LBNL-1003759

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Water Heater Technical Study to Improve MEPS – South Africa

Michael A. McNeil[1]
Theo Covary[2]
John Vermeulen[3]

Lawrence Berkeley National Laboratory, Berkeley, CA[1]
Unlimited Energy, Johannesburg, South Africa[2]
University of Stellenbosch, South Africa[3]

Energy Technologies Area
August 2015

This work was supported by the Collaborative Labeling and Appliance Standards Program through the U.S. Department of Energy under Contract No. DE-AC02- 05CH11231.

Disclaimer

Water Heater Technical Study to improve MEPS - South Africa

Abstract

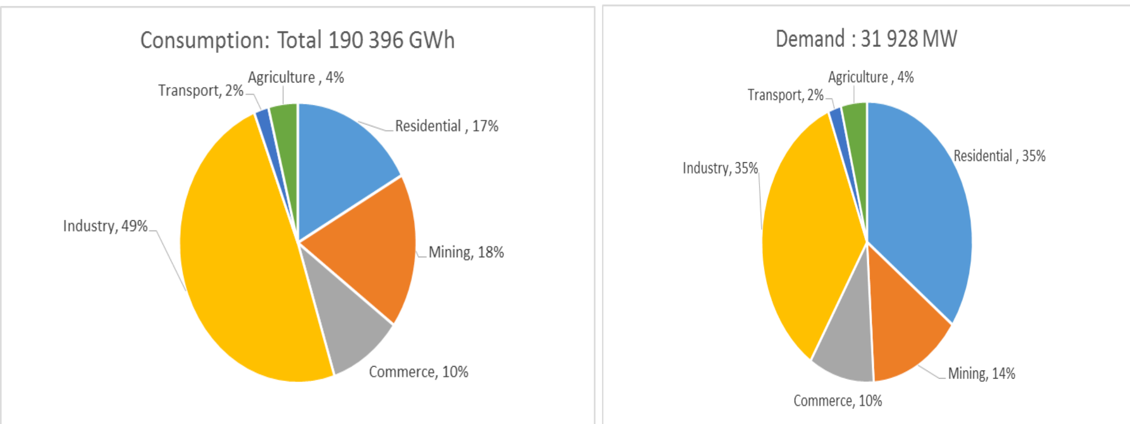
The residential sector accounts for approximately 17% of electricity use in South Africa, but as much as 35% during peak periods. Within households the electric water heater (WH), commonly referred to as a geyser in South Africa, is responsible for between 40-50% of total consumption and contributes substantially to morning and evening peaks. Although there is an existing Minimum Energy Performance Standard (MEPS) regulated by the standing heat loss test (SANS151) it was formulated many years ago and has not been improved since its introduction. In the current context it is considered low and ineffective.

Numerous attempts to improve the MEPS have proved futile primarily due to strong resistance from the industry. The Super-Efficient Equipment and Appliance Deployment (SEAD) is supporting the South African Government in implementing its Standards & Labeling (S&L) programme for residential appliances, which includes WH. In an attempt to break this 'deadlock' a cost efficiency technical study on WH was commissioned by SEAD. The research would use global and local industry experts to conduct the research so as to provide credible empirical data to clarify cost-effectiveness issues and allow for informed decision making.

Introduction

South Africa's electricity crisis has worsened since the country experienced large scale rolling blackouts in 2008 due to supply shortages. Two mega coal generation plants, with a combined generation capacity of 9,600 MW, which were expected to start delivering power in stages starting January 2010 are still under construction in February 2015. The delay has forced the national utility (Eskom) to run its existing power stations harder and to delay essential maintenance work. The consequence five years later is an increase in plant accidents and failures. Power from the country's much celebrated Renewable Energy Independent Power Producers Programme (REIPPP), initiated in 2011, starting generating power in 2014 but the quantities are as yet still insufficient to cover the shortfall. The country's Demand Side Management (DSM) Programme, operated by Eskom, had delivered verified savings of 3,500 MW **[1]** since its inception in 2007 but was suspended in October due to budget constraints. Eskom generates more than 95% of the country's electricity. In December, 2014 the Minister of Public Enterprises, Eskom's sole shareholder, warned that it is '*going to be very tough for about two years longer and patience will be needed on the part of all citizens'.* Since that declaration the country has been experiencing rolling electricity blackouts on a daily basis.

