Cost analysis of energy efficiency measures: case study of the South African electricity sector

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Abstract

During the past decade, the South African electricity power system has been coping with a serious electricity supply crisis. The cause of this crisis has been mainly attributed to insufficient generation capacity as well as an important growing electricity demand from consumers. Consequently, the national power grid has been operating under strain. To mitigate this situation, the state-owned electricity utility Eskom decided to introduce energy efficiency measures into its power system. The introduction of these can play a significant role in the sustainability of South African progress towards reducing the dependence on fossil fuels in its power system. However, the implementation of energy efficiency measures into a power system requires a significant investment. Therefore, this study aimed at estimating the costs of saving energy in the South African power system. To date, cost analysis of new and existing power plants has been the focus of several studies over the past decades. Our new cost analysis of energy efficiency initiatives contributes to the body of knowledge by offering decision makers a more accurate picture of the trade-offs involved in decisions affecting the electricity utility. To this end, we calculated and then compared the costs per Megawatt (MW) and kilowatt-hour (kWh) saved across multiple types of energy saving programs, across different sectors including commercial and industrial, residential, low-income, and other sectors. We also evaluated the trend over time of the costs of saving energy from 2011-2016. And the results were tested through sensitivity analysis to discount rate variation. The results revealed that energy efficiency measures are efficient and cheaper to run, thus, they can hinder the need of building new power plants, which require huge capital investment costs.

Keywords.
Energy efficiency programmes, costs of saving energy, South African electricity sector.

I. Introduction

Electricity is assuredly the master key for energy source across the world; meaning that the world has become modern due to electricity. All the facilities and equipment that developed countries rely upon and developing countries seek, from lighting to the most sophisticated electronic devices, require electricity to operate. Electricity is a product that is hard to store since it is the most fleeting among all types of energy. Therefore, it must be consumed as soon as it is generated (Paul, 2010). These two elements (most fleeting and hard to store) make electricity both the most important and one of the most difficult product to understand economically. Due to its magnitude and economic importance, the electricity sector often needs significant investments to increase its power capacity to meet demand from consumers. Because, any lack or shortage of electricity has a serious damage over the economy's activities (Griffing, 2009).

1.1. The South African case

Currently, the South African electricity sector is facing a power supply crisis. This electricity shortfall is threatening the stability of the national grid. The reason for the power shortfall has largely been attributed to insufficient generation capacity and a growing demand for energy. The power crisis has led the utility to build new power plants, and implementing EEDSM programmes across the country to counteract the current electricity shortage issues and to seek sustainable solutions to meet future electricity demand (Eskom, 2010). The South African economy is counted among the developed and emerging economies across the globe. South Africa is rich in coal, and consequently has made online an infrastructure to harness the energy it has in her domestic resources stock. Around the world South Africa is among the countries that deploy coal at large-scale. For example, Burnard and Bhattacharya (2011) report that, the share of coal in producing electricity was approximately 93% in 2011 and coal counted for nearly 70% of total South African primary energy supply. This may not be unexpected knowing that South African coal export prices range amongst the cheapest in the world. South Africa is the most progressive economy across Africa. Griffin (2009) states that, the healthier an environment becomes, the more significance is given to clean energy supply and to energy security matters. Although competitive companies such as mining, automotive, agriculture, food processing, manufacturing and a thriving service area has emerged in South Africa, both energy security and clean energy supply still represent a big obstacle for the country. External impacts from air pollution, usage of insufficient water facilities and carbon dioxide emissions from a considerable burning of hydrocarbons are a huge issue, especially in the Mpumalanga region, where coal power stations with a capacity of 30 GW are installed (Eskom, 2012a). The South African government has acknowledged the necessity for a clean and reliable energy system for its environment and economy. In 2003, the Department of Minerals and Energy (DME), predecessor of today's Department of Energy (DoE), has made an agenda for future energy planning. This agenda was called the Integrated Energy Plan (IEP) and includes South Africa's main principle files for energy planning. The Integrated Resource Plan (IRP) is placed in the IEP and controls the production of electricity and transmission capacity planning. It is regularly reviewed, in accordance with the new technological and cost developments (DoE 2013).

