Smart geyser devices, insurance, and the end of loadshedding

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ABSTRACT

Smart geyser devices save individuals money by minimising the duration that geysers need to be on, as well as when they need to be on. They simultaneously detect leaks early, presenting risk mitigation, claims severity reductions and claim frequency reductions. A new product on the South African market considers the entire network of smart geyser devices rather than in isolation, enabling the reduction of aggregate electricity demand. At scale, it is estimated that this could reduce the on-peak demand of electricity in South Africa by 4,000 megawatts, consistent with the eradication of four stages of loadshedding. In South Africa's history, the marriage between technology, society and insurance has never been clearer.

KEYWORDS

Public interest, wider fields, smart geyser device, technology, insurance, geyser, network effect, shared value, electricity, energy, loadshedding, homeowner's insurance

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1. INTRODUCTION

1.1 South Africa is in the midst of an energy crisis, and it does not look as though it will be ending any time soon. Plunged into worsening levels of loadshedding, which started as early as 2007, South Africans faced 3,776 hours (*BusinessTech*, 2023) – or 157 days – of power outages in 2022. For nearly half of that time, electricity was unavailable for up to eight hours of each day.

1.2 Throughout the now nearly 30-year democracy of South Africa, the private sector has demonstrated its ability to remain resilient despite the best efforts of a partially corrupt government, contributing to the solution of pressing issues facing South Africa in the face of dysfunctional state-run enterprises.

1.3 Ingrained in the very fabric of our actuarial profession is our promise to consider and/or act in the public interest. There could not be a more obvious topic that is within the interest of the public than having access to electricity – that hallmark of modern civilisation without which roads can – and have – become death traps, manufacturing and production grind to a halt and businesses close.

1.4 Smart geyser devices are products that serve risk-reduction purposes on homeowners insurance policies by preventatively detecting leakages, whilst simultaneously providing households with a way to save money by reducing the electricity used by their geysers; geysers do not have to draw electricity all day long to remain at an acceptable temperature. However, most South Africans using electric geysers require hot water at the same two times of the day: before they leave home in the mornings and before they go to bed in the evenings. This does not serve the electricity grid; indeed, the onerous electricity demand spikes seen currently at approximately 7 am and 7 pm would simply be shifted back a few hours should all households with electric geysers have a geyser timer installed.

1.5 A new South African smart geyser device paves the way for an added social benefit by ensuring that all such devices are part of an integrated network of devices which speak to one another. In this way, demand for geyser electricity will not rise rapidly during peak times as is currently the case, as the pre-heating of geysers will take place at carefully optimised times such that their peak demand is instead distributed more evenly throughout other parts of the day.

1.6 At scale in the South African market, such a product is estimated to be capable of reducing up to 4,000 megawatts (MWs) of aggregate demand from the grid, when it matters the most, and significantly reduce (eliminate) the extent of loadshedding.

1.7 In this paper and presentation, a business case for the inclusion of such products as part and parcel of homeowners' insurance policies is provided. Where such inclusion proves unviable, suggestions are made which may enhance viability. Inclusion of smart geyser devices in homeowners' insurance products can create a positive feedback loop which maximises the benefit to all parties. These parties include:

— Insurers, who would benefit from significantly reduced claims frequency and severity resulting from damage caused by leaking or burst geysers.
— Policyholders, who would benefit from a reduction in electricity used (in total, as well as during peak hours) and therefore money spent on electricity, and possibly their premiums.
— Society, which would benefit in the medium- to long-term from the network effect of this new type of smart geyser device which reduces aggregate electricity demand by an amount that could reduce the extent of loadshedding significantly and thus improve their quality of life.
— Small businesses which are more severely impacted by loadshedding, and which are an important contributor to employment and Gross Domestic Product.
— Smart geyser device providers, who would benefit from a partnership with insurance companies in whose direct interest it is to rapidly scale the smart geyser device.
— The power utility, Eskom, whose grid dynamic is altered in the long-term to move away from the bimodal demand curve to a flatter demand curve.
— The government, whose tax receipts will increase as fewer businesses close and fewer jobs are shed, and which will need to fund fewer unsustainable diesel purchases.

1.8 While the research presented will be based on a South African case study, the demand-side nature of this energy crisis intervention generalises to countries which experience sharp peaks in electricity demand attributable to electric geysers. The scaling of products which directly benefit insurers can be very rapid depending on their levels of new business volumes, and the need to reduce electricity demand (or increase supply) is a world-wide concern.

2. RESEARCH QUESTIONS

The work of this project aims to answer the following three research questions:

— Do electric geysers drive a significant proportion of South Africa's aggregate electricity demand?
— Is there evidence to suggest that the inclusion of smart geyser devices is economically viable for insurance companies?
— If such inclusion is not immediately economically viable, what can be done to make it so?

3. UNDERSTANDING ELECTRICITY

3.1 An introduction to energy and electricity

3.1.1 A pleasing discovery that Alant (2023, pp. 26–33) wrote a paper on South Africa's electricity system. Indeed, in such detail that it would be inappropriate for this paper to consider the topic of introducing South Africa's electricity system to actuaries. The reader is encouraged to read the work of Alant for a thorough description of South Africa's electricity system.

3.1.2 Throughout this paper, reference may be made to acronyms popular in the energy sector. For the purposes of this paper, a subset of Alant's glossary of terms is referenced, with some additional terms.

Table 1 Glossary of terms

Term	Meaning/usage/application
watt (W)	A unit of power. A watt is often used for measuring the energy consumption of small devices such as a cell phone charger or a light bulb.
kilowatt (kW)	1 kW is equal to 1,000 W and is typically used when speaking of how much power geysers use.
megawatt (MW)	1 MW = 1,000 kW and is typically used when speaking of units of power in excess of 1,000 kW. An example is a power station, producing power of, say, 1,500 MWs.
Selection (anti-selection)	In insurance this is taken to be the specific case of the exploitation of information asymmetry whereby a policyholder who holds information the insurer does not have uses that to their advantage e.g., those believing themselves more likely to claim from a motorbike accident because of their weekend hobby are more likely to obtain insurance.
Positive selection	A case of selection, but in the circumstance that an individual likely to exhibit positive behaviours is attracted to a product e.g., a product which rewards healthy behaviour would reflect healthier lives in part because of those lives having the most to gain.

Source: Alant (2023) with appended terms.

4. CONSTITUENTS OF SUPPLY

4.1 Understanding supply

As in the introduction, the reader is referred to Alant's work (2023, pp. 26–33) on the South African electricity system to better understand the drivers of supply of electricity in South Africa. Of particular interest is the proportion that each source of energy supplies of the total electricity generated in South Africa – see Figure 1.

5. CONSTITUENTS OF DEMAND

5.1 Total demand

5.1.1 In South Africa, there are several users of electricity. These users may be categorised as industry, transport, residential, commercial and public services, agriculture and forestry and other. Of particular focus in this paper is the residential demand. The composition is illustrated in Figure 2.

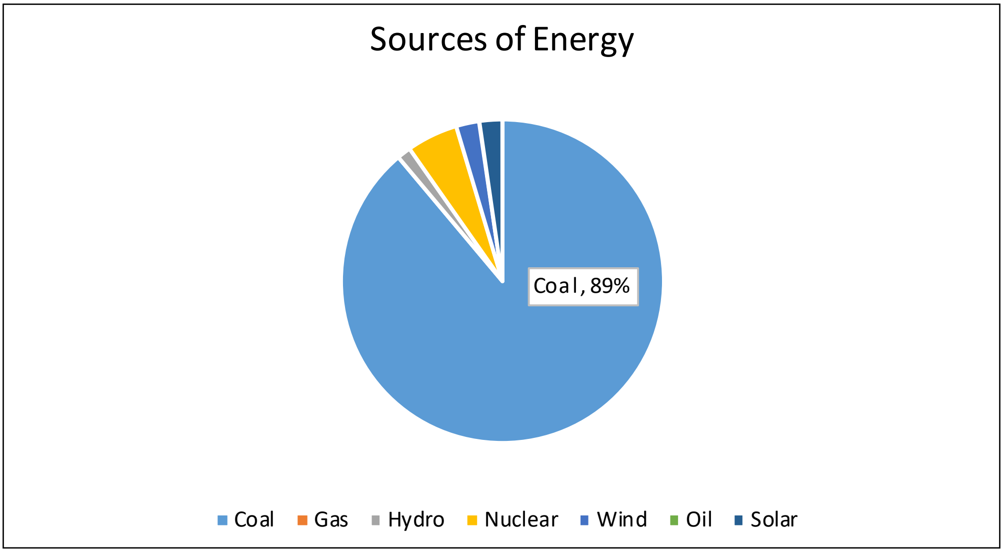

FIGURE 1 Sources of energy, South Africa, 2017
(Source: own illustration, based on Alant (2023, pp. 26–33))

