



Electric Water Heaters

Country

South Africa

Authors: Theo Covary, Thomas Götz

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Contact:

South African National Energy Development Institute (SANEDI) – Barry Bredenkamp
Wuppertal Institute for Climate, Environment and Energy, Germany – Dr. Stefan Thomas

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1 Country-wide saving potential

Electric Water Heaters

About **6.2 million** Electric Water Heaters are in use in South Africa (reference year 2010). The average annual consumption of each of these Electric Water Heaters amounts to about **1,248 kWh**. In total, this causes an annual electricity consumption of **7.7 TWh**. As model calculations show, enormous efficiency improvements can be achieved, especially if old inefficient models are replaced by modern efficient ones. The calculations of the efficiency scenario are based on the assumption that every time a new Electric Water Heater is bought, the most efficient “Best Available Technology” (BAT) model is chosen and that the improvements of the most efficient models over the years are taken into account. By this means, even an absolute decoupling of the annual energy consumption and the increasing stock of Electric Water Heaters can be achieved. While the stock is expected to grow by 45 % between 2010 and 2020, in the efficiency scenario (B) the energy consumption can be reduced by 12 %. Although the stock is expected to grow by another 44 % until 2030, in the efficiency scenario the energy consumption can be reduced by another 3 % (Figure 1). Thereby, higher living standards (e.g. increasing appliance ownership rates and household numbers) have been anticipated. In contrast, in the baseline scenario (A) with moderate efficiency gains the energy consumption would increase by 21 % until 2020.

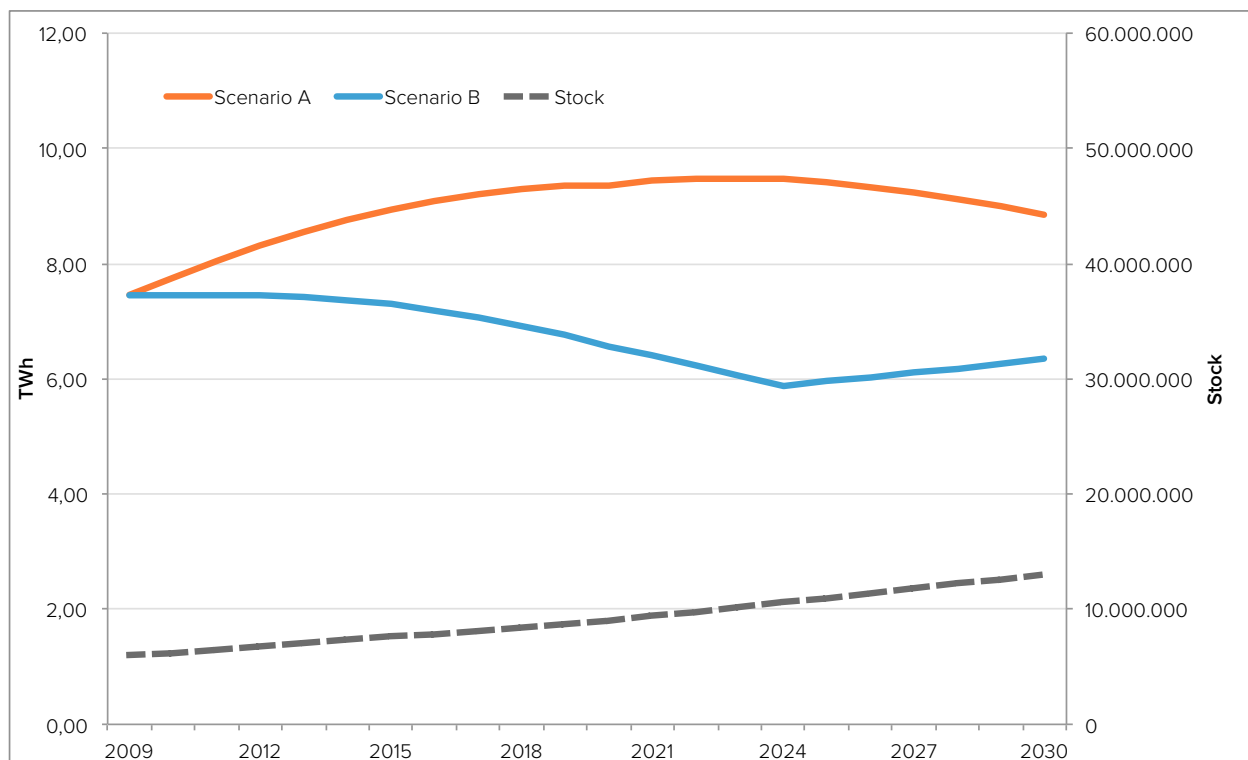


Figure 1: Electricity consumption Water Heaters, Baseline Scenario (A) vs. Efficiency Scenario (B)

Source: Wuppertal Institute (2015)

Table 1: Country-wide saving potential 2010 - 2030: Electric Water Heaters

Base year 2010	Total energy consumption of Electric Water Heaters per year [TWh/year]	7.74
	Stock number Electric Water Heaters	6,200,000
	Average annual energy consumption of Electric Water Heaters in the stock [kWh/year]	1,248
	Total annual CO ₂ eq emissions related with Electric Water Heaters [Mt/year]	5.23
2020	Energy savings potential in 2020 vs. baseline development [TWh/year]	2.8
	Resulting change in energy consumption 2020 vs. 2010 [TWh/year]	-1.17
	CO ₂ eq emission reduction potential vs. baseline development [Mio.t/year]	1.84
	Stock number of Electric Water Heaters in 2020	9,000,000
	Average annual energy consumption of new Electric Water Heaters (all BAT) in 2020 [kWh/year]	500
	Total incremental investment costs [not discounted] until 2020 (end-user perspective) [€]	180,622,012
	Total incremental investment costs [not discounted] until 2020 (societal perspective) [€]	158,440,361
	Total economic benefit until 2020 [not discounted] (end-user perspective) [€] scenario B vs. scenario A	1,717,718,825
	Total economic benefit until 2020 [not discounted] (societal perspective) [€] scenario B vs. scenario A	866,720,925