Additionally, to environmental deterioration, energy supply problems are considered as issues, which often take place. Generally, power outages occur during the period of peak demand and both generation and transmission systems are nearly regularly under their utmost strain (Eskom, 2012, McGreal, 2008). Yet, the installed power system is not controlled sustainably and the infrastructure keeps on wearing out as upkeep times are lessen to maintain the lights on. To direct peak demand and the charge over the system, Eskom (2013), the South African electricity utility, supplies the energy users with live system alerts. The current strain over transmission and regional distribution grids is published and advices that appliances must be switched off to prevent the system from collapsing. Electricity market in South Africa is governed and still controlled by one electricity utility and wholesaler-Eskom. It produces and sells electricity to different sectors and municipalities. Electrical energy outages and increasing prices have motivated a rising trend within self-production, especially for the private sector and households. Electricity consumers within these classes have been investing in solar, cogeneration and other distributed producer projects to have absolute direction over electricity feeds and reduce the impacts of electricity outages and growing tariffs.

II. Energy Efficiency Demand Side Management (EEDSM)

The National Energy Regulator of South Africa (NERSA) assigns the Electricity Distribution Industry (EDI) to target 450 000 new electrification connection in South Africa annually (Clark, 1997). It has been predicted that the increase within the consumption of energy involves a construction of new power generation plants to meet the predicted demand. As more and more households are connected to the grid, this mean the augmented consumption of electrical energy especially during peak times. Meanwhile, it was anticipated that electricity demand in South Africa would exceed the present capacity in the next decade (DME, 2003). This medium-run capacity limit has led Eskom to develop DSM as a technology to reduce energy demand in South Africa. This involves the implementation of numerous EEDSM lighting pilot programmes, mostly developing efficient lighting awareness campaign through Elektro-Wise project (Figueres & Bosi 2006). The residential sector is the main target since it most susceptible to peak load demand, as its load constitutes 75% of the total national variable load (Clark, 1997).

II.1. Objectives of EEDSM Programs

EEDSM programmes aimed at:

- Providing electricity consumers and ESCOs a fixed rate for delivering energy and/or demand savings, enabling them to effectively and quickly build and suggest EEDSM projects
- Streamlining the project approval process and scale-up project development and execution
- Simplifying the contracts among the electricity supplier and the ESCOs or end-users
- Reducing the load on the utility staff for project assessment and processing
- Providing lucidity to project promoter on the disbursement for produced savings
- Facilitating the leveraging of commercial financing for EE projects

- Reducing the risk of utility by making the disbursement performance-based and pay only for measured and verified savings

II.2 Programs Design
The EEDSM programmes have been designed in a way of allowing Eskom to buy peak demand savings and/or energy savings from electricity consumers by a fixed amount of money. These programmes have simplified assessment of project proposals and payment for the incentives or subsidies, therefore decreasing the load on Eskom team and enabling a wider pipeline of projects. The more lucidity the shorter processing times, and decreased transaction risk of EEDSM programmes also enabled gathering of commercial financing, important for achieving a considerable scaling up of investment (Etzinger & Andrew, 2011).

II.3 Eligibility criteria
The subsequent kind of organizations (called project developers) are qualified for providing proposals to Eskom under these programs: Any organization that consumes electricity produced by Eskom or of municipal electricity supplier in the commercial and industrial sectors, Any ESCO, described as a business organization, which supplies any of the subsequent services: energy engineering, Energy efficiency program design, equipment installation, equipment upkeep, and financing services on a performance-contracting basis. If the project developer is not an electricity user or facility owner, an arrangement among the electricity users or facility owner and project developer will be needed, which must transfer ownership of verified energy saved from the users or facility owner to the project developer. It is a condition of the program that the project developer be registered with Eskom as a seller (Etzinger & Andrew, 2011).

II.4 Approved Technologies
A list of accepted technologies has been published by Eskom for payments under EEDSM programmes. Eligible project developers should prove that his project will reduce decrease energy use at the project site during Eskom's peak period, and ensuring that the energy savings will correspond to the size expected by Eskom, according to the different programmes. The figure 1 below shows the types of technologies that are approved by Eskom.