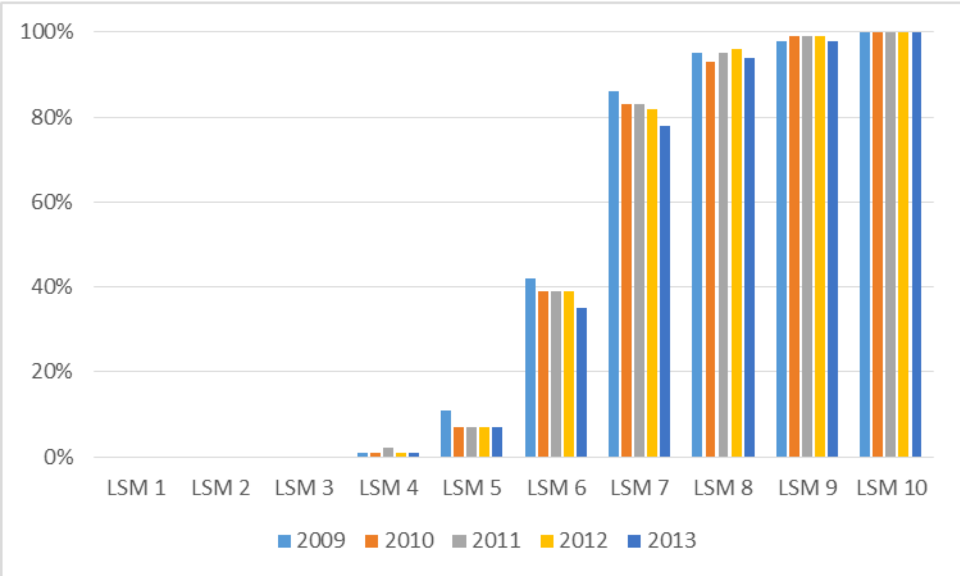
Under these circumstances all efforts to reduce consumption become significant. South Africa's residential sector can play a meaningful role not only because it is the second largest consumer of electricity but because of how it influences demand. The residential sector accounts for approximately 17% of electricity use in South Africa, but as much as 35% during peak periods **[1]** (Figure 1).



Source: Eskom (2012)

Figure 1: Sectoral electricity consumption and peak period demand

As recently as the late 1980's the country's electrification rate for residential households was low (35%), whereby almost all white households had electricity and the electrification rate of non-white households was extremely low. An electrification programme was implemented in the early 1990's and by 2001 the electrification rate had increased to 61% **[2]**, by 2011 it was 83% **[3]**. By the late 1990's the country's electrification programme expanded the market for electrical appliances by an estimated 50% **[4]**. But the country's high income inequality segregates the population **[5]** and means that different residential segments have very different consumption profiles. The Living Standards Measure (LSM) is the most widely used marketing research tool in South Africa and measures affluence by dividing the population into 10 groups, 10 (highest) to 1 (lowest). Groups 1-4 are low income or indigent (3.8 million households in 2013), 5-8 middle class (8.9 million households in 2013) and 9-10 represents upper income (2.3 million households in 2013). One of the questions asked in the annual survey is: '*Do you have hot water from a geyser? (electric water heater)*' The responses for the period 2009-2013 are shown in Figure 2.



Source: All Media and Product Survey (AMPS)

Figure 2: Penetration of WH by LSM group 2009 - 2013

As can be seen in Figure 2 only middle and high income households use electric water heaters. The lower middle and indigent households source their hot water from electric kettles or by boiling large pots of water. This may be done on an electric stove or from a coal or wood fire. A study conducted by Eskom (2013) **[6]** found that the average middle income household uses between 750kWh and 1,100kWh per month, of which the WH is the biggest consumer accounting for 39%. The second biggest consumer of electricity is space heating (16%). WHs have thus been correctly targeted for electricity savings for many years by: 1) Consumers looking to reduce their electricity bill; 2) Government to achieve its energy savings targets under the National Energy Efficiency Strategy and its international commitments to reduce greenhouse gas emissions; and 3) Eskom under its DSM programme and to manage peak demand, by offering a rebate on Solar Water Heaters (SWH) and Heat Pumps (HP) and a free WH blanket to improve the insulation and thus reduce standing losses.