2030	Energy savings potential in 2030 vs. baseline development [TWh/year]	2.50
	Resulting change in energy consumption 2030 vs. 2010 [TWh/year]	-1.39
	CO ₂ eq emission reduction potential vs. baseline development [Mio.t/year]	1.63
	Stock number of Electric Water Heaters in 2030	13,000,000
	Average annual energy consumption of new Electric Water Heaters (all BAT) in 2030 [kWh/year]	450
	Total incremental investment costs [not discounted] between 2021 and 2030 (end-user perspective) [€]	245,258,554
	Total incremental investment costs [not discounted] between 2021 and 2030 (societal perspective) [€]	215,139,083
	Total economic benefit until 2030 [not discounted] (end-user perspective) [€] scenario B vs. scenario A	4,288,484,424
	Total economic benefit until 2030 [not discounted] (societal perspective) [€] scenario B vs. scenario A	2,536,051,482
Lifetime data for Electric Water Heaters purchased in the analysed timeframe	Total electricity savings, scenario B compared to scenario A [TWh]	62.25
	Total GHG emission reductions scenario B compared to scenario A [Mt]	40.76
	Total incremental investment costs [not discounted] (end-user perspective) [€] scenario B vs. scenario A	425,880,566
	Total incremental investment costs [not discounted] (societal perspective) [€] scenario B vs. scenario A	373,579,444
	Total economic benefit [not discounted] (end-user perspective) [€] scenario B vs. scenario A	5,296,258,914
	Total economic benefit [not discounted] (societal perspective) [€] scenario B vs. scenario A	3,234,305,756

Source: Wuppertal Institute (2015)

In this context all consumption figures for Electric Water Heaters refer to the compensation of standing losses only (which are used as performance criteria in South Africa) and not to the electricity consumption for specific domestic hot water usage (for which usage profiles would be required).

It is also assumed that the proposed MEPS (energy Class B) come into effect by 2020. Based on techno-economic analysis studies [7], manufacturers of traditional electric water heaters will be able to meet the new MEPS by improving the insulation of storage tanks significantly, but will find it difficult to improve from there. Therefore, for comparison purposes, also results for Solar Water Heaters with electric resistance backup heating element are presented in the next section.

Comparison: Solar Water Heaters

In contrast to the calculations for Electric Water Heaters, besides a significant improvement of storage tank insulation, a system change to Solar Water Heaters (SWH) with 20 % electric backup is assumed as BAT. Again only the compensation of standing losses as comparable performance criteria in South Africa is presented and not the electricity consumption for specific domestic hot water usage.

By this means, even a much earlier absolute decoupling of the annual energy consumption and the increasing stock of Water Heaters can be achieved. In this efficiency scenario (B) the energy consumption can be reduced by 18 % between 2010 and 2020 and by another 41 % until 2030. Overall, the energy savings potential in 2030 vs. the baseline development is around 4.9 TWh/year (See Figure 2).

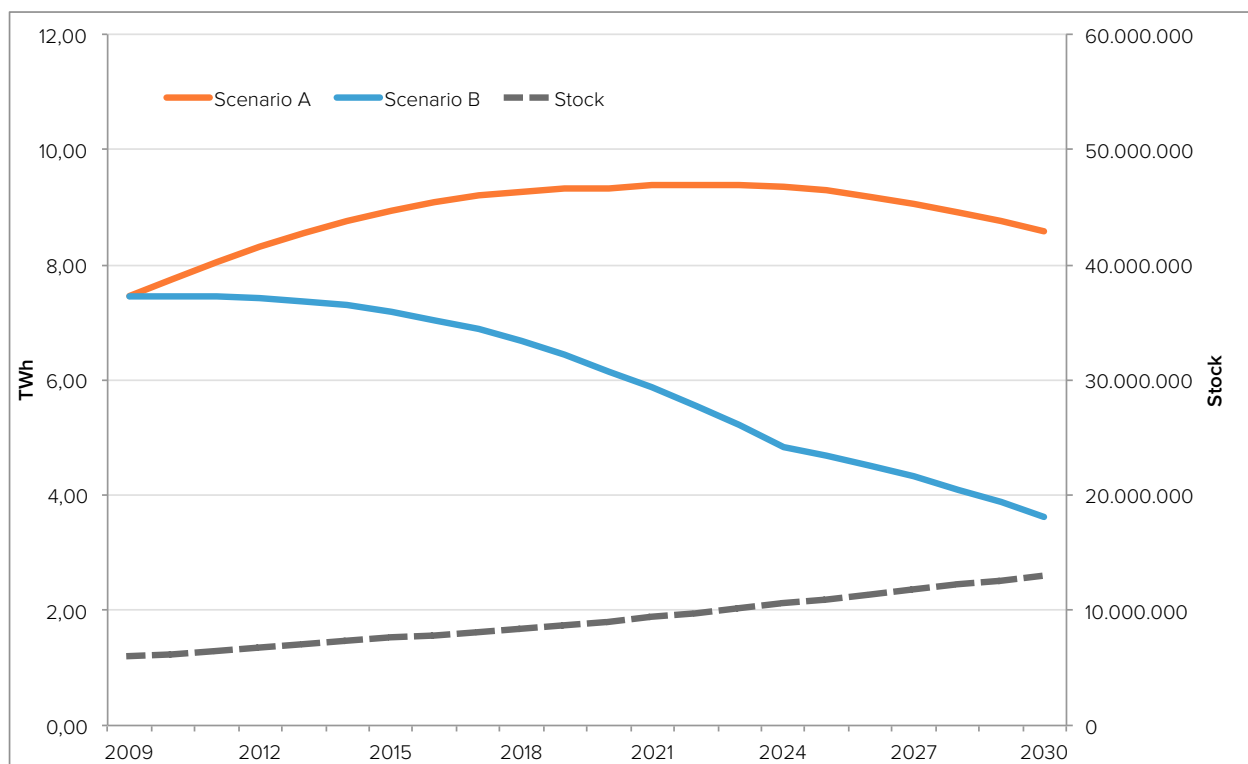


Figure 2: Electricity consumption Water Heaters, Baseline Scenario (A) vs. SWH Efficiency Scenario (B)

Source: Wuppertal Institute (2015)

2 Subtypes and markets

The electric water heater (geyser) market in South Africa is well established and is controlled by a small number of local manufacturing companies. The vast majority of middle and upper income households use the same technology, which is a 150 L water tank that uses a 3 kW resistive electric heating element. As the technology is straightforward, products are largely homogeneous and manufacturers compete mainly on price, guarantees, distribution and support. Market volumes are usually stable and predictable from year to year but can also increase by as much as 20 % during construction booms.