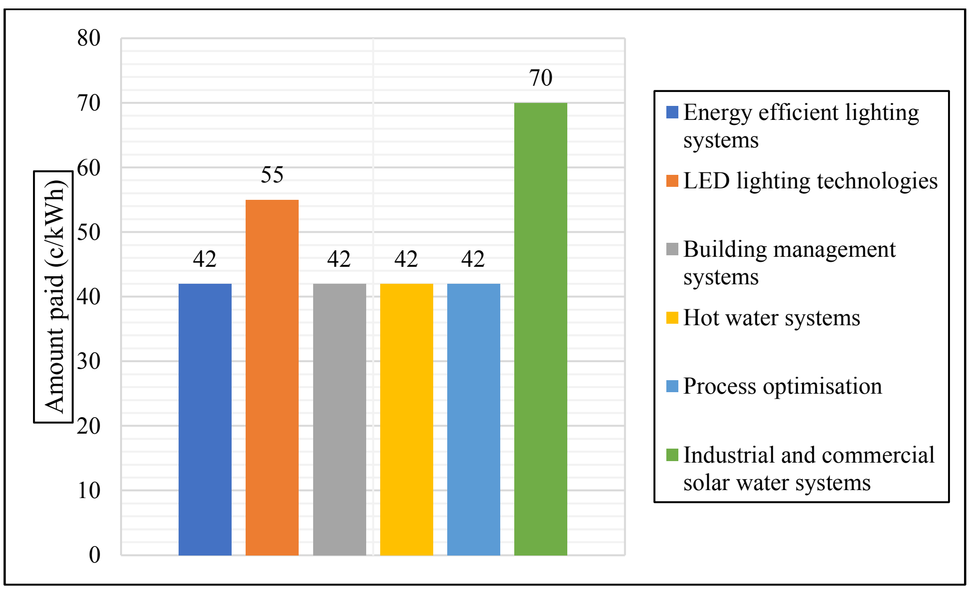

Table 1. Technologies approved under DSM programmes (Skinner, 2012).

II.5 Type of EEDSM programmes

To reduce the energy supply outage issue, the following EEDSM programmes are being carried out by the Eskom:

- Compact Fluorescent Lamps Rollout
- Residential Mass Rollout

- Standard Offer
- Standard Product
- Performance Contracting
- Solar Water Heating
- ESCO Model

II.5.1 Compact Fluorescent Lamps (CFL) rollout campaign

The present programme has been designed to replace incandescent lamps. The market focus of this campaign is residential sector. A CFL consumes up to 75% less power and last up to 10 times longer than incandescent lamps (Mascha & Gerswynn, 2009). That is why, Eskom is currently promoting the usage of CFLs that are distributed free of charge to household across South Africa. These CFLs are being rolled out in various ways, as presented below:

a. Door-to-door

In door-to-door programmes fieldworkers visit households' door to door in a area and remove incandescent lamps by installing CFLs. Mostly, these projects target the low and middle income households. The advantage of this kind of intervention is that lamps are installed directly, while replaced incandescent lamps are destroyed. This guarantee that the rollout results in its optimal savings with a high degree of certainty. The programme requires thorough record-keeping and savings should to be checked with follow-up audits on a regular basis (Mascha & Gerswynn, 2009).

b. Exchange

This intervention requires that end-users exchange their incandescent lamps for CFLs at a designated exchange point (i.e. Shoprite stores, Municipal offices, and Eskom branches). This approach is less labour intensive at the point of exchange, than the door-to-door programmes. And, there is a direct exchange and the replaced lamps are destroyed. Nevertheless, there is no certainty that the use of CFLs will be straight away. Thus, calculating the savings attributable to these CFLs with a high degree of confidence is not easy. In addition, because this is a voluntary programme, consumer participation may be insignificant (Mascha & Gerswynn, 2009).

c. RLM-accompanied CFL

As a motivation for enabling the installation of a geyser relay switch in residential sector, homeowners are given several CFLs free of charge. In this case, no extra labour needed to roll out the CFLs, however some effort is needed to capture the details of the drop-off. Like the exchange projects, it is not known whether these CFLs are used directly or are shelved (Mascha & Gerswynn, 2009).

d. Sales campaigns

This programme encourages the sale of CFLs by reducing the price of the lamps. The details of the end buyer are not known and the use of the lamps is difficult to follow. Several surveys may be required to capture any important information on the adjustment elements. M&V team form North-West University (2010) reports that CFL campaign may be divide into some categories in accordance with certain characteristics related to a CFL project that involves the type of CFL project as well as the income classifications of residential sector. A home may be categorised into a low, middle or high income group by assessing the number of rooms in the home or externally by observing the quantity of cars or garages within a home. The income classification is defined in table 1 below.

Table 1: Income classification of households

Income classification		
Low income	Middle income	High income
1-6 rooms No car / no garage	7-8 rooms One car / one garage	9-10 rooms Two cars / two garage

These different income classifications method allows the M&V team members to quickly evaluate the income group without interviewing the homeowner.