Two opportunities exist for energy savings from WHs. The first is to improve the existing technology used to heat the water, which is electric resistance elements, by migrating to gas fired boilers, SWH or HP. The second is to minimise heat losses. This country's S&L programme targets the second opportunity and limits itself to improving insulation efficiency at the manufacturing stage.

Evolution of the Water Heater Market in South Africa

The manufacture of WHs, has evolved slightly differently as compared to the other large residential appliances. This is in line with the way the electric WH market has developed internationally where there is a large variation in the product class and use of hot water. Climate and culture play important roles in the need for hot water and dictate the practices of its use. This wide variation in climate and culture is correlated to the variation in type and size WHs used in households and available locally. Colder and wealthier countries tend to use large storage tank WHs. In warm-climate countries, if households have a dedicated WH at all, these units tend to be smaller and are not turned on continuously. Electric resistance storage tank water heaters are most common in South African households **[7]**. Gravity fed WHs dominated the market up until the 1950's. In the 1960s 100 kPa copper WHs entered the market followed by 400 kPa steel WHs in the 1980s. Steel WHs were transformed to 600 kPa in the 1990s, which became and remain the market standard. Fibreglass and plastic WHs were also introduced in the 1990s but these make up a very small percentage of the market. Copper WHs are now virtually redundant **[8]**. The use of gravity fed WH required that they be placed at the highest point in a house. This meant that all residential WH were installed in the space between the ceiling of the top floor and the roof, or attic. With the introduction of pressurised WHs it was no longer necessary to install the WH in the attic, but the practice was entrenched and architects continued to design and specify that WHs be installed in the attic. In addition WHs are installed directly above the bathroom which they service. It is not uncommon for large houses to have as many as three WHs. All bathrooms must have access to an exterior wall for effluent plumbing requirements and with minimum dimensions of 1.1m X 0.6m are not able to fit vertically in this limited space due to the pitch of the roof. To overcome this WHs were installed in a horizontal rather than a vertical position. These unique practices as well as other factors such as the quality of the water in different geographical areas with some regions having particularly hard water (high content of calcium and magnesium), the relatively straightforward technology needed to manufacture WH and the high costs to import them due to their physical size and low value and national standards which have evolved to serve the local market means it is not economically viable or practical to import units and almost all WHs in South Africa are locally manufactured. Kwikot, the country's oldest and dominant manufacturer with a market share in excess of 65% was established in 1903. The rest of the market is made up of smaller companies, two of which control a further 25% and the balance is made up of small privately (family) owned business which serve regional or local markets. A few high end products are imported such as gas fired water storage heaters but these are niche serving the top end of the market and have a negligible market share.

WHs enter the market in one of two ways. It is a contractual requirement for all houses that are financed (bonded) to take out building insurance. This insurance covers all fixtures and WHs installed on the property are insured. Should a WH fail households contact their insurance company and not a plumbing service. The insurers outsource this function to plumbing companies who install a new unit within 24 hours. Other than reporting the incident, the household has little involvement in the process. This practice accounts for over 60% of annual sales. The other 40% of the market is made up of sales to newly built houses or renovations, and once again the owner is generally not involved as the WH is sourced and installed by the contractor responsible. In both instances the decision makers have no incentive to install a more efficient model, which in all likelihood is probably more expensive. Their only obligation is that the WH installed is certified and meets the mandatory health and safety requirements as set out by the South African Bureau of Standards **[9].**

South Africa's Standards and Labelling (S&L) Programme and National Standards

The Energy White Paper (1998) was lauded as a progressive policy document that aimed to liberalise the market by introducing independent power producers (IPP) and supporting the introduction of renewable energy and energy efficiency. The Paper specifically addressed residential appliances under the section of Energy efficiency in par. 3.5.3: 'A domestic appliance-labelling programme may also be introduced' **0**.