The manufacture of electric water heaters, referred to as geysers in South Africa, has evolved slightly differently as compared to the other large residential appliances. This is in line with the way the water heater market has developed internationally where there is a large variation in the product classes and use of hot water. Climate and culture play important roles in the need for hot water and dictate the practises of its use. This wide variation in climate and culture is correlated to the variation in type and size of water heaters used in households and which are available locally. Colder and wealthier countries tend to use large storage tank water heaters, and are also highly reliant on natural gas to heat water. In warm-climate countries, if households have a dedicated water heater at all, these units tend to be smaller and are not turned on continuously. Instantaneous water heaters have been popular in many countries (e.g. Brazil and China) historically, and by now have gained popularity in others, like Australia and the USA.

While electric resistance storage tank water heaters (geysers) are most common in South African households with water heaters, solar water heaters are gaining in popularity due to strong government support. [1] The design of geysers has evolved significantly, and uniquely, since they were introduced in early 1900. Gravity fed geysers dominated the market up until the 1950's. In the 1960s 100 kpa low pressure copper geysers entered the market, followed by 400 kpa high-pressure steel geysers in the 1980s. The steel geysers were transformed to 600 kpa in the 1990s, which became and remain the market standard. Fibreglass and plastic geysers were also introduced in the 1990s but these make up only a very small percentage of the market. Copper geysers are now virtually redundant.

The original use of gravity fed geysers required to place them at the highest point in a house. This meant that residential geysers in South Africa were traditionally installed in the space between the ceiling of the top floor and the roof, otherwise known as the attic. With the introduction of pressurised geysers it was no longer necessary to install the geyser in the attic, but the practise was entrenched and architects continued to design and specify to install geysers in the attic. In addition geysers would generally be installed directly above bathrooms, which they service. Therefore all bathrooms are also required to have access to an exterior wall due to effluent plumbing requirements. Geysers, which have

typically minimum dimensions of 1.1 m X 0.6 m, were often not able to fit vertically in this limited attic space due to the pitch of the roof, and as a result the practise developed of installing geysers in a horizontal rather than vertical position. These unique practises 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 geysers as well as the high costs to import them due to their physical size and low values mean that it is economically not viable to import such units and thus, almost all geysers in South Africa are locally manufactured. The country's oldest and dominant manufacturer with a current market share of more than 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 (see Table 3 below). A few high-end products are imported, such as gas fired water storage heaters, but these are niche products, which serve the top end of the market and volumes are very low.

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] and 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].

However, geysers fall somewhat outside the traditional large white goods appliance market (refrigerators, washing machines, dishwashers, etc.). There are two reasons for this. The first reason is that under the Government's Reconstruction and Development Programme (RDP) indigent persons qualify for free housing. This takes the form of a 40 m² freestanding structure, which has a small garden. The house has water and electricity supply, but a geyser is not supplied. This is left to the owner to install, should they chose to do so. Due to the high operational costs of a geyser and the mostly sub-tropical climate found throughout the country, most households tend to buy other appliances first and 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.

The South African Government recognised the difficulty this creates, the inefficient use of energy and the suppressed demand that this may be creating. Thus, in 2009 the Department of Energy announced its intention to install one million Solar Water Heaters by 2014 [5]. The programme targets high, medium and low-income households. A rebate is offered on qualifying high-pressure SWH for middle and high-income houses and at the low end of the market low-pressure units are installed by the Government for free. Figure 3 shows the installation of low-pressure SWH units on RDP houses. Whereas high-pressure units typically have an electrical backup heating system, the low-pressure units do not and thus do not consume any electricity.

The second reason and difference to the traditional large white goods appliance market is that because geysers are stored in the attic the occupants of the household have little to no direct contact with the unit on a day to day basis.



Figure 3: Low pressure SWH installed on Government housing (Zanemvula SWH pilot project)

Source: Nelson Mandela Bay Municipality (<http://www.nelsonmandelabay.gov.za>)

Another anomaly of the South African market is that it is a legal requirement for all houses that are financed (bonded) to take out building insurance. This insurance covers fixtures and thus also all geysers installed on the property are insured. So when a geyser fails households usually contact their insurance company and not a plumbing service. The insurers have agreements with plumbing companies to repair or to remove old and install new units. This is typically done within 24 hours. Other than reporting the incident the household has little involvement in this process. This practise accounts for over 60 % of annual sales of geysers. The other 40 % of the market is made up of sales to newly built houses or renovations, where once again the owner is generally not involved as the geyser is sourced and installed by the contractor responsible. In both instances the respective decision makers have no incentive to install a more efficient model, which is probably more expensive. Their only obligation is that the unit they install is certified and meets the mandatory health and safety requirements as set out by the South African Bureau of Standards.

All electric geysers in South Africa must comply with the South African National Standard (SANS) 151:2013 Edition 7.1 “*Fixed Electric Water Storage Heaters*”. This is a specific South African standard and is not linked directly to any International Electrotechnical Commission (IEC) or other standard. Under the SANS 151 all units must meet requirements for standing losses over a 24-hour period. This in effect is a MEPS and geysers have had to comply with these requirements for many years. However these values were already set in the 1970s and have not been revised since. Any attempt to improve them over the years was met with fierce opposition from the manufacturers.

Market Characteristics

Electric geysers dominate the household water heating market in South Africa. As mentioned previously indigent and low income households often use other sources of energy to heat water; such as coal, wood or even electric stoves. In contrast, some middle and high-income households may have installed SWH, heat pumps or gas water heaters in recent years, but these volumes remain small despite the Government’s rebate programme, as the upfront capital investment is still out of reach for most households (please refer to bigee.net South Africa policy section for further details).