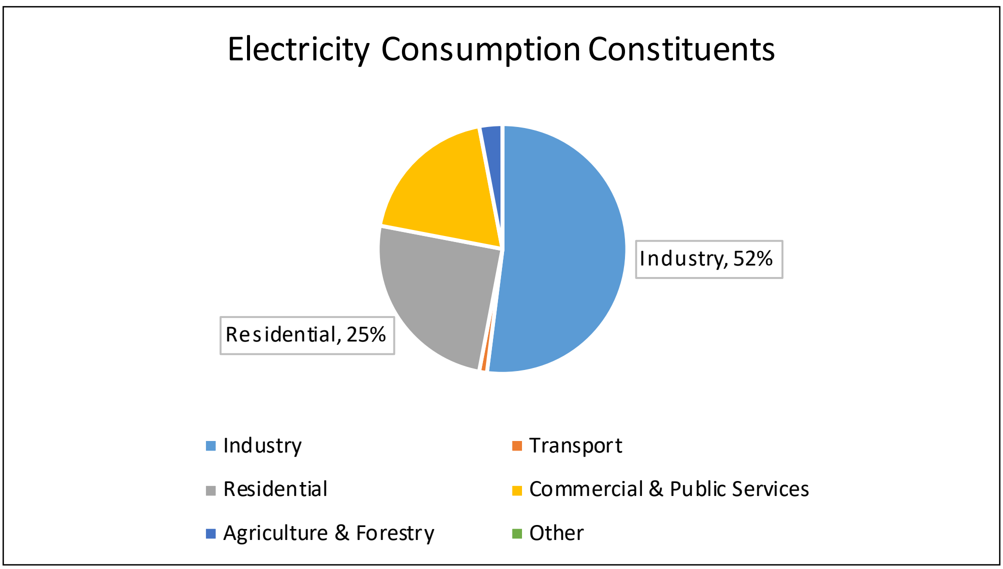

FIGURE 2 South Africa's electricity consumption by sector (percentage of total), 2020
(Source: own illustration, based on Alant (2023, pp. 33–36))

5.1.2 A typical demand curve for South Africa's electricity looks similar throughout various points in the year, but with accentuated peaks during winter times. In Figure 3, the Eskom contracted demand curve is shown for 18 May 2023. There is a bimodal structure to the demand curve: a peak in the mornings as well as in the evenings.

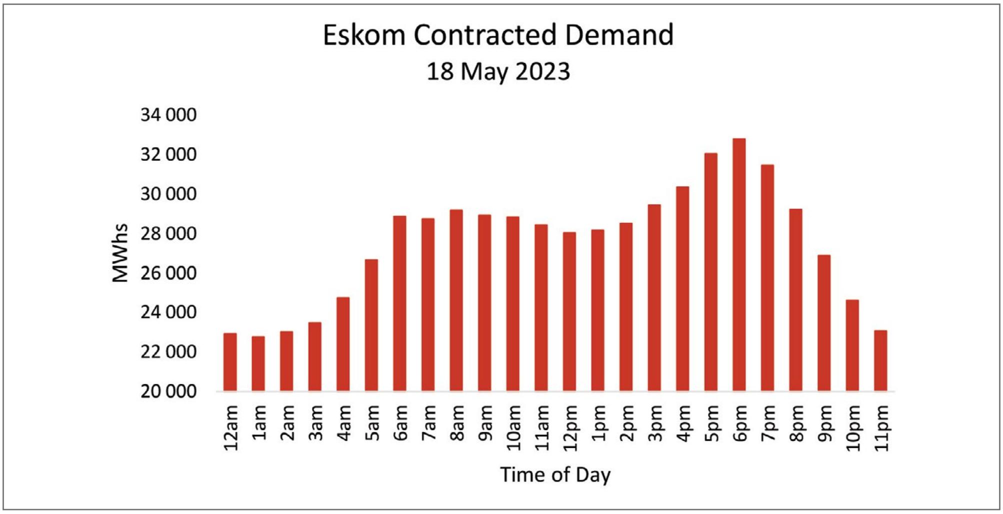

FIGURE 3 Eskom contracted demand on 18 May 2023
(Source: own illustration, based on Eskom data (2023))

5.1.3 A different view of this demand is to examine it within the context of the available generating capacity (or supply) on that same day. Figures 4 and 5 examine the supply and demand for electricity on 18 May, the latter from 4 pm to 8 pm (the evening peak).

5.1.4 From Figure 4 it can be seen that there was one interval (4 pm to 7 pm) throughout the day where demand exceeded supply, and Figure 5 examines that time interval more closely.

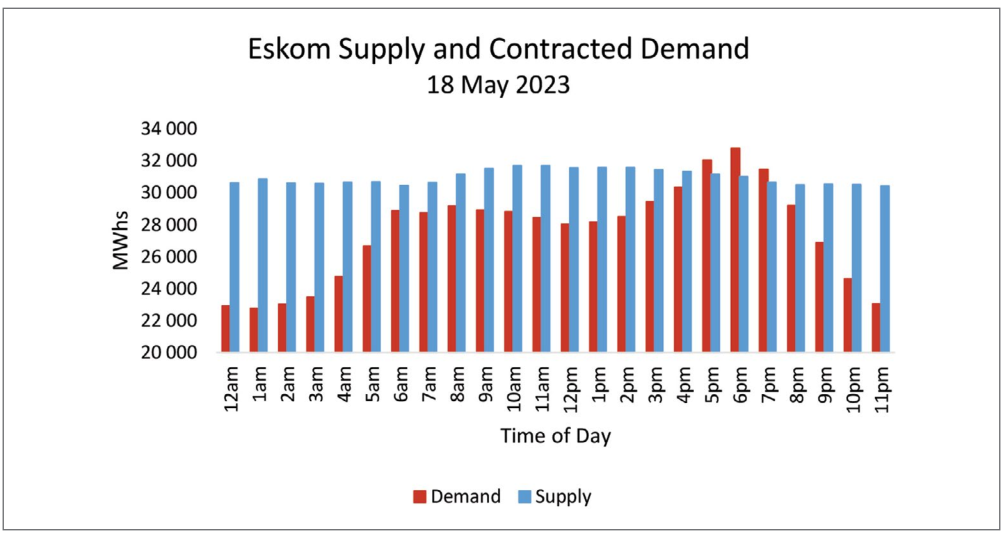

FIGURE 4 Eskom Supply and Contracted Demand on 18 May 2023
(Source: own illustration, based on Eskom data (2023))

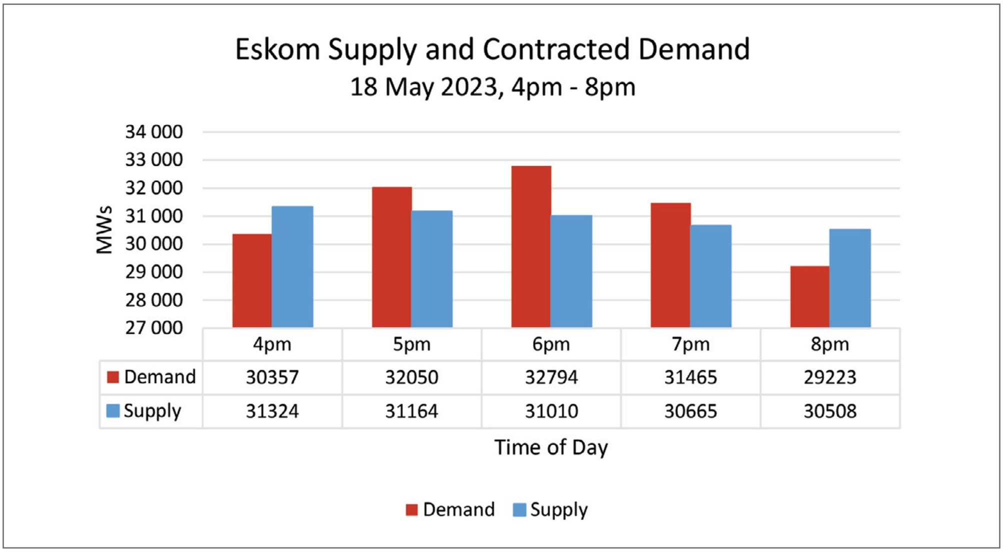

FIGURE 5 Eskom Supply and Contracted Demand on 18 May 2023 during the evening peak (Source: own illustration, based on Eskom data (2023))

5.2 Residential demand

5.2.1 From Figure 2 it can be seen that a quarter of South Africa's electricity consumption was consumed by the residential sector. Furthermore, this number is estimated to increase to as much as 35% during peak hours (McNeil et al. (2015, p 21)).

5.2.2 There have been multiple studies which aim to determine the proportion of residential electricity demand explained by various factors. Hughes and Larmour (2021, p 48) investigated the constituents of residential electricity demand; the results were broken down by income categories as either low (less than R5,000 per month), middle (between R5,001 and R20,000 per month), or high income (more than R20,001 per month) (Hughes & Larmour (2021, p 10).

5.2.3 According to Hughes and Larmour (2021, p 48), the low-income category makes no use of hot water geysers. This changes rapidly for the middle- and high-income categories where hot water geysers explain 34% and 37% of residential demand respectively.