The National Energy Efficiency Strategy (NEES) issued by the South African Department of Minerals and Energy (now Department of Energy - DoE) in 2005 set a national voluntary target for EE improvement of 12% by 2015 (using a 2000 baseline). Under the residential sector the NEES states '*Appliance Labelling with Minimum Performance Standards*' as one of the four interventions **[11]**. In the same year the DOE introduced a voluntary labelling scheme, which was a precursor to a mandatory Standards and Labelling (S&L) Programme. The voluntary scheme targeted refrigerators but encouraged manufacturers to extend it to all their appliances. The voluntary programme had limited impact. With no support or signals from Government on the implementation of a mandatory programme it was soon forgotten and abandoned by manufacturers and retailers. In 2007 the South African DoE and the United Nations Development Programme (UNDP) country office agreed to submit a joint application to the Global Environment Facility (GEF) for financial support to implement a mandatory S&L programme Error! Reference source not found..

An imperative for the South African Government was that the introduction of a mandatory S&L programme does not exert any excessive pressure on local manufacturers and consumers. To properly assess the situation and provide local manufacturing an opportunity to provide input, an impact analysis study was commissioned by the Department of Trade and Industry and sponsored through the Fund for Research into Industrial Development, Growth and Equity, FRIDGE (2011) Error! Reference source not found.. The objective was to determine the baseline performance (base case) of residential appliances in the market, how these compared to locally manufactured models, and identify a MEPS level that would maximise energy savings with an acceptable impact to manufacturers and consumers. The findings of the study would be used as a benchmark for the MEPS to be adopted. The large energy savings potential from WHs made them a natural inclusion in the country's S&L programme. Standing losses from WHs in South Africa are high and exceed 2 kWh per day or 730 kWh per annum **[7,13]**. An improvement of 15% or more amounts to over 100 kWh in yearly savings per unit for the household. With a minimum of 450,000 WH being sold annually savings of this order are significant in terms of avoided generation and reduced GHG emissions **[13].**

WHs, unlike the other appliances selected for the country's S&L programme, were already subject to energy performance requirements. All WHs must attain SANS 151 **[14]** certification before they can enter the market. This national standard includes a maximum allowable standing loss per 24 hours. For the two most popular models in the market, the 150 L and 200 L it is 2.59 kWh and 3.02 kWh respectively. These levels were set when high pressure steel WHs were first introduced and have not been revised since. The development of standards consider health, safety and environment. Where personal injury may result the South African Bureau of Standards will set the minimum requirements. The remaining requirements are developed by technical committees (TC) made up of industry, Government and any other interested parties. Requirements are agreed by the TC based on mutual consensus and reaching agreement can be contentious due to the vested interests of the numerous participants. Under this arrangement it is often the case that the lowest common denominator is adopted.

An outcome of the latest review of the SANS 151 in 2011 was the introduction of an energy performance label that would be affixed to all WH. No improvements would be made to the existing standing loss requirements. The WH industry was approached to participate in the FRIDGE study but only two manufacturers, who jointly controlled < 5% of the market, agreed to participate. The rest of the industry argued that they fell under the SANS 151 process. As a result the FRIDGE study was not able to complete a detailed analysis **[13]**. A public meeting hosted by the National Regulator for Compulsory Specifications (NRCS) in 2012 to discuss the adoption of improved MEPS was met with fierce opposition from the industry. The reasons cited were as follows:

- WHs fall under SANS 151 and not the S&L National Standard (941).
- An international survey undertaken by the industry found that the existing standing loss requirements in South Africa are amongst the highest in the world.
- There is growing international consensus that the standing loss approach is an outdated and ineffective measure to improve energy performance. A more appropriate test is the simulation test which the EU was developing. It would be more prudent to wait for the outcome of EU regulations and then customise these for the South African market.
- Due to the structure of the market the purchaser of the WH is not the end user making S&L, a consumer oriented programme, ineffective.
- WH sizes in South Africa are not random but based on standard cut steel sizes and access points into the attic.

The industry concluded that the proposed requirement to improve the energy performance via increased insulation would mean a disproportionate increase in costs due to retooling requirements, customised steel sheets and additional effort to access the attic. These costs would be substantial and would result in a net cost to the consumer. After considering all representations a communication was put out in 2013 by the NRCS **[15]**:

In light of these comments, lack of agreement in the EU and elsewhere, and available evidence, the Government authorities have concluded that there is insufficient reliable information regarding SA needs for more efficient water heating systems to take a decision on MEPs for water heaters. The

FRIDGE study is useful but the conclusions are open to question due to the small number of local manufacturers that participated.

