE programme can have several EE projects that are implemented at the same site as time goes by, such as Project A_1, A_2, and A_3. In addition, an EE programme can also include EE projects implemented at different geographically locations at the same time scale, such as Projects A_1, B_1, and C_1. However, these projects should have the same energy target, which is in line with the objective of the energy programme. In general, project evaluation supports the programme evaluation. The programme evaluation is the process to analyse and compare the project performance matrix, in order to tell the effectiveness and efficiency of various EE projects under the programme. Similarly, the programme evaluation also supports policy evaluation. The policy level evaluation is to guide national policy making, to prioritize EE programs and projects to achieve certain social welfare, or national targets or international commitment and obligations. The outcome of the policy level evaluation is to select the most cost-effective and efficient programmes and projects.

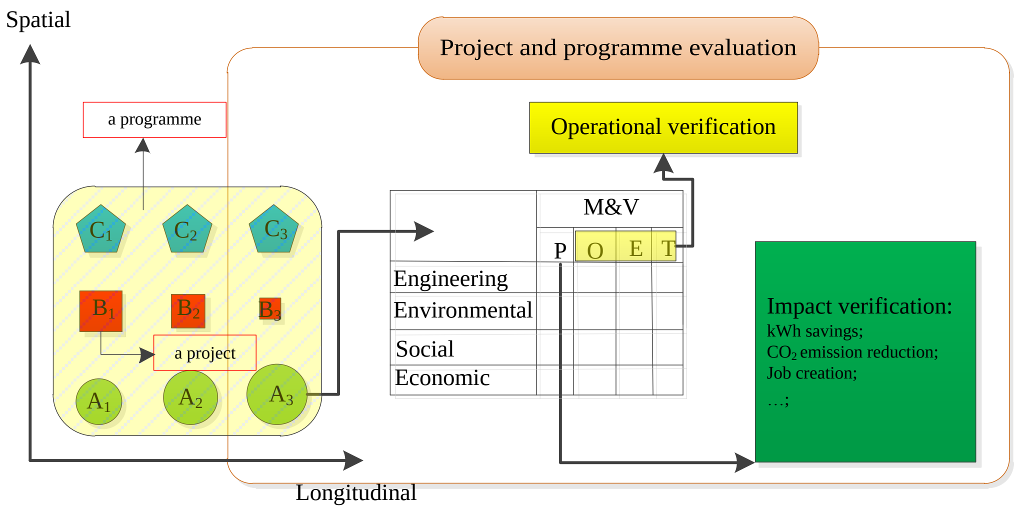

Figure 3. Project evaluation and programme evaluation.

In this paper, a bottom up approach is proposed to conduct the energy performance evaluation framework. At the project level, energy performance evaluation can be performed by an M&V approach under the POET framework from both the energy and non-energy perspectives. And the outcome of the project evaluation can be summarized in a performance matrix as shown in the central of Figure 3. In the project performance matrix, the key factors of interest are documented to further support programme and policy evaluations.

3.2 Project Evaluation

In the M&V process, the project level energy performance evaluation includes two types of verification, namely operational verification and impact verification. The operational verification checks whether the planned intervention has been fully implemented and functional properly; while the impact verification evaluates whether the EE project achieves its target. In this paper, the M&V process is specially carried out under a technology, equipment, operation, and performance (POET) framework. Under the POET framework, the operational verification aims to check the effectiveness of the technology, equipment, and operation components of the implemented energy efficiency intervention, while the impact verification focuses on quantifying the project performance in terms of energy or demand savings, carbon emission reductions, job creations, etc. The project performance can be evaluated from a broader energy perspective in terms of engineering and environment aspects, or non-energy perspectives such as the social and economic aspects. More details on the POET framework, and the different perspectives of energy performance are introduced below.

3.2.1 The POET framework

In this paper, measurement of energy efficiency is summarized to have the following four components: performance efficiency (P), operation efficiency (O), equipment efficiency (E), and technology efficiency (T). This POET classification maintains energy efficiency at its broadest possible scope, taking all aspects of efficiency into consideration. The four components of efficiency are discussed below.

Technology efficiency (T)

Technology efficiency is a measure of efficiency of energy conversion, processing, transmission, and usage; and it is often limited by natural laws such as the energy conservation law. Technology efficiency is often evaluated by the following indicators: feasibility; life-cycle cost and return on investment; and rates of energy conversing/processing/transmitting. Technology efficiency is characterized by its novelty and optimality. On the one hand, ground breaking and feasible novel technologies often defeat older peers and occupy the market quickly. On the other hand, these novel technologies always challenge optimality through the pursuit of scientific limits and the quest for new possible extremes.