SANS 151 [6] identifies three types of storage water heaters:

- **Cistern type:** combination unit storage water heater having a container supplied by water under gravity from a cistern which is incorporated in or directly fixed onto the appliance within a height of 500 mm above the upper surface of the water container. The expanded water can return to the cistern. The flow of water is controlled by one or more valves in the outlet system. Typical sizes are 5 - 12 cubic feet (341 - 510 litres)
- **Closed:** storage water heater that is unvented and that is intended to operate at the design working pressure of the water heater, the flow of water being controlled by one or more valves in the outlet system (By far the most common unit in South Africa)
- **Open Outlet Type:** storage water heater in which the flow of water is controlled by only a valve in the inlet pipe and in which the expanded or displaced water flows through the outlet from the water heater

Under SANS 151 the open and closed type systems have the same standing loss specifications while the cistern has weaker requirements for heat losses. Typical geyser sizes increase in 50 L increments, except for a few specialised units, starting at a minimum of 50 L and going up to 300 L. The most common unit size and which dominates the market in South Africa is 150 L.

Product Characteristics and Opportunities for Energy Savings

As mentioned above, an electric water storage heater is a relatively straightforward appliance. An electric resistance heating element is fitted into a steel storage tank, which heats up water. As the household draws water from the tank it is replaced with cold water and the element, via the thermostat, is activated to heat the water to the set temperature. The steel tank is covered by a steel jacket, or outer tank. The area between the two tanks is filled with insulation material to reduce standing losses due to convective and radiative heat transfer. The thermostat, which controls the water temperature, has various set points which are typically 55, 60, 65 and 70° Celsius. It is common practise in South Africa for units to leave the factory default with the thermostat set on the maximum set point. Disregarding the electricity generation process, the sole transfer of heat from the electrical heating element to the water within the storage tank is efficient and almost no opportunities exist to improve this performance under the current design. The only opportunities for energy savings (besides a system change to other technologies, such as SWH or HP) are to improve the general design or configuration of the unit and / or to reduce the heat losses, which occur during storage.

There are two types of losses: The first are standing losses, which are controlled by the insulation efficiency (material and thickness of the insulation); and the second are the 'bypass' losses which are all other losses which occur through the fittings, structural supports and across other thermal bridges [7]. In setting a MEPS, SANS 151 does not distinguish between these two types of losses and it is up to the manufacturer to find the most cost-effective solution to reduce the losses so that the product meets the specified MEPS. Thus, in relation to energy efficient electric geysers, this paper considers the options to reduce standing or bypass losses and looks generally at more efficient generation approaches such as SWH or Heat Pumps.

Penetration Rates and Sales

Although less pronounced (compared to other appliances), sales of electric geysers follow also economic cycles and increase mainly during construction based expansion periods. Annual sales figures are not readily available as the industry in South Africa is made up of a small number of privately owned companies who are well established and it is generally very difficult for new entrants to enter the market. The market is split into two categories: the replacement market and new builds, with the former responsible for 60 % of sales and the latter the other 40 %. However during building booms, as experienced in South Africa in the period 2004-2008, the new build market increases its share and can account for as much as half of annual sales.

Meetings held with the various manufacturers and insurance companies during the geyser study [7] have confirmed that annual sales of electric geysers vary between 400,000 and 550,000 units per annum depending on the economy, with 450,000 being the mean. Sales of high-pressure SWH under the Government's rebate scheme totalled 89,842 for the period 2009 until October 2014, which amounts to approximately 18,000 units per annum [8]. The actual figure is probably slightly higher as not all buyers make use of the rebate scheme but this is a small number, as such behaviour would be economically not reasonable. Just over 300,000 low-pressure SWH systems have been installed over the same period but as these units do not have an electrical backup heating system, they consume no electrical energy. Overall, 80 % of annual sales of geyser are in the 150 L class with closed high-pressure system. Figure 4 illustrates the percentage of households who have their hot water supplied by geysers. The figure shows the increase in households accessing water from geysers in the period 2004 to 2008 when the economy was growing and how it stagnated after 2008 when it entered into recession. With an expected lifespan of 15 years those units stay in the system and because they carry insurance the penetration levels achieved will in all likelihood be maintained.

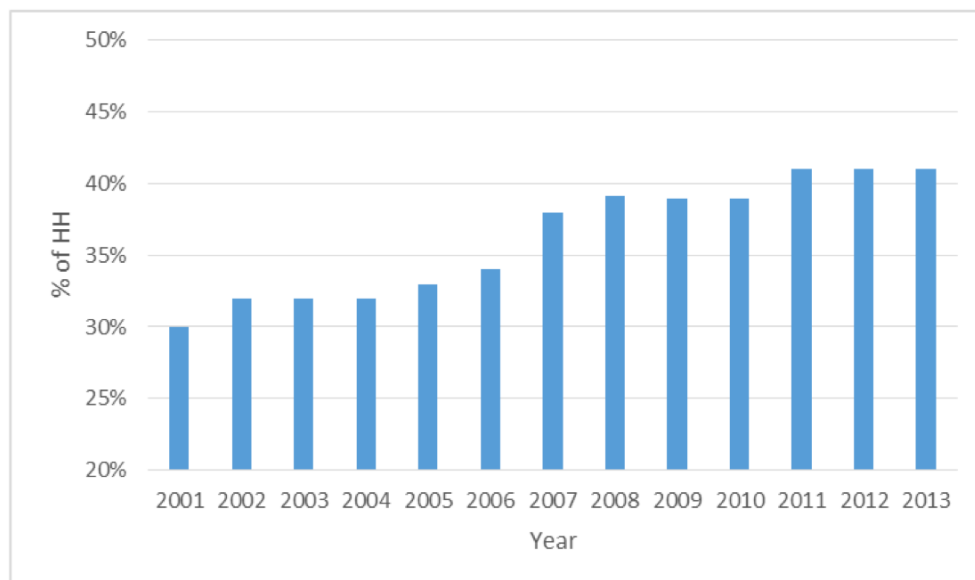


Figure 4: Penetration rate of hot water supplied by geysers in SA households 2001-2013 (%)

Source: AMPS

Geysers Market – 1995

First interest in energy efficient appliances in South Africa dates back to 1995, when a cost benefit analysis [10] was undertaken by the Department of Minerals and Energy. The study analysed the typical consumption figures of electric geysers. The monthly consumption of electricity is the total for the losses as well as the hot water used. Typically the losses would be 3.5 kWh per day for a standard SABS mark bearing geyser and the improved insulated geyser may reduce this by 1 kWh per day resulting in a saving of 30 kWh per month. The existing geyser would be replaced after 15 years [11].