It was decided that further research into the efficiency of water heaters is necessary before taking any decisions on MEPs and a timetable for implementation. At least a year is required to complete such a study, and terms of reference will be drafted and tenders called for. SANEDI is investigating sources of funding.'

The NRCS statement did not address the question of costs and it is questionable as to whether NRCS had any real intent in sourcing the required funding, or whether it was even likely that SANEDI would be able to source the funding, without which the study could not be undertaken. The NRCS position implied that it was unlikely that the MEPS for WH would be improved in the short to medium term. As GEF funding is based on GHG reductions the entire S&L programme was at risk as the removal of WHs meant that the forecast energy and resultant GHG savings of 3.8 TWh by 2030 would be halved **[13].** The need for a technical study was therefore crucial but a year had passed and still no funds had been allocated. International funding for the study was secured from SEAD as a consequence of the ongoing relationship between LBNL, who collaborated in the FRIDGE study and identified the relevance of such a study, and their decision to appoint a local consultant to provide input and advice to the local S&L project team and feedback to SEAD itself who are not based in the country.

International Cooperation and Technical Studies

As a signatory to the Clean Energy Ministerial (CEM), South Africa's S&L programme has received technical support since 2011 from the Lawrence Berkeley National Laboratory (LBNL) through the Super-Efficient Appliance Deployment (SEAD) Initiative. It was resolved to try and overcome the technical and information barriers which were delaying decision making by undertaking a series of studies to address the concerns raised by industry, many of which were anecdotal but difficult to dispute due to the lack of available and credible research.

International Survey of Electric Tank WH Efficiency and Standards

A paper was presented by LBNL and Unlimited Energy at the South Africa Energy Efficiency Conference (November, 2013), which surveyed international WH efficiency and standards **[7]**. The paper compared the various test parameters used around the world and assessed if in fact it was true that the existing MEPS for WH in South Africa are among the best in the world. The study found that the approach used in South Africa is not dissimilar to the ones employed in other major economies (Table 1) and therefore comparable. In stark contradiction to the claims made the WH industry that South Africa has among the highest MEPS, the country was found to have weak MEPS (Figure 3), and as a result large savings for standing loss improvements exist.

Table 1: Test Parameters for Electric Storage Tank Water Heaters

Economy	Test Parameters
South Africa	48 hour standing loss test, Δt 45°C
India	Standing loss test, Δt 45°C
European Union	Proposed, simulated use test. Eight draw patterns. Separate standing loss test for hot water storage tanks
United States	Simulated use test, six draws at one hour intervals, Δt 37,5°C

Figure 3: Comparison of standby loss requirements for MEPS and labelling categories for 200L WH

Water Heater Insulation Cost-Effectiveness Study

The findings of the international survey provided sufficient evidence for a detailed techno-economic analysis, which was broken into two separate studies, namely a technical study funded by SEAD and an economic study funded by S&L programme. The objective was to determine the projected cost to manufacturers and consumers to reduce WH standing losses to varying degrees in order to formulate MEPS supported by analysis of net financial impacts to consumers.

To gauge the distribution of performance of the WH market, 5 models were selected, purchased and subjected to testing. Due to a high degree of consolidation in the market, the sample was estimated to represent close to 90% of the market in the most common capacity category of 150 L. Each WH was then subjected to the following four sub-tasks **[16]**:

- *Product testing:* The WH was tested according to the national standing loss test procedure. These test measurements formed the technical baseline of the study.
- *Product tear-down measurements:* The WH was disassembled to determine the corresponding engineering configuration of the baseline.
- *Component cost determination:* Market information on material and labour costs was gathered.
- *Standing loss and cost determination:* The impact of additional insulation was modelled and the final costs to manufacturers and consumers was calculated.

The findings of the study are summarised in the Table 2 below.