II.5.2. Residential Mass Rollouts (RMR)

RMR is an EEDSM program designed to alleviate electricity supply burden by rolling out determined energy efficiency technologies at residential households. RMR involves mass replacement of inefficient lighting, implementation of energy saving technologies and load control devices within the residential sector. This programme is shaped to run until December 2015. But, Eskom reserves the right to break off, revise and/or carry on with the programme (Eskom, 2012). In addition, the RMR programme has been made online to urgently respond to the necessity of alleviating the national electricity supply system burden. RMR programme is only shaped for residential sector to solve the electricity supply issues stated in the above lines. It should be noted that residential sector is the major contributor to the evening peak demand, thus, the primary goal of RMR is to reduce the demand on the grid during peak period, specially the evening peak demand (Eskom, 2012). Currently, Eskom is replacing inefficient technologies with a pre-approved suite of energy efficient products as presented below:

- CFL replacing Incandescent lighting
- LED replacing Halogen Downlighters
- Geyser Controllers
- Geyser blankets
- Showerheads

The RMR is a replacement program offered free of charge to the consumer. The market focus is residential sector. The size of energy savings must be between 1MW and 5MW. The rebate is according to the installed technology (Andrew, 2011).

II.5.3. Standard Offer Program (SOP)

SOP can be described as a method for obtaining demand-side initiatives (Energy efficient and load management) under which an electricity industry buys energy savings and/or demand reductions from electricity consumers by deploying a fixed amount of money that will be paid based on a unit saved, for example c/KWh. The fixed rate per unit saved is paid to any electricity consumer or ESCO, which is able of delivering electricity and/or demand savings. This fixed cost is paid after finalizing the EEDSM project and verification of the saved energy by an authorized M&V team. Basically, SOP deals with EEDSM projects in a way of encouraging energy users to reduce their consumption by efficiently use electricity, and considering that the energy or demand reductions as resources that the utility will pay for (World Bank, 2011). The fixed rate to be paid for the energy conservations and/or demand reductions under a SOP is based on the quantity of energy conservation to the utility grid. The energy efficiency policies of South African government (DoE 2009) has designed SOP as the best system for implementing EEDSM initiatives. Currently, SOP is the selected system for executing the incentives from the EEDSM Fund that is set by Eskom through an energy tariff surcharge signed on by NERSA. In 2010, a pilot SOP was carried out by Eskom carried out, afterward a SOP based on three-year was introduced into the electricity market (DoE, 2010).

II.5.4. Standard Offer Product (SPP)

SPP is an energy efficiency measure designed to purchase energy from commercial consumers that deliver a verified load saving that is superior at 100 kW and only apply to technologies that have been approved under this program. SPP has been designed with the goal of creating capacity to implement small and medium-sized projects where electricity consumers are encouraged to replace inefficient technologies with energy efficient equivalents (Coetzee et al, 2012). Which is implemented by consumers themselves to receive an agreed upon rebate from the Eskom. The payments are made according to worth of the technology installed and depend on the size of energy saved. The payment is 85% of the SOP fixed rate (36-59c/kWh), paid based on the technology. (Vermeulen, Bekker & Jakoef, 2012).

II.5.5. Performance Contracting Program (PCP)

PCP is a power conservation measure aiming to purchase a bulk verified energy savings from industrial consumers throughout numerous sites and technologies by contracting with a single Project Developer. The target of this program is to save at least 30GWh of energy during a period of three years. The core of PCP relies on energy efficiency and Eskom will contract for energy savings mostly between 6:00 and 22:00 on weekdays' basis (Coetzee et al, 2012, Uken, 2012). Project developers are invited to bid through a tender process and payments are made at Multiple fixed rates per kWh based on time of savings (Peak period is 55 c/kWh, and Other 10 c/kWh). The contract period is three years (Skinner, 2012).

II.5.6 Solar Water Heating (SWH)

The SWH has been designed to supplies a standard, pre-determined rebate per unit for replacement of residential electric water heaters with pre-approved SWHs. The worth of the discount is capped in magnitude bands for the SWHs. This program is shaped to assist achieve the South African government's objective of installing more than 1 million solar water heaters by 2014 (Skinner, 2012).

II.5.7 Energy Services Companies (ESCO)

ESCO is a power conservation program aims at supporting a partnership between Eskom and Eskom's licensed Energy Services Companies (ESCOs) or business who wants to carry out energy efficiency programs. The markets target of this program is: commercial, industrial, mining and agricultural sectors where there is an opportunity for lowering energy use at consumers' electricity consumption at customers' buildings, and scoping, carrying out and implementing these programs on behalf of consumers (Rankin & Rousseau, 2008). The ESCO Model has also the objective of helping consumers to conserve electricity and, consequently, decreasing their operating costs by retrofitting and replacing intensive technologies with energy efficient technology solutions (Skinner, 2012). The aim of Eskom's support of energy efficiency programs is to reduce demand for energy during the day, however especially from 5pm to 9pm, the period of peak demand for electricity weekday's evenings. The size of saving should be beyond 1MW and the payment is between 50-70c/kWh.