6. ELECTRIC GEYSERS

6.1 Electric geysers

6.1.1 An electric geyser is a metal tank with an electric heating element inside. The element heats water inside the tank and it is controlled by a thermostat. The element is a physical object which is immersed in the lower compartment of the metal tank and which, when heated up, transfers that heat to the water.

6.1.2 In the plumbing industry, Garro (2020) explains that the thermostat is a device which monitors the internal temperature of the metal tank. When the tank's internal temperature is below the thermostat's set-point temperature, it permits electricity to the element. Conversely, when the tank's internal temperature is above or equal to the thermostat's set-point temperature, the thermostat disconnects electricity to the geyser.

6.1.3 Throughout the day, the thermostat cycles on and off to maintain the set-point temperature within the metal tank.

6.1.4 When using hot water, the tank begins to empty, and the water is gradually replaced by cold water which means that the internal temperature of the tank reduces. Therefore, the thermostat permits electricity to be drawn by the geyser during times where the geyser is used because the reduced internal temperature will likely fall below the set-point temperature.

6.1.5 An implication of this is that electric geysers are expected to draw more electricity during times where they are utilised.

7. SMART GEYSER DEVICES

7.1 Electric geyser timers

7.1.1 Geyser timers are a popular device in the South African market, enabling users of geysers to select when they want hot water and ensuring that their geysers turn on in time to provide hot water when it is needed. This tends to be during peak hours.

7.1.2 Timers are devices which are installed as an attachment to geysers, ensuring that the geysers switch on and off at specific times throughout the day. These times are typically selected by the users of geysers to which the device is fitted and coincide with the times in the day that they require their water to be heated.

7.1.3 Time-of-use (TOU) tariffs apply during peak hours in South Africa, primarily as what is meaningfully referred to by Alant (2023, p. 24) as an economic signal. That is, TOU tariffs can be considered a broad proxy method by which to correct negative externalities associated with the usage of electricity during times which are particularly costly for the power utility, Eskom. They disincentivise electricity usage during particular hours.

7.1.4 A primary deficiency of electric geyser timers lies within the consideration of their wide-scale adoption. Were all South Africans to fully adopt the usage of the timers, most users would select to have hot water at the same two times of the day: in the mornings before they leave home and in the evenings when they return home. Evidence of this may be seen in Figure 6.

7.1.5 To further emphasise that geysers drive two peaks of electricity demand i.e., a morning and evening peak, data from another estate in South Africa is shown in Figure 7. It can be seen that the same usage profile is present. Interestingly, the morning peak happens later for estate 1; this may be due to the estate being a retirement village.

7.1.6 In both estates 1 and 2, the average electricity consumption of geysers as a proportion of total demand is 33.1% and 33.5% respectively. If Hughes and Larmour (2021, p. 48) are correct then it might be said that estates 1 and 2 refer to middle income households in South Africa. That notwithstanding, the average usage implied by the

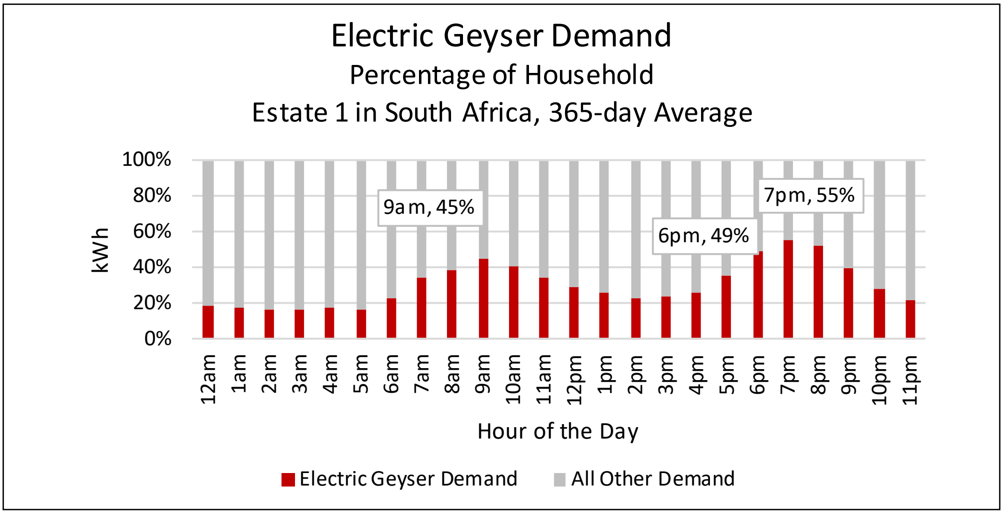

FIGURE 6 The 365-day average electricity demand of electric geysers in South African estate 1 with 750 properties (Source: own chart, based on data from Plentify (2023c))

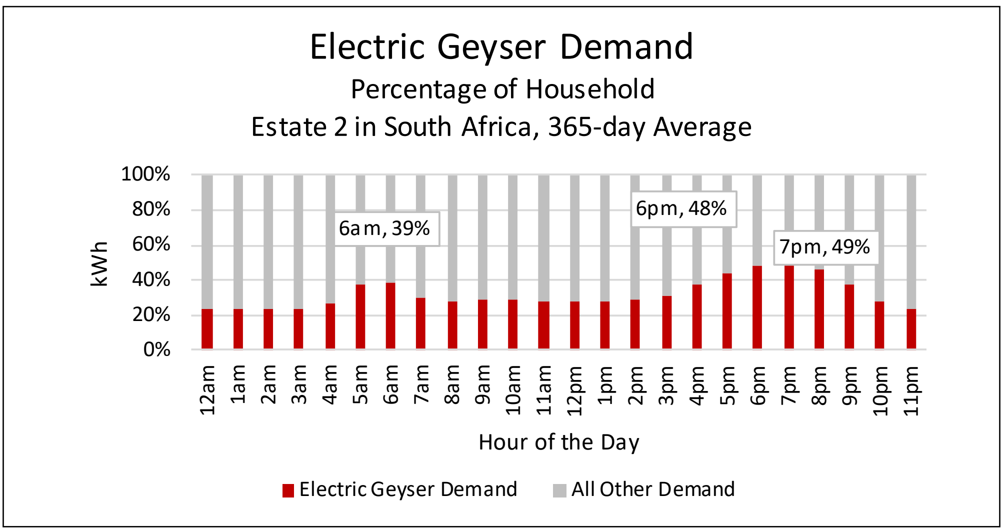

FIGURE 7 The 365-day average electricity demand of electric geysers in South African estate 2, also with 750 properties (Source: own chart, based on data from Plentify (2023c))

pilot data roughly confirms their findings, and differences will primarily depend on the population of users of geysers studied by them and those used in estates 1 and 2.

7.1.7 Note that for estate 1, the evening peak electricity demand from geysers is up 66% (the 7 pm peak expressed as a percentage increase to the 33.1% average), and the equivalent increase for estate 2 is 46%.

7.1.8 The timing of electricity usage of geysers corresponds directly to the timing of the usage of the heated water – this remains true even when using a timer. Figures 6 and 7 demonstrate this, and where the timing of the heating shifts back a fixed number of hours, so too will the electricity usage.

7.1.9 Therefore, the electricity grid is not expected to benefit from the wide-scale adoption of a geyser timer. Indeed, the intention of geyser timers may not traditionally have been to impose a positive demand-sided intervention to electricity usage.

7.2 Other design features

The primary benefit to consumers of timers is the cost savings associated with not having their geysers heated continuously. As can be seen from Figure 6, approximately 55% of residential demand is explained by electric geysers during the evening peak hour. The equivalent usage proportion in the morning peak hour is 45%. It is precisely these times during which customers pay the most for electricity as explained in ¶7.1.3. Typical geyser timers would switch geysers on in and around these times.

7.3 Smart devices

7.3.1 Not to be confused with timers, smart geyser devices are designed to perform smart work. While offering the typical benefits of a timer, smart geyser devices are different in a number of important ways. In particular, they monitor geyser temperatures as opposed to switching the geysers on and off at fixed times. This enables them to co-ordinate the on/off switching of geysers so that a given (specified) temperature is retained with minimal temperature variations. This implies that consumers spend less money on their electricity bill because the geyser does not need to heat water when consumers use hot water.

7.3.2 Aside from allowing consumers the ability to select when they have heated water throughout the day and ensuring delivery of that request in a smart way, smart geyser devices operate algorithms which simulate decision-making based on network inputs.

7.3.3 In a Harvard Business School Online article, Stobierski (2020) writes of network effects that they refer to any situation in which the value of a product, service or platform depends on the number of buyers, sellers or users who leverage it. Typically, the greater the number of buyers, sellers or users, the greater the network effect – and the greater the value created by the offering.

7.3.4 Leveraging a network effect as in ¶7.3.3, the more devices there are in a network providing information to a central control hub, the greater can be the accuracy of the response.

7.3.5 While there may be many theoretical benefits to leveraging off information from each constituent in a network of smart geyser devices, one specific benefit which is the topic of this paper relates to the ability of a smart geyser device to intelligently stagger the demand for electricity stemming from geysers. In understanding this, it is convenient to consider that if two households each had a geyser fitted with such a device, then the two geysers would not be on simultaneously, but would still ensure that the household has hot water when selected. In so doing, the deficiency raised in ¶7.1.4 is dealt with.