Geysers Market – 2010

A study undertaken by the Department of Trade and Industry [12] aimed to survey all the geyser industry, as there are only 6 or 7 manufacturers who control together more than 95 % of the market. The large energy savings potential from geysers made them a natural inclusion in the country's S&L programme. The study was commissioned specifically to identify the impact that such a programme would have on local manufacturers and to identify, in consultation with industry, the most cost-effective MEPS that would reduce energy consumption per appliance with the lowest impact on the end consumer.

The study was overseen by the Department of Trade and Industry, Labour and the private sector and industry participation was voluntary. The industry opposed the introduction of revised MEPS as they believed that they already fell under the SANS 151 process, which has a maximum energy loss requirement, regardless the fact that there was no improvement on this requirement for decades. Only two geyser manufacturers, who jointly control less than 5 % of the market, were willing to participate. As a result, the FRIDGE study was not able to complete a detailed analysis for this product group. A communication put out by the South African National Regulator for Compulsory Specifications (NRCS)¹, stated:

In the 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 MEP 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 MEP 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.

Geysers Market – 2014

In response to the events that took place during the FRIDGE study and comments from the NRCS, the Department of Energy's S&L Project Management team commissioned a new study in 2014 to address the concerns raised by the industry. This study [7] aimed to determine the projected costs for manufacturers and consumers to reduce electric geyser standing losses to varying degrees in order to formu-

¹ VC 9004 & VC 9006 – Collated Comments 28 March 2013

late MEPS supported by analysis of net financial impacts to consumers. To achieve this, the study would have: 1) To establish the likely cost and energy performance of each possible energy efficiency class; 2) To assess the impact of the proposed energy improvements; and 3) Determine the most appropriate MEPS for electric water heaters in line with the project objective to introduce more energy efficient appliances in the SA market. The main output of the study would be a set of data inputs, which could be used in techno-economic analysis of alternative MEPS levels in order to make a recommendation.

For the study five 150 L geysers were selected which adequately represented the market. Each geyser was then subjected to four sub-tasks [7]: 1) **Product testing**: the geyser was tested according the national standing loss test procedure. These test measurements formed the technical baseline of the study; 2) **Product tear-down measurements**: Once tested, the geyser was disassembled to determine the corresponding configuration of the baseline; 3) **Component cost determination**: Market information on material and labour costs; and 4) **Standing loss and cost determination**: Impact from additional insulation was modelled and the final costs to manufacturers and consumers were calculated. (Please refer to Section 6 for test results).

Table 2 gives the number of models available in the South African market. The data was sourced from popular online shopping websites²; manufacturer websites and data supplied by manufacturers themselves. The most popular, and the de facto industry standard, is the closed 150 L unit, followed next by closed 200 L models. The remaining model sizes are generally for more specific applications, for example the 50 L unit for access to hot water for a kitchenette in a small office.

Table 2: Number of models available in the South African market (2014)

Size	Number	Heating Element (kW)
50 L	4	2
100 L	7	2
150 L	10	3
200 L	6	4
250 L	4	4
300 L	3	4
Total	34	

South Africa has been in an economic downturn since 2008 and continues to experience sluggish growth. In October 2014 the Minister of Finance revised annual economic growth down to 1.4 % from a

² www.pricecheck.co.za and www.shopmania.co.za

forecast of 2.7 % in February 2014 [13]. The duration of these tight economic conditions and the steep rise in electricity tariffs, over the same period, have had a significant impact on household disposable income. Electricity tariffs more than tripled over the four-year period 2008 - 2012 and will continue to rise at an average of 12 % per year from 2014 to 2018. Geysers account for as much as 39 % of the typical middle-income household's electricity consumption, making it by far the biggest single electricity user in the house [14].

In response households, government and the national utility Eskom have correctly targeted this appliance for major electricity savings (please see also the bigee.net South Africa policy section for more details). Awareness programmes have been developed, geyser blankets have been distributed to reduce standing losses and rebates are available for SWH and HP. However, these interventions have had limited impact due to the unchanged installation location of the geysers and the persisting way in which new units enter the market without direct end user involvement in the decision making process. It is for this reason that the Geyser Study [7] was crucial, as the results were needed to provide empirical evidence to support an improvement to the existing MEPS, which are obsolete and ineffective. This single action is the most effective option, as it will directly influence the manufacturing process, ensuring adequate compliance.

Figure 5 shows the available numbers of models per energy class for the two most popular geyser sizes. The small number of manufacturers and models in the market necessitates a more detailed analysis. Table 3 lists the six major manufacturers, their market share and the energy class of their 150 L and 200 L models. Based on this evidence, it can be inferred that the baseline performance of 150 L geysers in the country is at the lower end of energy classes (D and E).

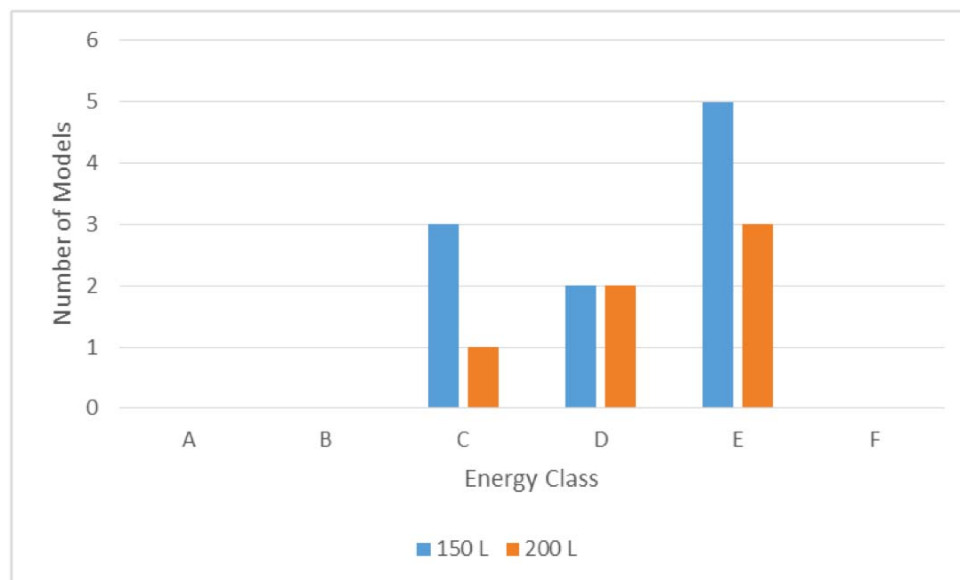


Figure 5: Energy Classes of 150 L and 200 L geysers

Source: Geyser Study [7]