III. Methods

The Cost of Saved Energy (CSE) was used in this study as a cost analysis method. CSE measures the costs associated with energy savings that accrue during the lifespan of the efficiency measures, and secondly CSE method considers the time between initial capital investment and future energy savings. Therefore, in his work Meier (1984) argues that LCSE is an investment statistic that simplifies comparison of conservation measures among themselves and against competing energy supplies. Meier (1984) adds by saying that CSE is especially useful when futures prices are uncertain. It should be noted that CSE is not a benefit-cost analysis because it does not aim to capture the monetized worth of efficiency to utility customers and shareholders (Molina, 2014). The reason of selecting CSE for the scope of this study is because it allows cost comparison between energy efficiency programs against one and another and CSE enables cost comparisons between energy efficiency programs versus power generating technologies. Meier (1982); Molina (2014); Cynthia et al (2005); Takahashi & David (2008), Meier (1984), Eto et al (1996), Joskow & Marron (1992), Ali et al (2010), (Friedrict et al. 2009), all state that CSE can be calculated according to the equations presented below:

$$\text{CSE per kWh} = \frac{\text{C}\times\text{CRF}}{\text{D}} \tag{1}$$

$$\text{Cost per MW} = \frac{\text{capital cost}}{\text{Demand savings}} \tag{2}$$

$$\text{CRF} = \frac{\text{A}\times(1+\text{A})^{\text{B}}}{(1+\text{A})^{\text{B}}-1} \tag{3}$$

$$\text{Demand savings} = \frac{\text{n}\times(\text{P}_{\text{i,BL}}-\text{P}_{\text{i,PJ}})\times\text{GUF}}{1{,}000{,}000} \tag{4}$$

$$\text{GUF} = \frac{\text{number of lamps burning during peak time}}{\text{Total number of lamps distributed}} \tag{5}$$

$$\text{ES}_{\text{i}} = \frac{\text{n}\times(\text{P}_{\text{i,BL}}-\text{P}_{\text{i,PJ}})\times\text{O}_{\text{i}}\times365}{1{,}000{,}000} \tag{6}$$

Where:

- CSE : cost of saved energy
- C : program costing

- CRF : capital recovery factor
- A : real discount rat
- B : estimated program measure life in years
- D : amount of energy saved by the program over one year
- Demand savings : the demand saved during peak time (MW)
- GUF: Global utilisation factor
- $P_{i,BL}$: Rated power of the baseline lighting devices of the group of "i" lighting devices (Watts)
- $P_{i,PJ}$: Rated power of the project lighting devices of the group of "i" lighting devices (Watts)
- n: number of types of equipment replaced and installed
- ES_i : Estimated annual electricity savings for equipment of type i, for the relevant technology (MWh)
- O_i : is the Average daily operating hours of the lighting devices replaced by the group of "i" lighting devices.

IV. Results

In this section, we analyse the results as calculated with different equations as presented in the above lines. First, we present the results regarding the costs related to CFLs rollout campaign. Second, we present the results for the costs of implementing EEDSM programs as well as the CSE of these energy efficiency programs. Third, we estimated the costs of saving energy in different sectors such as commercial and industrial, residential, low-income, and other sectors. Lastly, we evaluated the trend over time of the CSE from 2011-2016. All these results are discussed in the figures 2, 3, 4, and 5 below.

IV.1 CFL campaign

The cost analysis for the CFL campaign has been conducted based on the amount of distributed CFLs. Thus, the table 2 shows the CSE related to the replacement of incandescent lamps with CFLs.

Table 2. Cost associated with the replacement of incandescent lamp with CFL

Features	60W incandescent	15W CFL	Sources
No of replaced lamps	2.2 million	N/A	(Fikile et al, 2012)
No of installed lamps	N/A	2.2 million	(Fikile et al, 2012)
Cost of installation per lamp	N/A	R25	Assumption
Daily burning hours	3.5	3.5	(DoE, 2012b)
Number of lamps burn during peak time	1.6 million	1.6 million	Assumption
Project costing (Rm)	55		
GUF (%)	72		Equation (5)
Demand savings (MW)	71		Equation (4)
Annualised energy savings (GWh)	126		Equation (6)
Cost per MW (Rm / MW)	**0.77**		Equation (2)
CSE (c/ kWh)	**0.43**		Equation (1)

IV.2. Costs of implementing EEDSM programs

This sub-section will assess the costs of implementing energy efficiency measures against each other; the comparison is based on cost per Megawatt saved by each measure. Therefore, the table 3 and figure 2 below shows this cost analysis.