7.3.6 Furthermore, where more households make use of smart geyser devices, the staggering of demand for electricity from geysers is expected to have fundamental impacts on the pattern of electricity demand of users of geysers i.e., the residential sector.

7.3.7 A further typical design feature (Plentify, 2023a) includes a fast-response system of switching the geyser off, cutting water supply to the geyser, and/or alerting the owner of the household when detecting that a leak or burst has occurred. This has the effect of ensuring that, once a leak/burst is detected, any further potential consequential damage is avoided. While resolving the temporary inconvenience of a burst or leaking geyser to a consumer with a homeowners' insurance policy, the main benefit of this feature can be said to lie within its capacity to serve as a risk mitigation instrument for insurers writing homeowners' insurance policies.

7.3.8 While specific data on insurance companies is difficult to obtain, evidence from one insurer in South Africa suggests that 25% of total claim amounts paid, and 40% of frequency, on homeowners' insurance portfolios relate to geysers and consequential damage caused by leaks and/or bursts.

8. LOADSHIFTING/PEAK-SHIFTING

8.1 Load-/peak-shifting

8.1.1 Demand-side management, an often-overlooked method of resolving demand and/or supply constraints, is an increasingly common method of addressing key societal concerns. The South African environment has seen the advent of shared value which, according to Porter and Kramer (2011), refers to business models which create economic value while addressing societal needs. A comprehensive list of demand-side management techniques in relation to electricity is listed by Alant (2023, p 57–59). In particular, the notion of load-/peak-shifting features – a demand-side management initiative which shows a lot of shared value promise.

8.1.2 Indeed, most smart geyser devices and/or similar timers will accommodate customers as indicated above. Recent developments in the South African market are seeing businesses which operate in the domain of smart geyser devices innovate, with the introduction of the above-mentioned network effect.

8.1.3 The portrait painted of the demand profile of geysers in residential homes in South Africa through Figures 6 and 7 is fundamentally altered by the introduction of load-/peak-shifting via the network benefit described above. Evidence of this may be seen in Figures 8 and 9 which relate to estates 1 and 2 respectively.

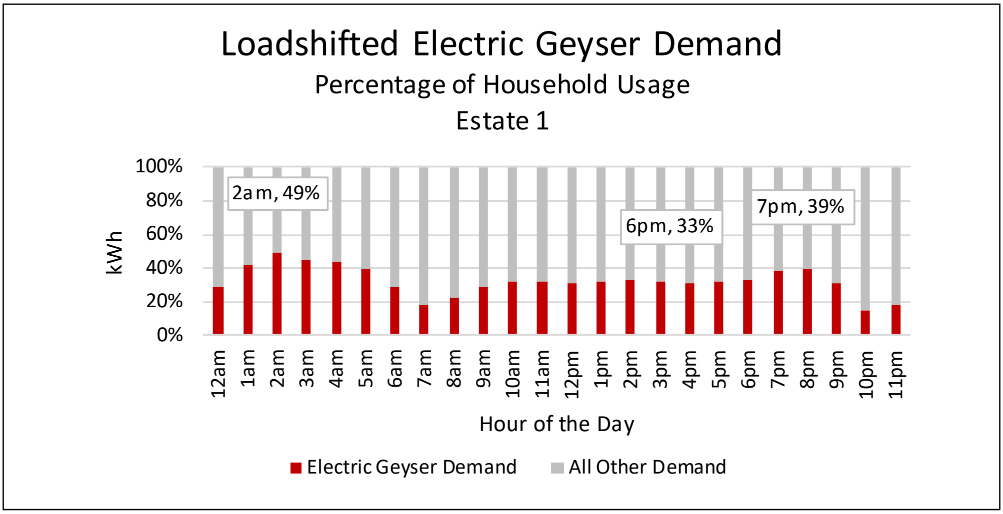

FIGURE 8 The 365-day average load-shifted electricity demand of electric geysers in South African estate 1, with 750 properties
(Source: own chart, based on data from Plentify (2023c))

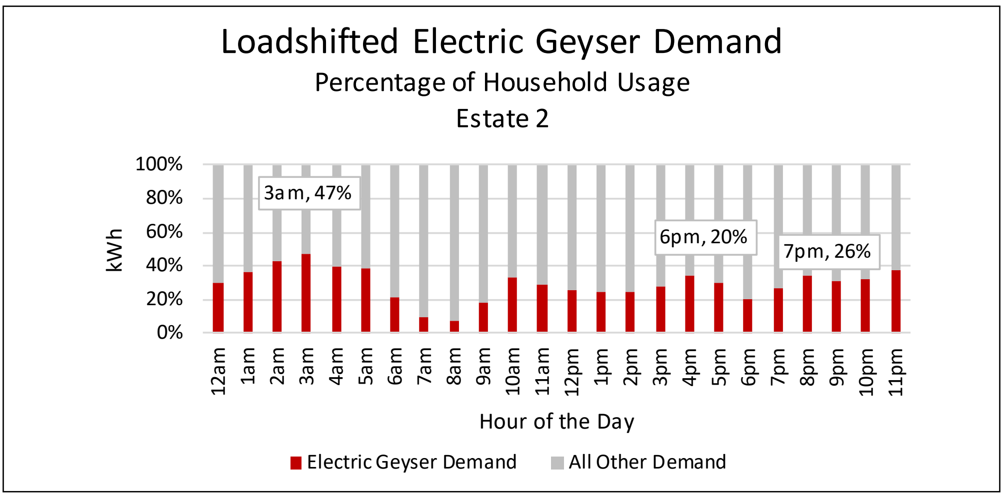

FIGURE 9 The 365-day load-shifted electricity demand of electric geysers in South African estate 2, also with 750 properties
(Source: own chart, based on data from Plentify (2023c))

8.2 Interpretation

8.2.1 An overlay of electricity demand from geysers, before and after load-shifting, is provided in Figure 10. From the figure the electricity demand curve for residential households can be seen to have been fundamentally altered and is flattened.

8.2.2 Several features may be noted by examining Figure 10:

- Where the demand before load-shifting peaked between 7 am and 10 am, that peak has shifted back a couple of hours and is broadly centred at 3 am.
- The morning peak, originally more accentuated with a clearly distinct peak at 9 am, has a far less distinct singular peak after load-shifting, reflecting a flattening of the demand curve.
- Where the morning peak would otherwise rise sharply before load-shifting, it in fact reduces and is at its all-time low throughout the day at 7 am.
- The evening peak, usually more severe than the morning peak, is also significantly flattened.
- The evening demand is now staggered throughout the early afternoon where higher demand post load-shifting can be seen between 1 pm and 4 pm.

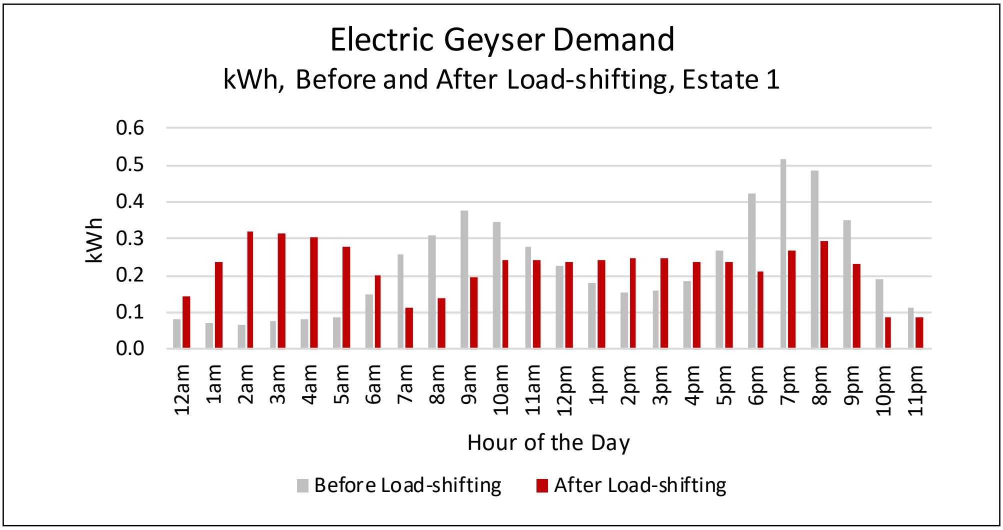

FIGURE 10 Overlay figures 6 and 8 to emphasise the fundamental shift in load for residential houses
(Source: own chart, based on data from Plentify (2023c))

8.3 The shape of the total demand curve and the residential demand curve

8.3.1 Examination of the total demand curve in Figure 3 reflects a bimodal curve which peaks in the mornings and the evenings. Figures 6 and 7 reflect this same bimodal demand curve, and this raises the question of whether it is a coincidence that the shape of the residential demand curve and the total demand curve are the same i.e., it raises the question of whether the residential sector's demand profile explains the bimodal nature of the total electricity demand.