Table 3: Market Share and Energy Classes of local manufacturers products

Manufacturer	Market Share (%)	Energy Class 150 L	Energy Class 200 L
M1	64	D	D
M2	18	E	E
M3	8	C	N/A
M4	3	C	C
M5	2	C	C
M6	2	E	E
Rest	3		

The results from the geyser study [7] were conclusive. The standing loss test confirmed that the market baseline is at the lower end of energy classes and also identified inconsistencies in the national standard. The tear down analysis found that the insulation thickness averaged in total but in most models it is applied inconsistently i.e. it is much thicker on the top than on the bottom.

The data collected on components allowed for accurate modelling and the results are shown in Table 4 below. Although not yet generally feasible (e.g. to structural reasons at the installation sites), the modelling revealed that it would be even economically viable for the insulation thickness to be increased up to 125 mm on each side. The three indicators used were life cycle costing (Δ LCC), payback period and cost of conserved energy (CCE).

Table 4: Cost Effectiveness Indicators for Increased Geyser Insulation Thickness

t	Δ LCC	Payback period	CCE
mm	R	Years	R
20 (baseline)	-	-	-
25	-1,486	0.15	0.05
50	-4,596	0.30	0.10
75	-5,595	0.47	0.16
100	-6,010	0.66	0.23
125	-6,173	0.87	0.30

Source: Geyser Study (2014) [7]

The results of the Geyser study were presented at a workshop held on 26 November 2014 by the Department of Energy. Participants included all relevant Government agencies, geyser manufacturers and other interested parties. All manufacturers accepted the findings and it was unanimously agreed that an energy class B could be achieved within one year at a cost not exceeding R300 per unit, which equates to a price increase of between 10-15 % at current prices. The Department of Energy resolved to initiate the process for the revision of the MEPS in SANS 151. This change would result in the allowable standing loss to drop from the current 2.59 kWh / 24 hours to 1.38 kWh / 24 hours for a 150 L geyser, a difference of 1.21 kWh / day and equalling a 46 % improvement.

Summary of the geyser market in South Africa:

- Electricity tariffs in South Africa were amongst the lowest in the world in 1995, thus there was little demand for energy efficient appliances. Tariffs have tripled over the four years period 2008-2012 and households paid EUR 0.10/kWh in 2014. The South African electricity regulator has agreed to a further annual 12 % tariff increase for the period 2014 - 2018.
- During the 1990's South Africa had low electrification rates. A priority of the new Government was to electrify all households, which it has largely achieved. The percentage of households that used electricity for lighting went from 58 % (1996) to 80 % (2007). This programme created a new market for manufacturers of electric appliances and the growth rates were high for the period 1995 - 2005. The impact on the geyser market was less marked as indigent households prioritised other appliances, but the penetration rate has increased nevertheless from 30 % to 41 % over the last 10 years.
- The distribution channels of geysers are such that tenants are almost never involved in the purchase decision and are therefore mostly unable to influence it. The decision is typically made by contractors who have no incentive to buy a more efficient model, especially if it is more expensive. Replacement cycles of geysers are approximately 15 years.
- Although MEPS for geysers have existed for a long time in South Africa, they have been in place for over 30 years and as a result are amongst the least demanding in the world [1]. A cost-effectiveness study undertaken in 2014 found that an energy class B is economically viable. Government and manufacturers have agreed to initiate the process of upgrading the existing MEPS.

3 Efficiency range and user savings

The most popular format in South Africa is the closed 150 L geyser. This format accounts for as much as 80 % of the geyser market. A MEPS, in the form of maximum allowable standing losses per 24 hours, is in place but the current level of requirements is low and should be improved as soon as possible. As geysers are a homogenous product group, which is typically not purchased by the household, there is little focus on energy performance. This is generally done retrospectively by installing a SWH collector or Heat Pumps.

In Table 5 below BAT is not a more efficient geyser with electric resistance heating element but different technology, namely SWH or a HP.

Table 5: Cost Efficiency range and user savings of Geysers

Level	Typical appliance in the stock (over all appliances in use)	Typical inefficient appliance on the market.	Typical appliance purchased (BAU – Business As Usual)	Best Available Technology (BAT)	Expected future BAT (Best not yet Available Technology)
Typical Capacity / Size	150 L				
Category	Geyser	Geyser	Geyser	Geyser fitted with HP or SWH	Geyser fitted with HP or SWH
Type	Electric	Electric	Electric	Solar with electric back up / Heat Pump	Solar with electric back up / Heat Pump
Lifetime (years)	15	15	15	15	15