Table 3. Capital costs and cost of saving energy

	RMR	SOP	SPP	PCP	ESCO	SWH	Sources
Capital costs, Rm	300	350	450	1 750	1 768	356	Eskom (2016)
Estimated program life, years	4	4	4	4	4	4	Eskom (2016)
Real Discount rate, %	8	8	8	8	8	8	Eskom (2016)
Energy savings, GWh	150	190	250	2547	1 276	71	Eskom (2016)
Demand savings, MW	49	60	77	260	417	14	Eskom (2016)
Cost per MW saved, Rm/MW	6	5.8	5.8	6.7	4.2	25.2	Equation (5)
Capital Recovery Factor, %	30.18	30.18	30.18	30.18	30.18	30.18	Equation (4)
LCSE, c/kWh	**60**	**56**	**54**	**21**	**42**	**151**	Equation (3)

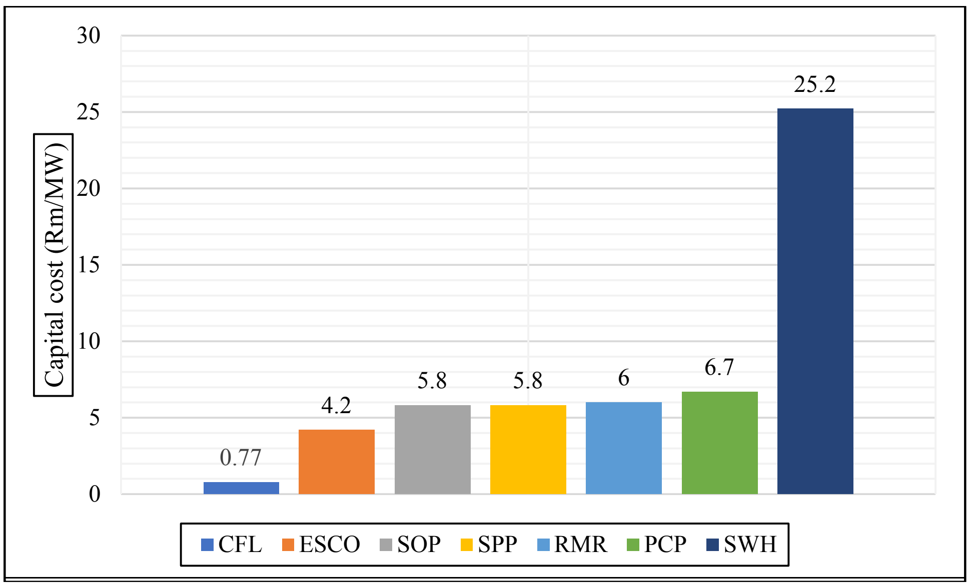

Figure 2. Capital cost comparison between energy efficiency programs

The figure 2 above shows that CFL represents a big opportunity to save energy and is not expensive like other programs. It can be seen from the result that the CSE varies widely, both among and within EEDSM program types. The reason maybe explanation is that the data used in this study consist of many large programs and for any given program type, larger EEDSM programs have lower CSE than smaller programs because of investment capital costs that are spread over more projects. Basically, commercial and industrial sectors use a lot of electricity. But when looking at the results from the figure 1 above, we can notice that the Residential Mass Rollouts whose market focus is residential sector has got the program costing, which is like the program costing of Standard Offer Program, Standard Product Program, and slightly less to Performance Contracting Program who's their markets focus is either commercial or industrial sectors. The reason may be attributed to the fact that during peak period when all residential consumers use electricity at the same time the demand in residential sector is higher especially during winter season. In 2015, Eskom report that the demand for electricity in residential sector accounted for 35% of the national generation capacity.

IV.2. Costs of saving energy

This sub-section aims at evaluating the costs associated with energy saved between energy efficiency programs. Therefore, the figure 3 below presents this analysis.