8.3.2 While causality is not strictly demonstrated here, the demand for electricity from geysers for estates 1 and 2 is overlaid against all other demand within the households of those same estates in Figure 11.

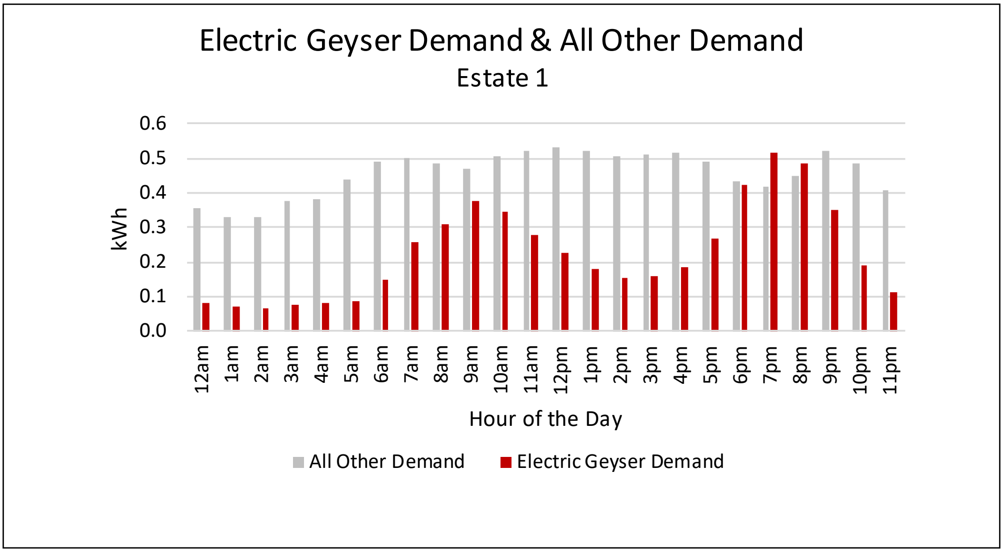

FIGURE 11 Overlay geyser electricity demand and all other electricity demand for estate 1 (Source: own chart, based on data from Plentify (2023c))

8.3.3 The data show that all demand other than geyser demand does not exhibit any obvious seasonality nor does it have the distinct two-peak structure seen for electric geysers. While the constituents of residential demand other than geysers is not in the scope of this paper, it is noted that factors which would serve as evidence that geysers are the primary driver of the shape of the residential demand curve requires further study of other primary drivers of residential demand. These include air conditioners, pool pumps, ovens, lighting, fridges and deep freezers, televisions, dishwashers and washing machines.

8.3.4 Combining the point raised in ¶5.2.1, namely that the residential sector explains 35% (up 40% from the daily average of 25%) of the total demand during peak hours, and the equivalent points for the residential sector in ¶7.1.6, it would seem clear that the residential sector drives a material component of the bimodality of the total South African electricity demand curve.

8.3.5 It is meaningful to consider the point raised in ¶5.1.4 in the context of geyser electricity demand: the only time interval in the day during which there is excess demand over supply coincides with the same time interval in the day where geysers are doing all their work (see Figures 4, 5 and 11). And there is evidence to suggest that geysers are driving all of that peak demand.

8.4 Generalising to the entire electricity grid

8.4.1 The statistics mentioned thus far can provide an instructive build-up of total electricity demand in South Africa. The build-up is summarised in Table 2 below and is illustrated using a waterfall chart in Figure 12.

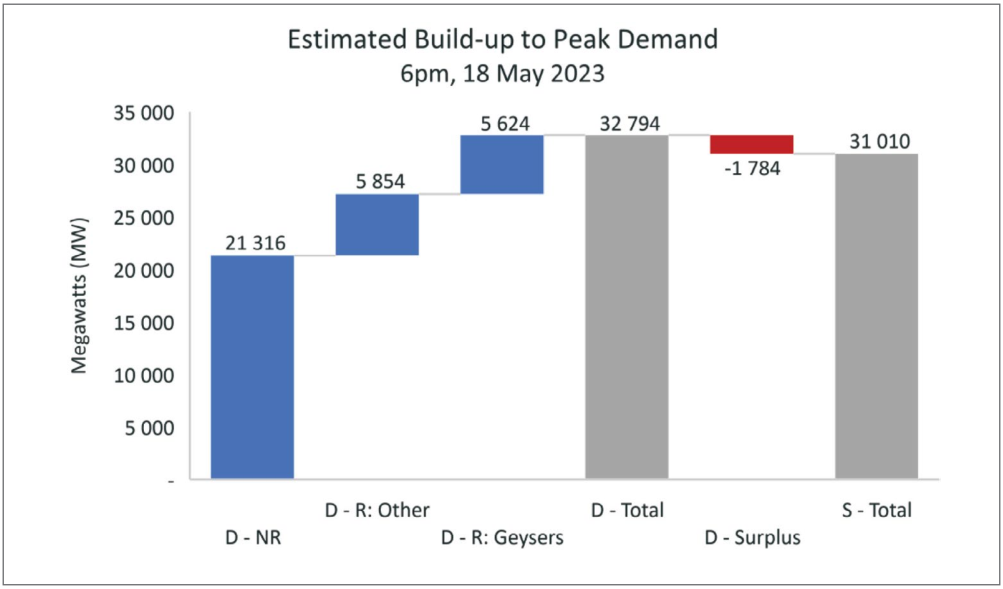

Figure 12 A build-up of total demand and then back down to supply on 18 May 2023 at 6pm (Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015))

Table 2 A build-up to total demand and then back down to supply on 18 May 2023 at 6 pm

Axis Label	Item of demand	Measurement (MW)
D – NR	Non-Residential	21,316
D – R: Oth	Residential – All Other	5,854
D – R: Geysers	Residential – Geysers	5,624
D – Total	Total Demand	32,794
D – Surplus	Surplus	1,784
S – Total	Total Supply	31,010

Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015)

The values of Table 2 are calculated in the following order:

— The total demand for 18 May 2023 at 6 pm can be seen from Figure 5 to have been 32,794 MWs.
— The percentage, at this hour, of that total demand explained by the residential sector is 35% thereof as seen in ¶5.2.1. This is 11,478 MWs.
— Of this 11,478 MWs of total residential demand, it is estimated that 49% thereof is attributable to electric geysers as can be seen in Figure 6. This is 5,624 MWs.
— The balance in demand is 5,854 MWs and represents all other residential demand.

— Non-residential demand is the difference between total demand and the residential demand. This is 21,316 MWs.
— The surplus demand is known from Figure 5 and equals 1,784 MWs.
— The total supply is the total demand less the surplus demand, which is 31,010 MWs. This can also be seen from Figure 5.

8.4.2 As seen in Figures 8 through 10, the proportion of residential demand during peak intervals changes fundamentally. The impact that load-shifting may therefore have on the full electricity grid can be estimated by changing the residential demand commensurate with shifted electricity loads. This is done as follows:
— Residential demand not related to geysers remains unchanged at 5,854 MW. This is because smart geyser devices implementing load-shifting are expected only to impact geyser electricity demand.
— Non-residential demand also remains unchanged, and for the same reason.
— The load-shifting impacts seen in estate 1 are generalised to the entire residential sector i.e., from Figure 8, 33% (down from 49%) of total residential demand is explained by geysers due to the impact of load-shifting at 6 pm. Therefore, the revised electricity demand from geysers in the residential sector is equal to:

$$\frac{33\%}{1-33\%} * (\text{Residential: All Other Demand})$$

This equates to 2,864 MW of demand attributable to geysers.
— The total demand is then the sum of the amounts determined in the above three bullet points and this is equal to 30,034 MW.
— The total supply remains unchanged at 31,010 MW.
— It is seen that total demand at 6 pm has fallen below the supply point, creating a position of surplus supply, in effect reversing the position from one of surplus demand to one of surplus supply. See Table 3 and Figure 13.