Equipment efficiency (E)

Equipment efficiency is a measure of the energy output of isolated individual energy equipment with respect to given technology design specifications. The equipment is usually considered being separated from the system and having little interactive effect to other equipment or system components. Equipment efficiency is evaluated by considering the following indicators: rated capacity; specifications and standards; constraints; and maintenance. Equipment efficiency is specifically characterized by its standardization and constant maintenance. The most important aim of equipment efficiency is to minimize the deviations of the actual equipment parameters to the given design specifications. The difference between equipment efficiency and technology efficiency is easily illustrated by considering the compact fluorescent lights (CFL) example: The study on the improvement of CFL technology to provide more efficient lighting facilities forms part of the category of technology efficiency improvement, while replacing incandescent lights with CFLs is part of the category of equipment efficiency improvement.

Operation efficiency (O)

Operation efficiency is a system wide measure, which is evaluated by considering the proper coordination of different system components. This coordination of system components consists of the physical, time, and human coordination parts. These parts can again be indicated by sizing, matching, skill levels, and time control of these system components. Operation efficiency has the following indicators: physical coordination indicators (sizing and matching); time coordination indicator (time control); and human coordination. In particular, sizing of a single system component is to consider the relationship of this component with respect to the rest components of the system, thus sizing of the system component is an operational issue comparing with the capacity consideration in the equipment efficiency context. Automatic driving is an example of 'matching'. When a car is driven through different speed restriction zones and different traffic flows, the automatic driving system must determine the different speeds of the car for different road conditions to minimize its fuel consumption, or equivalently to maximize its operation efficiency.

Performance efficiency (P)

Performance efficiency of an energy system is a measure of energy efficiency determined by external but deterministic system indicators such as production, cost, energy sources, environmental impact and technical indicators amongst others. The following lists some general indicators for the evaluation of performance efficiency.

- **Production**: Production is often determined by the market, and the performance efficiency can change whenever market conditions change.
- **Cost**: The change of the cost of a process will give rise to the change of its performance efficiency. For example, when a time-of-use (TOU) electricity tariff is introduced, an end user often tries to shift the load from peak time to off-peak time period, resulting in the corresponding electricity cost being reduced, and thus the performance efficiency improved.
- **Sources**: When an energy system consists of different forms of energy sources, for example, electricity, gas, coal, fuel and wood, amongst others, the performance efficiency of the system can be evaluated by considering the usage of these different sources. For instance, using gas in some circumstances will have better performance efficiency than using coal.
- **Technical indicators**: Some technical indicators are used as a means to measure aspects of performance. At other times, technical indicators may be built into the performance objective to drive the design process.

It is worth noting that sometimes these performance efficiency indicators are contradictory or in competition with each other. Any system will usually be expected to maximize the production and at the same time minimize cost, emission and social impact. Therefore the performance efficiency can only be improved when certain trade-offs among different indicators are made. The sustainability of the energy system could be reached when the engineering indicators (e.g. sources) do not compete with the social, economic or environment indicators (e.g. production, cost, environment concerns).

3.2.2 Different aspects of energy project performance

Programme and policy evaluations usually require certain level of details in data collection and analytical methodology that goes beyond routine performance-monitoring reporting. This helps the decision makers determine what kinds of timely adjustments may be needed in program design or implementation to improve the rate or quality of achievement relative to the committed resources. To this end, all the necessary aspects namely engineering aspects, environment aspects, social aspects, and economic aspects will be considered and prioritised in such a way that a comprehensive solution could be suggested. The use of a decision matrix that incorporates the above four major aspects of any energy efficiency project and an analysis of this matrix according to the various indicators of the POET structure are highly suggested. The matrix should include several indicators from each of the four important aspects to be considered. Detailed approach to determine the performance indicator matrix can be found in [28], and the key concerns of the project performance in the engineering aspects, environment aspects, social aspects, and economic aspects are summarized in the Table 2.

Table 2: Energy project performance evaluation.

Project Performance		**POET indicators (examples)**
Energy perspective	Engineering	T: lighting-LED E: 9 W, B22 Cap, warm white LED bulb O: dimming control, motion sensor P: kW/kWh savings
	Environment	T: cause of NO_x and SO_x emission, and the relevant technology to reduce or absorb the NO_x and SO_x emission E: absorption process and equipment for NO_x and SO_x O: production (ton) P: emission reduction (ton)
Non-energy perspective	Social	T: increased demand of human resource and skills in energy efficiency E: mechanism to attract international experts and professionals O: education and training P: job creation
	Economic	T: improved local manufacturing technology E: new factories for manufacturing O: local products are compatible with the market needs P: improved local contents in energy efficiency

Table 3 is an example of the evaluation of the installation of variable speed drives (VSD) for a water pumping system at the project level. The program evaluation panel determines to evaluate payback time, energy converting ratio, maintenance plan, optimal pump on/off scheduling plan, and the overall energy consumption. These evaluation criteria and the corresponding weighting factors are given to the program manager for program development. Then the program manager follows strictly the evaluation criteria and develops the corresponding energy efficiency measures to meet these criteria. For instance, an optimal pump on/off scheduling plan with a short payback period is chosen together with the VSD installation so as to have a higher score in the evaluation.