Table 2: WH Insulation Cost-Effectiveness Study

Activity	**Finding**
Standing Loss Test	• All units were found to be in compliance of the current MEPS; • Adjusted standing loss measurements ranged from 1.87 kWh/24hr to 2.54 kWh/24h in the horizontal position, placing one model in the 'C' category, 4 in the 'D' range and one in the 'E' range; • Significant differences were found in test results between the horizontal and vertical configurations; and • Ambiguities in the test procedure configuration specifications were found to produce significant variation in results.
Tear Down Analysis	The thickness of insulation averaged over different parts of the tank ranged from 20-26mm, but was highly non-uniform for some models

<table>
<tr>
<td>Cost Effectiveness of Increased Insulation</td>
<td>Cost-effectiveness indicators were calculated for various levels of insulation. The indicators used were: 1) Incremental Life Cycle Cost (ΔLCC); 2) Payback Period (years) and; 3) Cost of Conserved Energy (CCE)
<table>
<tr><th>t</th><th>ΔLCC</th><th>Payback Period</th><th>CCE</th></tr>
<tr><th>mm</th><th>R (EUR)</th><th>year</th><th>R (EUR)</th></tr>
<tr><td>20 (baseline)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>25</td><td>-1,486 (110)</td><td>0.15</td><td>0.05 (0.005)</td></tr>
<tr><td>50</td><td>-4,596 (350)</td><td>0.30</td><td>0.10 (0.01)</td></tr>
<tr><td>75</td><td>-5,595 (430)</td><td>0.47</td><td>0.16 (0.01)</td></tr>
<tr><td>100</td><td>-6,010 (460)</td><td>0.66</td><td>0.23 (0.02)</td></tr>
<tr><td>125</td><td>-6,173 (475)</td><td>0.87</td><td>0.30 (0.025)</td></tr>
</table>
</td>
</tr>
</table>

The overall findings of the study were as follows:

- WH are compliant with current regulations, but show significant opportunities for further reduction of standing losses.
- Increasing insulation thickness is demonstrably cost-effective from the consumer standpoint in terms of increased material costs well beyond the 50mm level considered to be feasible by manufacturers.
- As a result of this, and in light of other heat losses, a 'B' level is likely achievable by WH manufacturers and cost-effective to consumers.
- Ambiguities in the current test procedure language and methodology may result in large variation in results and should be reviewed to increase precision. These include aspects such as the nature of external pipe fittings present during the test, positioning of the internal temperature sensor relative to the heating element, exact temperature control range boundaries during test, orientation specifics, etc.

The WH industry was consulted extensively during the study to address the issues identified by the industry. Table 3 lists the issues and how each of these were addressed.

Table 3: WH Industry MEPS Improvement Concerns and Steps taken to address them

Industry Concern	Actions Taken to Overcome Barriers
WHs fall under SANS 151	Largely a ruse used by the industry to delay proceedings. This was overcome through cooperation between the DOE and SABS who confirmed that an industry can be compelled to comply to multiple standards and regulations as long as they are not contradictory
SA WH MEPS are already amongst the highest in the world	The international survey on WH efficiency and standards **[7]** dispelled these claims. The findings of the paper were not questioned by the industry
Standing loss test is outdated. Wait for EU to develop simulation test	Although the EU is developing a simulation test, a standing loss test is still required. It was incorrect of the industry to imply that a standing loss test would become redundant
Purchaser of WH is not the end user	For the economic analysis, the insurance industry was approached and found to be supportive of more stringent MEPS. The additional increase to monthly premiums was very low. For the building trade, contractors must buy SABS approved WHs and any additional costs will be passed on to the consumer, which are cost effective and thus beneficial
Costs associated with retooling make increased insulation prohibitively expensive	The technical study found that increased insulation was cost effective as shown in Table 2

The final results were presented to all stakeholders at a meeting hosted by the DOE in November, 2015 where all manufacturers, except one[1], confirmed that: 1) a 'B' energy class is possible; 2) energy class 'B' can be achieved within one year of the industry being notified of the requirement to do so; and 3) the retail price of WH would not increase by more than R300 (EUR23). In return, the WH industry required a clear timetable and a commitment that all manufacturers would be required to comply with the MEPS when it came into effect. The use of incentives was raised and is to be considered in 2015 by the DoE and National Treasury. In January, 2105, the DoE is initiating the process to revise the MEPS for WHs from energy class E to B.