TABLE 3 A revised build-up to total demand and then back down to supply on 18 May 2023 at 6 pm assuming that the load-shifting impacts of estate 1 generalises

Axis label	Item of demand	Measurement (MW)
D – NR	Non-Residential	21,316
D – R: Oth	Residential – All Other	5,854
D – R: Geysers	Residential – Geysers	2,864 (–49%)
D – Total	Total Demand	30,034 (–8%)
D – Surplus	Surplus	–976 (–155%)
S – Total	Total Supply	31,010

Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015)

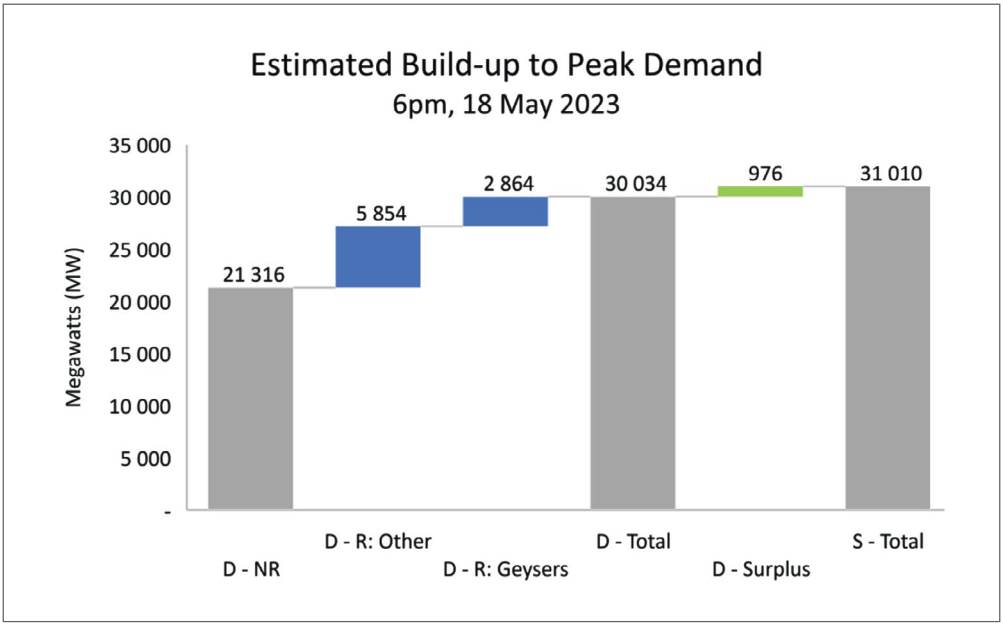

Figure 13 A build-up of total demand and then up to supply on 18 May 2023 at 6 pm assuming that load-shifting has been implemented (Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015))

8.5 The workings of Section 8.4 above can be applied to estate 2 and is shown in Table 4. Figure 14 illustrates that table. The calculations instead assume, as can be seen in Figure 9, that estate 2's load-shifted geyser demand at 6 pm equals 12% of residential electricity rather than 33% as for estate 1.

Table 4 A revised build-up to total demand and then back down to supply on 18 May 2023 at 6 pm assuming that the load-shifting impacts of estate 2 generalises

Shorthand	Item of demand	Measurement (MW)
D – NR	Non-Residential	21,316
D – R: Oth	Residential – All Other	5,969
D – R: Geysers	Residential – Geysers	1,505 (–73%)
D – Total	Total Demand	28,790 (–12%)
D – Surplus	Surplus	–2,221 (–224%)
S – Total	Total Supply	31,010

Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015)

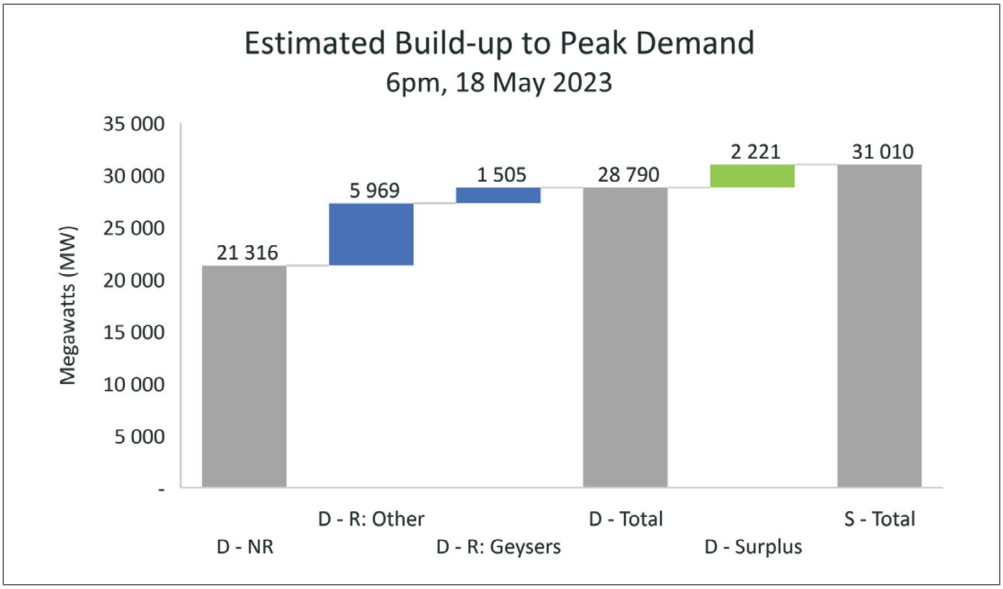

FIGURE 14 A build-up of total demand and then up to supply on 18 May 2023 at 6pm assuming that load-shifting has been implemented and that estate 2's benefits are generalised to the grid (Source: own table, based on data from Eskom (2023), Plentify (2023c) and McNeil et al. (2015))

8.6 CONCLUSION

8.6.1 It is seen that wide-scale adoption of smart geyser devices which harness network effects to stagger geyser demand for electricity, and to spread it over time intervals where there is traditionally no peak, may have the effect of creating surplus supply on the grid.

8.6.2 This does not conclude that geysers are the primary driver of load-shedding. Indeed, there are supply- as well as demand-side issues resulting in the need for loadshedding. In particular, the underlying reasons for loadshedding are published in the public domain and are well-summarised in an amaBungane article by Comrie (2022). For ease of reference these reasons are ageing power plants, a lack of political will to fund new power stations, inaccurate projections and inappropriate planning, unrealistic targets, cost cutting of critical maintenance, gross mismanagement, state capture and corruption, a lack of revenue, and more.

8.6.3 Theoretically, total demand from the residential sector is not expected to reduce due to load-shifting. Indeed, the smart geyser device analysed above is expected to have the effect of changing the incidence of geyser demand, not the total amount. However, there are examples (estate 2) which show case that users of smart geyser devices do indeed use less electricity after load-shifting – see Figure 15. Reasons for this may include genuine behaviour change resulting from cost savings observed or positive selection whereby customers who are already electricity-savvy are the ones who choose to use smart geyser devices because they know they have something to gain.

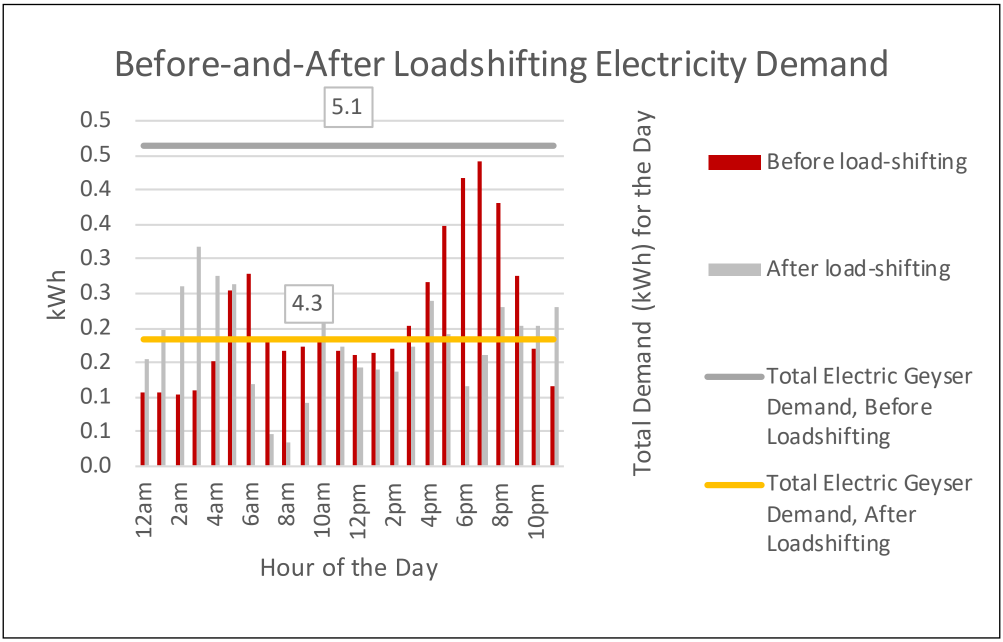

FIGURE 15 An example of residential demand reducing by approximately 16% in the presence of a smart geyser device
(Source: own table, based on data from Eskom (2023) and Plentify (2023c))

9. BENEFITS OF IMPLEMENTATION

9.1 Although the benefits mentioned thus far have related primarily to the South African electricity grid, there is a wide variety of benefits resulting from wide-scale implementation of smart geyser devices. The benefits already mentioned include cost-savings for customers who would otherwise pay for electricity usage during peak hours, and reduced loadshedding.

9.2 The benefits cross multiple domains and affect a variety of stakeholders. It is difficult, and potentially misleading, to state that the benefits of wide-scale adoption of smart geyser devices are attributable to a single party. The benefits, ranked in accordance with the perception of most direct to most indirect, are discussed with a view to the benefits for insurance companies.

9.2.1 The most direct benefit associated with wide-scale adoption of a smart geyser device relates to its capability of detecting leaks and/or bursts and shutting off geysers/water supply to prevent further damage. This would be expected to be beneficial to homeowners' insurance portfolios. Such portfolios are expected to benefit from reduced claims size and frequency associated with geyser leaks and/or subsequent bursts if the geysers they insure are fitted with a device designed to reduce further damage upon the detection of leaks and/or bursts.