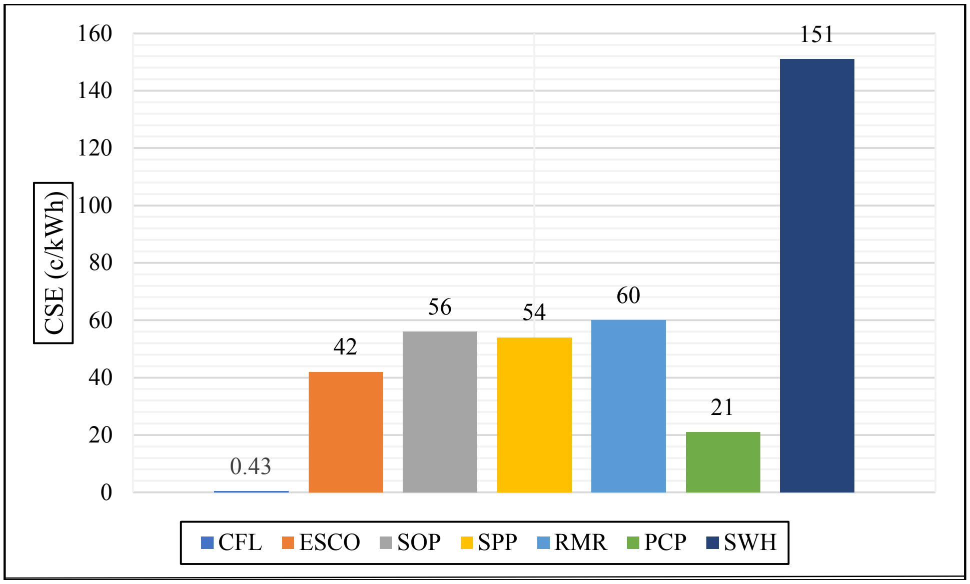

Figure 3. CSE comparison between EEDSM programs

The figure 3 above shows that CFL rollout campaign has the least cost than any other program. While, SWH rollout program is the most expensive. One possible explanation is that the replacement of inefficient geyser with a pre-approved Solar Water Heater is expensive when comparing to lighting technologies. Another reason may be due to the market focus of SWH rollout campaign, which is residential sector. In this sector during peak period consumers use a lot of electricity. Peak periods are the times when the demand for electricity is high – generally when everyone is using a lot of electricity at the same time, i.e. from 7 am to 10 am and 6 pm to 8 pm. Especially during winter season, and another explanation is that electricity is most wasted in residential sector, where some of consumers do not know how to use it wisely. Therefore, any savings made in residential sector will have important benefits for the national economy.

IV.3. CSE sensitivity analysis to discount rate

This sub-section aims at testing the results of CSE of different sectors including commercial and industrial, residential, low-income, other sectors. In this sense, a CSE sensitive analysis to discount rate is shown in the figure 4 below with two discounts rate 3% and 6%.

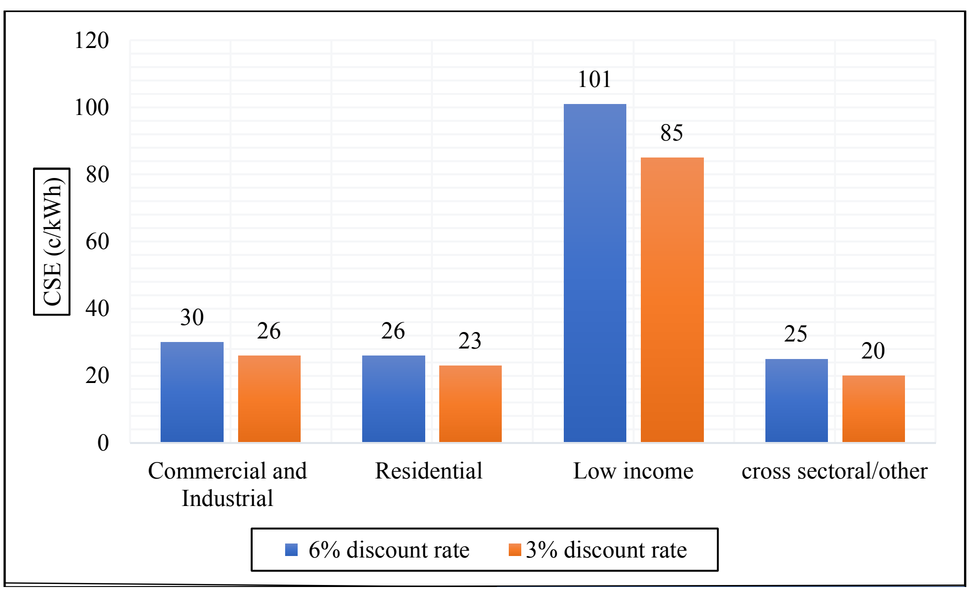

Figure 4. CSE for EEDSM programs by sector

The first observation from the figure 4 above is that although commercial and industrial sector is the biggest consumer of energy. But when looking at the results from both 3% and 6% real discount rate, it can be depicted that it is extremely expensive to save energy in low-income sector than in any other sector. One possible explanation is that in most low-income households, energy inefficient technologies are the most used. Hence, energy is seriously wasted in low-income sector than in any other sector. And this situation increases the price of electricity. Another reason is that during peak period when all low-income consumers use electricity at the same time the demand in this sector is higher especially during winter season. These programs aim at achieving specific social policy goals regardless of energy resource acquisition objectives. The low-income programs are generally carried out at no cost to energy users. In 2015, Eskom report that the demand for electricity in residential sector accounted for 45% of the national generation capacity.