Conclusion

The WH industry initially opposed all efforts to improve the existing MEPS. A study undertaken by the Government to assess the impacts of moving from energy class E to D or C failed as it met with resistance from the majority of the industry who provided seemingly compelling, but unsubstantiated, evidence as to why an improvement was not feasible. Access to international technical experts to conduct empirical research to ascertain the validity of the industry's concerns, supported by the South Africa Government, found the contrary and that a move to an even higher energy class (B) is cost-effective. The energy savings are significant as the maximum allowable standing losses for a 150 L will decrease from 2.59 kWh to 1.38 kWh per 24 hours, i.e an improvement of 46%. It is unlikely that this result would have transpired without the close cooperation of the international and local entities supporting the S&L programme and the funding made available by the international agencies.

At a more general level although the South African Government committed itself to a residential S&L programme as far back as 1998 almost no implementation took place. It is also unlikely that the programme would have: 1) Commenced without GEF funding ($4.3 million); and 2) Whether barriers would have been addressed to the extent that they have without the international technical assistance received from organizations such as SEAD. There are several reasons for this but key amongst these is that such projects are considered low priority, especially in a context of low electricity tariffs and an over-supply of electricity which was the position South African was in until mid-2000; there is generally a shortage of skills and priority within Government institutions to conduct such technical studies and / or a shortage of funds to contract private skills to undertake the work; and finally, such initiatives require the co-ordination of multiple Government institutions.

In the South African experience, it is thus fair to conclude that the implementation of a residential S&L programme is a direct result of international funding and the progress made to date has been supported and advanced through international technical cooperation.

References

[1] Andrew Etzinger, Senior General Manager, Eskom. Available at: www.slideshare.net/classicevents/andrew-etzinger-eskom-idm

[2] NER (2001): *Lighting up South Africa*. National Energy Regulator, Pretoria.

[3] StatsSA (2011): Statistics South Africa. *General Household Survey 2011*. Available at: http://www.statssa.gov.za/publications/p0318/p0318april2012.pdf

[4] Bezuidenhout, A. (2002): *Overview of the South African White Goods Market*. University of the Witwatersrand.

[5] Euromonitor International (2014): *Consumer Appliances in South Africa.*

[6] Eskom (2013): *Make the switch that saves you 10% or more*. Available at: http://www.eskom.co.za/OurCompany/MediaRoom/Documents/10pcsavingsBrochure.pdf

[1] The manufacturer did not agree as there were staff changes and the manager who had just started was not involved. A commitment was made to conduct an internal review with a view to reversing their original position

[7] McNeil, M. Johnson, A. Lutz, J. and Covary, T. (2013): *An International Survey of Electric Storage Tank Water Heater Efficiency and Standards*. Paper published at the South African Energy Efficiency Convention in 2013

[8] Discussions held with industry representatives at workshop hosted by the Department of Energy, November, 2014.

[9] Covary, T. and Gotz, T, (2015) BigEE: Electric Water Heaters. Wuppertal Institute.

[10] Department of Minerals and Energy (1998): *White Paper on the Energy Policy of the Republic of South Africa*. Available: http://www.energy.gov.za/files/policies_frame.html

[11] Department of Minerals and Energy (2005): *National Energy Efficiency Strategy of the Republic of South Africa*. Available: http://www.energy.gov.za/files/esources/electricity/ee_strategy_05.pdf

[12] http://undp-ccmap.org/projects/market-transformation-through-energy-efficiency-standards-labelling-appliances-south-africa

[13] Covary, T. (2012): *Energy Performance and Labelling Requirements for Specific Electrical Appliances and Equipment*. Fund for Research into Industrial Development, Growth and Equity (FRIDGE) Report, Unlimited Energy Resources (Pty) Ltd for Trade and Industry Chamber.

[14] SANS 151:2013 Edition 7.1. *SOUTH AFRICAN NATIONAL STANDARD: Fixed Electric Water Storage Heaters*.

[15] VC 9004 & VC 9006 – Collated Comments, 28 March 2013.

[16] McNeil, M. Vermeulen, H.J. and Covary, T. (2015): *Water Heater Insulation Cost Effectiveness Study*, Super-Efficient Appliance Deployment (SEAD)