9.2.2 Reduced loadshedding is expected to see more orderly roads where traffic lights spend less time offline and motor accidents are reduced to their pre-loadshedding levels, all other factors being equal. This would be expected to create a benefit for all writers of motor insurance, and even writers/reinsurers of life insurance contracts to the extent that motor accidents caused by loadshedding-induced chaotic roads are fatal.

9.2.3 Reduced loadshedding is expected to see surge-related claims come down. In his audited results presentation, Anton Ossip (2022) articulated clearly that power surge frequency is not only strongly correlated to loadshedding events, but that their claim experience shows power surge claims falling well outside of their 95% confidence interval and to an increasing degree over time. Another insurer in South Africa's data reveals that surge claims have been up 60% over the past three years.

9.2.4 Reduced loadshedding is expected to see companies and government spending less money on burning of diesel to supplement the deficient power grid in South Africa. The expenses incurred to generate electricity using diesel are significant and an environment seeing reduced levels of loadshedding would imply that less diesel needs to be purchased and used.

9.2.5 According to Du Toit (2023) Eskom had spent R3 billion per month on diesel on average in the 2023/24 fiscal year as at June 2023.

9.2.6 According to *BusinessTech* (2023), South African grocery store Pick n Pay spent over R520 million on diesel amounting to 24.8% of their earnings before tax.

9.2.7 Absa Group reported that they expected to pay between R200 million and R350 million on diesel for the 2023 financial reporting period if loadshedding stayed between the February 2023 level and stage 6, in an article by Moodley (2023).

9.2.8 Crime rates have been reported to have increased because of loadshedding. While no evidence is presented to prove that loadshedding was the cause, the opportunities created by loadshedding for criminal activity to thrive should not be dismissed.

9.2.9 Costs associated with business continuity management in the event of a grid collapse may be severe and may interact with other catastrophic events whether economic or political. Reduced loadshedding reduces the likelihood of a grid collapse and hence the risk associated with a grid collapse.

9.3 Eskom would see significant benefits from wide-scale implementation of smart geyser devices because they would fundamentally alter the profile of electricity demand.

9.3.1 Where traditionally the demand for electricity is pronounced in the mornings and evenings – requiring fast ramp-up of power plants to meet the rapidly rising demand at those times – a flatter demand curve reduces the need for the utility to have fast ramp-up rates. Alant (2023, p. 39) explains that coal and nuclear generators typically have slow ramp-up rates and collectively represent at least 86% of South Africa's power grid.

9.3.2 Open-Cycle Gas Turbines (OCGTs) – generators which burn diesel to create electricity – have quick ramp-up times and are therefore the preferred method of accommodating rapid rises in electricity demand (Alant, 2023, p. 44).

9.4 Reduced loadshedding is expected to see more small businesses opening and fewer closing. The Bureau for Economic Research (BER) estimates that South Africa's gross domestic product (GDP) could have been between 3.8% and 12.4% higher at the end of 2022 had there been no loadshedding (BER, 2023).

9.4.1 The BER plotted four scenarios which depict the time of day that load-shedding occurs including:

- all days at any time of day;
- excluding weekends and public holidays;
- excluding weekends and public holidays, only including loadshedding between 07:00 and 19:00; and
- excluding weekends and public holidays, only including loadshedding between 09:00 and 17:00.

9.4.2 Rather than placing an average on the figures, Figure 16 has been prepared with emphasis on the range of possible values of the cost of loadshedding from years 2018 through 2022.

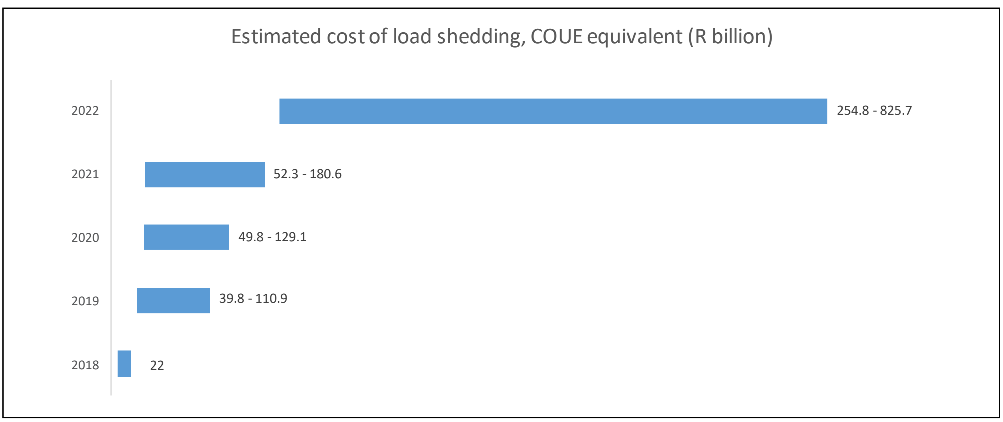

FIGURE 16 BER estimate of lost GDP by end of 2022 due to loadshedding across various scenarios
(Source: Bureau for Economic Research (2023))

9.5 People are severely affected by loadshedding. From the long and potentially less safe journey home after long days at work, being unable to enjoy the leisure activities of the 21st century, and incurring a significant cost (if at all) of financing to provide back-up power systems, to the sense of hopelessness attached to an issue which seems too large to be solvable by any one individual, the mental impact of loadshedding on South Africans is likely understated.

9.6 The South African Depression and Anxiety Group (SADAG) sent a survey to 30,000 SADAG members, the majority of whom reported a sense of helplessness, increased likelihood to lose their tempers and associated road rage, and a concern that, with a stagnating economy, their personal circumstances will worsen (SADAG, 2023).

9.7 Listing the benefits of reduced loadshedding is a challenging task; the obvious ones are listed above and that list is not exhaustive. The boiling frog apologue comes to mind when contemplating our fellow South Africans who have slowly become accustomed to worsening conditions. There is a social imperative attached to solving loadshedding.

10. OBTAINING SCALE

10.1 A critical point of departure regards the scale of smart geyser devices which, in accordance with the above, are demonstrated to be capable of eliminating or, at the very least, significantly reducing, loadshedding.

10.2 Given the clear theoretical benefits to writers of short-term insurance contracts, the most clear of which relate to homeowners' insurance in the mitigation of geyser-related claims, a method of scale would relate to the modification of the product design of homeowners' insurance contracts to include the installation of a smart geyser device. In the remainder of this section, scaling of these devices through insurance is discussed.

10.3 There may, broadly speaking, be two methods by which to offer these products to policyholders. The first relates to the sale of a new policy or upon the renewal of an existing policy, where the insurance company undertakes to have a smart geyser device installed.

10.4 The second relates to the claims-stage installation of the device upon visiting and performing contractual repairs required because of a geyser which has leaked or burst.

10.5 Data from specific insurance companies regarding the quantum of new business volumes, renewals or claims per year are not easily available as this is commercially sensitive data. Knowing how many policies are sold and/or renewed each year, as well as how many claims take place each year would provide meaningful insight into the expected volumes of smart geyser devices that may be issued per year (or month). This may be known at the level of an individual insurer.

10.6 A third – and potentially larger – opportunity for scale lies within the domain of bancassurance. Traditionally understood to be a bank with a concurrent vanilla life insurance offering, there would be little to preclude a bank which issues home loans from offering – or pointing to a provider of – homeowner's insurance whose product design is such that it includes a smart geyser device.

11. NOTED DIFFICULTIES

11.1 Anti-selection risk

11.1.1 An important difficulty raised in discussions with actuaries versed in the argument relates to the lapse risk created by the anti-selective behaviour of policyholders who would, in the event of the offering of a smart geyser device alongside their homeowner's insurance policy, take up a policy only to lapse after receiving the installation.

11.1.2 Indeed, the proposed anti-selective behaviour would result in an insurance company being incapable of recuperating the costs incurred in the acquisition of smart geyser devices. This assumes that the insurer fully funds the purchase of the device. However, even should the device be partially funded by the insurance company the anti-selection risk would persist to a degree.

11.1.3 This line of argument presupposes that the specific insurance company offering the smart geyser device is the only beneficiary of the features of the device. If the primary benefit of wide-scale adoption of smart geyser devices is reduced loadshedding then it would be in the interest of all insurance companies – indeed all companies – to scale up the usage of such devices. Where one policyholder lapses their homeowner's insurance policy selectively, they may either have no insurance or move to another insurer. In either scenario, the ongoing usage of the device is expected to have the benefit of reducing loadshedding.

11.1.4 It could therefore call for an industry fund structure not dissimilar to the Risk Equalisation Fund (REF) notion studied in the healthcare industry. The notion of a REF is outside the scope of this paper but is listed as a topic of further research. Note that it is not proposed that a REF is used; rather, it is proposed that a similar industry fund is used i.e., parties to the fund contribute and withdraw in proportion to their means and needs respectively. Those who experience worse selective lapsing would withdraw more from the fund, and those with better experience would withdraw less (or none).

11.2 Guarantees and/or warranties on geysers

With regard to guarantees and warranties, accredited installers of electric geyser timers and smart geyser devices would need to provide a valid electrical compliance certificate upon installation, with a primary intention that guarantees or warranties on electric geysers are not voided. This is an industry norm for such devices.