Qualitative performance classification of the provided service:	<input type="checkbox"/> Poor <input type="checkbox"/> Low <input type="checkbox"/> Average <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/> No information	<input type="checkbox"/> Poor <input type="checkbox"/> Low <input type="checkbox"/> Average <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/> No information	<input type="checkbox"/> Poor <input type="checkbox"/> Low <input type="checkbox"/> Average <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/> No information	<input type="checkbox"/> Poor <input type="checkbox"/> Low <input type="checkbox"/> Average <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/> No information	<input type="checkbox"/> Poor <input type="checkbox"/> Low <input type="checkbox"/> Average <input checked="" type="checkbox"/> Good <input type="checkbox"/> Excellent <input type="checkbox"/> No information
Yearly energy consumption: <u>electricity</u> (kWh)	1,248 kWh / annum (losses)	820 kWh / annum (losses)	650 kWh / annum (losses)	< 484 kWh / annum (losses)	< 400 kWh / annum (losses)
Yearly energy cost (ZAR)	1,871 (losses)	1,230 (losses)	975 (losses)	< 726 (losses)	< 600 (losses)
If applicable: yearly energy consumption for further energy carriers	N/A	N/A	N/A	N/A	N/A
If applicable: yearly water consumption	N/A	N/A	N/A	N/A	N/A
Yearly water cost (national currency)	N/A	N/A	N/A	N/A	N/A
Purchase cost in (ZAR)	2,500	2,500	2,600	20,000	30,000
Operation & Maintenance cost (ZAR)	1,500 (lifetime)	1,500 (lifetime)	1,500 (lifetime)	2,500 (lifetime)	3,000 (lifetime)
Labelling class	E	D	C	B	A

4 Performance and information requirements

All geysers in South Africa are required to comply with mandatory safety standards, administered by the Bureau of Standards (SABS). The national standard includes a maximum allowable standing loss, which is measured in kWh/24 hours. All models must comply with this requirement in order to be certified. This MEPS, which came into effect in mid-1970ies, has not been improved since it was introduced. The updated national standard (SANS 151) of 2013 requires all geysers to display also an energy label but the level of the MEPS was not yet improved.

Energy Label

The South African Energy Strategy of 1998 identified residential appliances as an effective means to achieve energy savings in the residential sector in South Africa. In 2005 the country's first National Energy Efficiency Strategy (NEES) was developed and in the same year the Department of Minerals and Energy (now Department of Energy) 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. It was decided to use the EU designed label, largely because historically the majority of South Africa's appliances were imported from Europe. A label was designed (Figure 6) and included some minor changes to the EU label being used at the time, most notably a star with the colours of the South African national flag. The label was registered with all the relevant national and international authorities.

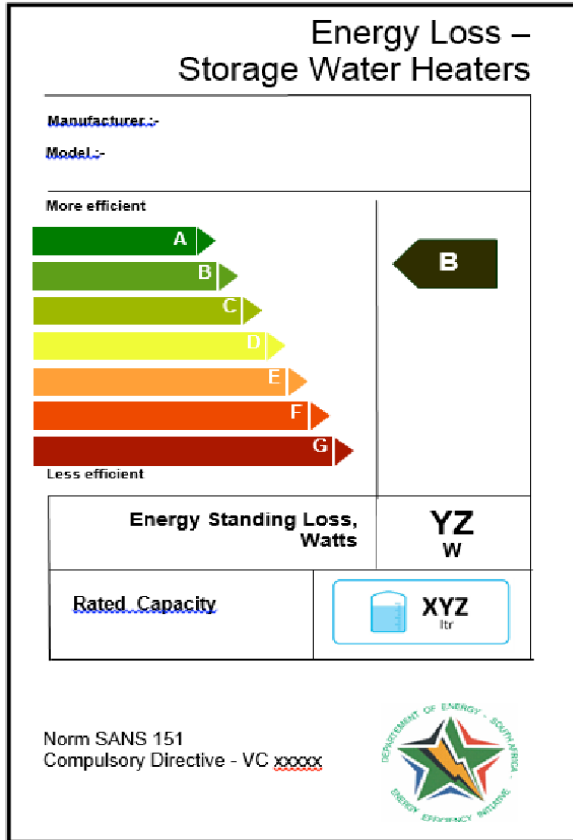


Figure 6: South African Energy Label for Geysers

Source: South African Bureau of Standards

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 Department of Energy (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 in order to implement a mandatory S&L programme.

In 2008, the South African Bureau of Standards (SABS) formed the Working Group 941 (WG941) who was mandated to develop the South African National Standard “SANS 941 - Energy Efficiency for Electrical and Electronic Apparatus for Electrical and Electronic Apparatus”. SANS 941 identified energy efficiency requirements, energy efficiency labelling, measurement methods and the maximum allowable standby power for a set of appliances. The testing standard for geysers is SANS 151:2013. The proposal for the GEF funded S&L programme (submitted in 2010 and approved in 2011) selected the appliances based on SANS 941 and included geysers due to their high energy saving potential.

The South African energy label in its current format has certain shortcomings. These include:

- The label designed in 2005 is obsolete, as it does not go beyond A. The standard states ‘the indicators for A+ / A+++ shall be placed at the same level as for class A’;
- Focus Groups undertaken 2012 found that all consumers viewed the programme would benefit them and supported its implementation. However, reported issues concerning the label included confusion regarding the words used for descriptions on the label. For example, why does it say energy and not electricity? As South Africa has many languages (11 official) so this also means that certain words may be misunderstood; and
- Including extra information was also questioned. For example, why were noise levels included if it is an energy label?

Based on the above listed findings, a review and re-design of the South African label is recommended to incorporate the issues identified locally and in the EU (which has almost eliminated all text in favour of pictograms). The South African S&L project team is currently (2015) deliberating whether to make changes to the existing label in line with the upgrades made to the EU label, which makes greater use of symbols (pictograms) rather than text. Exemplarily, the proposed changes to the label for refrigerators are shown in Figure 7 below:

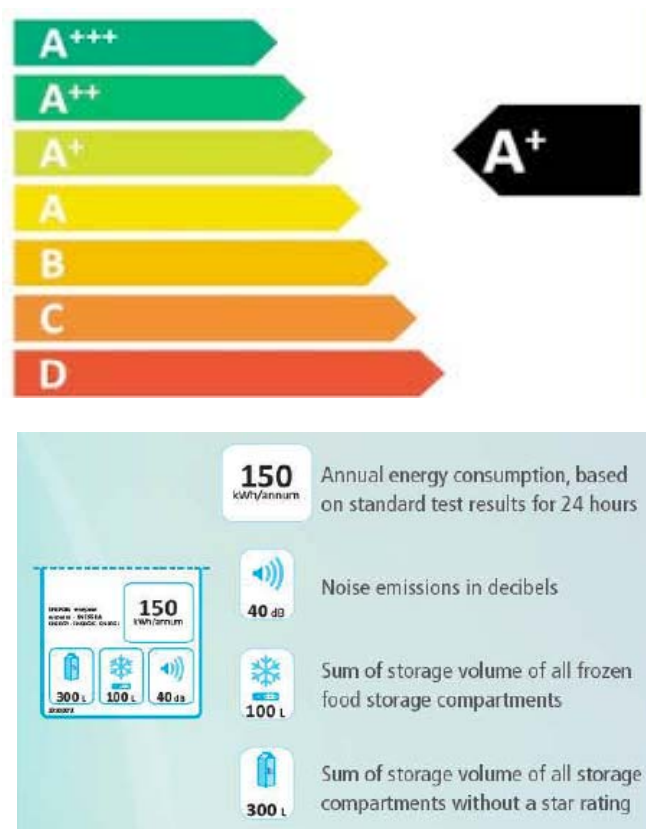


Figure 7: Draft for a new South African Energy Label (Example for refrigerators)