IV.4 Trends over time of CSE

In this sub-section, we evaluated the evolution of average CSE by size of EEDSM programs from 2011-2016.

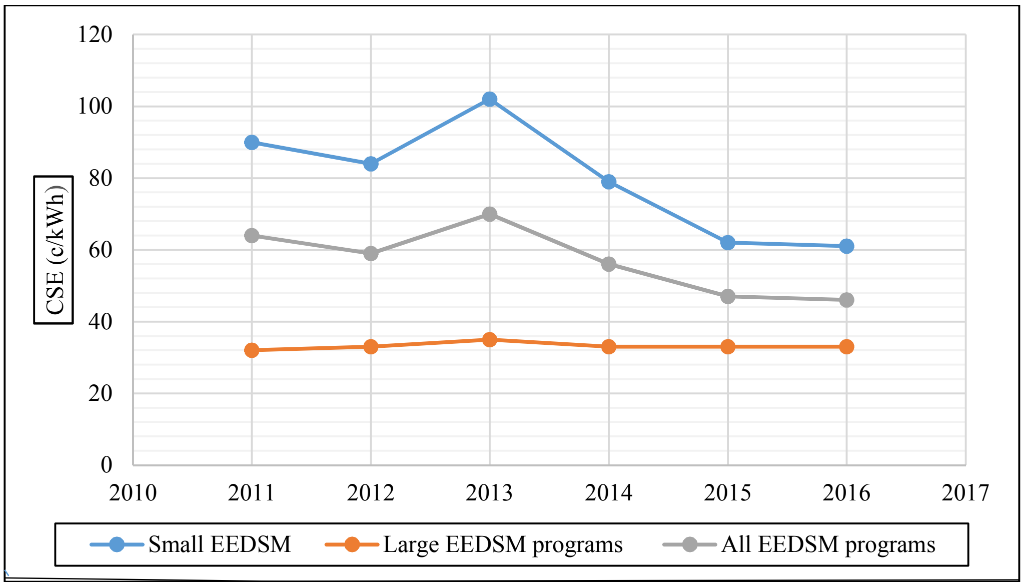

Figure 5. Average CSE by size of EEDSM program and year, 2011 to 2016

The figure 5 above illustrates a comparable picture for CSE per kWh saved. It can be depicted from the figure a decrease in overall average CSE parallels the decreasing CSE of smaller EEDSM programs. Whilst, the CSE of larger EEDSM programs are almost constant at around 33 c/kWh saved. In 2016, the overall average CSE per kWh saved of the large EEDSM programs was approximately 72% of the CSE per kWh saved in 2011. Whereas, for small EEDSM programs the 2016 costs fell to 68% of the 2011 level. In conclusion, EEDSM programs are growing bigger over time, whilst the CSE of smaller programs are decreasing. In the intervening time, the CSE of large programs are almost constant from year to year, at approximately 33 c/kWh per kWh saved. This is far below the average wholesale costs of delivering electricity.

V. Conclusion

Over the current decade, South African economy has been growing at a fast pace that is reflecting the consistent high national power demand growth. As a result, the electricity utility is coping with a rapid decreasing reserve margin throughout the load profile. The surplus capacity under which the utility operated during the past decades has been mainly exhausted and it is expected that the utility's power system stays restricted whilst new capacity is being built. During the previous decade, the utility has introduced into the market energy different EEDSM programs, which have demonstrated theirs worth in mitigating high electricity demand during peak period. Considering this, the main objective of this study was to evaluate the costs of saving electricity in the South African power system. The results revealed that EEDSM programs will play a crucial role in the future South African electricity supply by alleviating the financial burden of producing electricity through power plants. Additionally, with the implementation of EEDSM program, the utility can make the best use of its existing supply capacity to improve the current energy crisis in South Africa. Additionally, the implementation of EEDSM initiatives in commercial and industrial, residential, low-income, and other sectors can create a sustainable energy and gain socio-economic development. Furthermore, as most of South African primary energy are supplied by coal technology, the implementation of EEDSM programs will help to reduce the amount of carbon dioxide (CO_2) emissions into the atmosphere, and hence to combat climate change and global warming. Since CO_2 causes many damages to human being health. To sum up, EEDSM measures are efficient and cheaper to run, thus, they will hinder the need for building new power plants, which generally require a huge investment.

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