Table 3. Example of program evaluation from engineering aspects.

Engineering aspects	**Technology**		**Equipment**	**Operation**	**Performance**
Application of VSD	Life cycle cost	Energy conversion ratio (electrical → mechanical)	Maintenance	Matching of system components	Energy consumption
Key items for scoring	Payback = 3 months	Pre: 60% Post: 90%	Optimal maintenance plan	Optimal on/off schedule	Pre: 90MWh / year Post: 60MWh / year
Scores (out of 100)	80	70	65	85	75
Weighting factors	10%	10%	10%	20%	50%
Subtotal	=80*10%+70*10%+65*10%+85*20%+75*50%				

Important to note that although the evaluation on the social and economic aspects of an EEDSM program brings a lot of new exciting evaluating factors in the M&V projects, existing M&V professionals will still be able to handle the new challenge since the evaluation process is exactly the same as the current energy saving M&V projects. Note further that some programs focus only on electrical energy savings, and usually the energy consumption will be a performance indicator to evaluate these programs. These programs also have positive impacts to the environment and the reduced CO_2, SO_x, and NO_x can be calculated from the amount of energy saved, thus these emission indicators should not be double counted in the corresponding program evaluation. There are also programs with the only purpose of emission reduction. For these programs, the performance indicators such as the amount of CO_2, SO_x, and NO_x emitted into the air will play a key role in the evaluation and thus are highly weighted in calculating the scores, while the energy consumption indicator will play a less important role and will be weighted much less. For programs which focus on both the energy saving and emission reduction, the energy saving and emission related performance indicators will be evaluated, and the weighting factors are chosen according to particular program descriptions.

3.3 Programme Evaluation and Policy Evaluation

3.3.1 Programme evaluation

Programme evaluation is supported by the project evaluation. The project level evaluation calculates all relevant indicators in the four aspects under the POET framework, while programme evaluation compares these indicators in order to assess the effectiveness of an EE programme. On availability of the performance matrix at the project level, program evaluation panel can select important issues for evaluation. After the scoring on engineering, environment, social, economic, and financial aspects, a comparison matrix can be further established to understand the output from the program. Table 4 serves as an example of such a comparison matrix, where it can be read, for the impact from this program, that for every MWh saved, there will be 20/500=0.04 job·year created; and similarly, for every ton of CO_2 reduced, there will be 0.02 job·year created. It shows also that the cost for each created job·year is R10000/20=R500. The figures in the table could be ones taken from the previous four tables and the financial viability study. The figures in Table 4 are indicative.

Table 4. Example of a comparison matrix.

	Energy saved: 500 MWh	CO_2 reduced: 1000 ton	Annual job created: 20	Economic growth R 25000	Program budget (R 10000)
Energy saved: 500 MWh	1/1	500/1000	500/20	500/25000	500/10000
CO_2 reduced: 1000 ton	1000/500	1/1	1000/20	1000/25000	1000/10000
Annual job created: 20	20/500	20/1000	1/1	20/25000	20/10000
Economic growth R 25000	25000/500	25000/1000	25000/20	1/1	25000/10000
Program budget (R 10000)	10000/500	10000/1000	10000/20	10000/25000	1/1

3.3.2 Policy Evaluation

The decision matrix can also be used for policy evaluation. After the subtotal scores of the programme have been given from the engineering, environment, social, economic, and financial aspects, then each of the five subtotal scores are multiplied with a corresponding weighting factor, and the products are summed together to find the total score for the programme. This process is illustrated by the following decision matrix in Table 5 which is used to help the decision-making of stakeholders. The comparison and decision matrices are useful tools to compare and rank competing and progressing projects and programmes. In Table 5, the subtotal scores S_i, $i = 1,2, \ldots ,5$ are calculated according to the approach introduced in Table 3, which takes consideration of all the POET factors of an EE project. The weighting factors are decided on a subjective manor. In practice, the weighting factors are decided by an average score from the experts' opinions for each programme.

Table 5. Final score at programme level for policy evaluation.

	Engineering	Environment	Social	Economic	Financial
Subtotal scores	S_1	S_2	S_3	S_4	S_5
Weighting factors	ω_1	ω_2	ω_3	ω_4	ω_5
Total score	$S = \sum_{i=1}^{5} \omega_i S_i, \ \ i = 1,2,\cdots,5$				

4. Conclusion

This study gives clear definitions of the three levels of evaluations and shares the South Africa experiences, which will further assist program managers, program evaluation panels, and M&V practitioners to prioritise important energy efficiency factors in design or evaluation of the programs and policies. Based on the information gathered from the project level and program level evaluations, the policy level evaluation is conducted by addressing the most important issues in terms of the key performance indicators from the engineering, environment, social, and economic aspects, in conjunction with the financial viability considerations.

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