Source: South African Bureau of Standards

It should be noted that the issues listed above are less relevant for geysers as in 2015 there are no geysers available in the market which exceed a C energy class and it is unlikely that an A+ can or will be achieved even in the long term. However it is prudent for the sake of uniformity that the geyser label design conforms to the energy labels being used on other appliances.

Minimum Energy Performance Standards (MEPS)

Of all appliances chosen for the country's S&L programme, geysers were the only product group already addressed by an existing National Standard and an operational testing laboratory at SABS. A revised standard, the SANS 151 came into effect in 2013, and incorporates the existing standing loss test. This is defined as '*energy consumed by a full water heater connected to the electrical supply (after steady state conditions have been reached) during any 24 h period when no water is withdrawn*'. What this test determines is how effective the insulation of the geyser is at maintaining the temperature of the water stored in the vessel – the better the insulation the lower the losses. Any electric geyser on the market must meet the requirements for heat losses as specified in the Standard (SANS 151).

The minimum performance, which was decided upon by SABS and industry for the SANS 151, is shown in Table 6, however the performance levels did not change and therefore no incentive for manufacturers exists to improve the standing loss performance of their geysers. The permissible standing loss requirements have been in place for many years and go back as far as the mid 1970's. SABS certifies geysers based on the outcome of the mandatory testing which all geysers must undertake. However, it is SABS policy not to make the standing loss test results public and only confirmation is given that the geyser has passed the test and met the minimum requirements. [7]

Table 6: Maximum permissible standing loss per 24 hours (kWh)

Nominal capacity of water heater	Permissible standing loss (kWh) (for closed type of water heater)
50 L	1.62
100 L	2.16
150 L	2.59
200 L	3.02

Source: SANS 151:2013

5 Test procedures and standards

All electric geysers in South Africa must comply with the South African National Standard (SANS) 151:2013 Edition 7.1 “*Fixed Electric Water Storage Heaters*”. SANS 151 is a specific South African standard and is not linked directly to any International Electrotechnical Commission (IEC) or other Standard. Under this standard all units must meet requirements for standing losses over a 24-hour period.

The standing loss calculations are performed using the controller temperature, ambient temperature and energy measurement data recorded during the 48 hr standing loss test period (The energy consumption of the water heater is measured for a total of 48 hours, and corrected to 24 hours). Where necessary, temperature sensor calibration data is used to correct the recorded temperature readings.

The loss calculation methodology specified in SANS 151 relies on the assumption that the mean control temperature inside the geyser is 65°C. The standing loss is calculated using the relationship

$$Q = \frac{45E}{2(65 - \theta_a)}$$

where

Q denotes the standing losses [kWh/24hr],

E denotes the total energy consumption [kWh]

and

θ_a denotes the mean ambient temperature [°C].

The mean ambient temperature θ_a , assuming a fixed temperature sampling rate, is calculated using the relationship

$$\theta_a = \frac{1}{N} \sum_{i=1}^N \theta_{a i}$$

where

$\theta_{a i}$ denotes the i^{th} ambient temperature reading [°C]

and

N denotes the total number of ambient temperature readings for the 48 hr standing loss test period.

The calculation methodology normalizes the calculated losses to a temperature differential of 45°C between the internal geyser temperature and ambient temperature.

Energy Efficiency Classes

Label levels are calculated for a 150 L geyser according to the formulas provided by SANS 151, shown in Table 7.

Table 7: Label Levels according to SANS 151 Formula for 150 L

Efficiency Level	Formula	Standing Losses kWh/24 hrs
A	$S \leq 5 + 4.16V^{0.4}$	0.86
B	$S \leq 11 + 6.25V^{0.4}$	1.38
C	$S \leq 16.66 + 8.33V^{0.4}$	1.88
D	$S \leq 21 + 10.33V^{0.4}$	2.34
E	$S \leq 26 + 13.66V^{0.4}$	3.06
F	$S \leq 31 + 16.66V^{0.4}$	3.71
G	$S > 31 + 16.66V^{0.4}$	> 3.71
MEPS	SANS 151 Table 2	2.59

6 Application of the Standard

The SANS 151 formulas to derive the energy class are complicated and the practical application is difficult to understand for non-experts. To provide a reference point, the results of the geyser study [9], which tested five different 150 L geysers, are provided.

The tests were conducted by the electrical engineering department of the University of Stellenbosch.

Table 8 summarizes the standing losses determined for the various geyser models and mounting orientations. The maximum allowable loss for 150 L geysers is 2.59 kWh / 24 hours.

Table 8: Standing losses according to SANS 151

Geyser	Orientation	Standing losses [kWh/24 hours] based on SANS 151 test methodology
Geyser 1	Horizontal	2.23
	Vertical	2.33
Geyser 2	Horizontal	1.90
	Vertical	2.24
Geyser 3	Horizontal	1.86
	Vertical	1.77
Geyser 4	Horizontal	2.51
Geyser 5	Horizontal	1.90

Source: Geyser Study (2014) [8]

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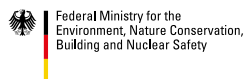
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Dr. Stefan Thomas • bigeen@wupperinst.org

Wuppertal Institute for Climate, Environment and Energy • Doeppersberg 19 • 42103 Wuppertal • Germany • Phone: +49 (0)202 2492-129