11.3 Centralised control

11.3.1 The notion of giving a third party, and perhaps even the power utility, the ability to shut off our geysers at a whim is a grim one. Indeed, not having hot water when it is needed and/or wanted is not ideal.

11.3.2 However, South Africans are accustomed to not having electricity as a whole (which is inclusive of geysers going off) due to centralised control of our electricity access by Eskom. If geyser-shedding is all that is required to ensure that we may have electricity throughout the day, it would be a significant improvement to our lives. That centralised control would not be necessary, however, as customers would be able to select when they need/want hot water and smart geyser devices would ensure that that is possible while also reducing the extent of loadshedding required.

12. FINANCING

12.1 A theoretical funding model

Fairness might postulate that if a system or product benefits a defined set of beneficiaries then they ought all to contribute to that system's cost in proportion to their benefit. A non-exhaustive list of the beneficiaries of a smart geyser device are summarised in Table 5. Each beneficiary's main benefits are classified as direct or indirect, the former meaning that those benefits result directly from usage of smart geyser devices, where indirect means that those benefits result from eventual reduced loadshedding.

12.2 Partial funding by insurance companies

12.2.1 As seen in Table 5, a plethora of beneficiaries exist. The responsibility of alleviating the impacts of the energy crisis may rightly be understood to be the primary responsibility of the government. This is because Eskom is state-owned and receives public funds to provide sustainable electricity solutions. The proposition that the private sector become involved in the energy crisis might imply that the government and Eskom cannot be depended on to roll out smart geyser devices – at least initially. In principle, this is not ideal, but may prove to be the most successful short- to medium-term approach.

TABLE 5 A non-exhaustive list of beneficiaries of smart geyser devices

Beneficiary	Main benefit	Category
Homeowners' insurance portfolios	Reduced claims frequency and severity associated with leaking and/or burst geysers.	Direct
Motor insurance portfolios	Reduced claims frequency related to chaotic roads due to lack of working traffic lights or other lighting.	Indirect
Death cover portfolios	Reduced claims frequency related to opportunistic crime, as well as deadly road accidents.	Indirect

Household contents portfolios	Reduced power surge claims frequency, as well as reduced opportunistic crime.	Indirect
Purchasers of diesel	Reduced purchase of diesel for back-up power systems.	Indirect
Government	Reduced diesel expenditure, more tax revenue because more people are working and fewer companies are closing down.	Indirect
Eskom	A fundamentally altered electricity demand curve which is flatter and implies a grid which is less costly to maintain.	Indirect
Smart geyser device companies	Demand for this product will see businesses thrive.	Indirect
Society	Improved mental health, lower unemployment rate, safer.	Indirect

(Source: own table)

12.2.2 What would remain if political entities were not included is a device funded by a triad including insurers, providers of smart geyser devices and policyholders. An illustration of this triad may be seen in Figure 17.

12.2.3 Indeed, policyholders can be said to be better risks to insurance companies if they had smart geyser devices attached to their geysers. To that end, the clearer benefits to policyholders could be viewed as reduced premiums, those policyholders' reduced electricity costs notwithstanding. Viewed in this way, the virtuous feedback loop created by the provision of smart geyser devices is well-illustrated.

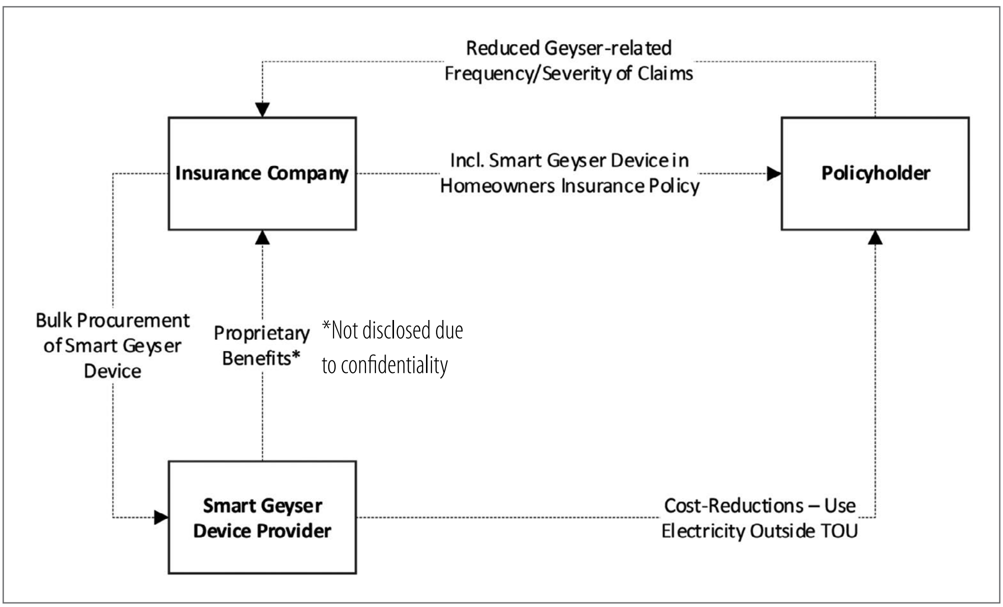

FIGURE 17 An example of smart geyser devices, insurance companies and policyholders forming a shared-value cycle
(Source: own figure)

12.3 Full funding by insurance companies

12.3.1 While policyholders may be said to most naturally benefit by having reduced premiums, the funding generated by directly reduced geyser claims frequency and severity may be best utilised by funding the smart geyser devices. This requires the cost of acquiring such devices to be less than or equal to the benefits created by their usage.

12.3.2 This sends a message to the public of corporate social responsibility and maintains that the public should not be held solely responsible for the energy crisis. Indeed, it implies that the private sector is responsible, but the proposition that insurers fully fund smart geyser devices should not be taken to suggest that. Rather, the pace at which the private sector may roll out such initiatives would most likely exceed that of the public sector, and the easier it is for customers to install smart geyser devices, the better.

12.3.3 In a study on smart meter-related data privacy concerns, von Loessl (2023) explains that customers typically require significant compensation to share their electricity consumption data. As such, direct sales to customers might be expected to be less successful than if the devices are automatically included as part of something like an insurance purchase where the process of obtaining the device is as frictionless as possible. A plethora of alternative (or complimentary) methods of scale come to mind, such as default inclusion of smart geyser devices with geyser sales.

12.4 Assessing the cost

12.4.1 The cost of smart geyser devices vary and it should be noted that, for the purposes of this paper and at the time of writing (2023), the understanding is that there is only one company in South Africa whose smart geyser device has the network effect described in Section 7.3. The costs may change over time due to increasing competitive pressures or added product features, but it might be expected that partnerships would present certain economic benefits to insurance companies who may wish to bulk-acquire smart geyser devices.

12.4.2 The market leader's product costing is summarised in Table 6, with current (2023) costing of R1,500 upfront and R99 per month on an ongoing basis. There are penalties for cancelling early.

Table 6 Smart geyser device costs, per device, ZAR

Scenario	Present value of costs*	Total costs
24-month Payment	R 3,779	R3,876
36-month Payment	R 4,750	R5,064
60-month Payment	R 6,415	R7,440

(Source: own table, based on Plentify (2023b)

*Applying an effective interest rate of 8% p.a.

12.4.3 The costing profile for a given insurance company may look slightly different and some reasons for this would include bulk purchase attracting a different costing profile, insurers may not necessarily fund all of the device, the term chosen would depend on the particulars of the insurer's portfolio in how acquisition costs are to be recovered e.g., the duration of that specific insurer's portfolio , and the impact that product design will have on policyholder behaviour.

12.4.4 A simple model which expresses expenses as a percentage of premium income i.e., through an expense ratio might see the expense ratio increase by incorporating the above costing profile into their budgeting exercise.

13. CALL TO ACTION

13.1 In a partnership between the City of Johannesburg, Dialdirect, and Discovery Insure, the trio has been filling potholes on South African roads (Discovery, 2021). This is a joint partnership not only between two competing private companies, but between the public and private sector. It is encouraging to see such initiatives which recognise the relationship between the work the private sector does, and the benefits that may be had by society.

13.2 In another example of private-public partnerships, in a MyBroadband article Illidge (2023) notes that, as of 30 January 2023, South Africans can renew their passport or apply for a smart ID card at more than 30 bank branches. This is encouraging considering the burden of queueing at Home Affairs which for so long has plagued many South Africans.

13.3 The Actuarial Society of South Africa's Code of Conduct (Actuarial Society of South Africa, 2015) stipulates that members are encouraged to "consider the public interest when rendering actuarial services". The work presented in this paper serves as a call to action and to consider the next big step in South Africa's future as regards the marriage between the work done in the private sector, the skills of actuaries, technology and society.

14. CONCLUSION

The objective of this paper was to answer three specific research questions, and there are insightful answers to all three questions. While there is a lot of work remaining, it is my hope that this serves as the bedrock for more work by actuaries in this sector, whether thinking up creative solutions themselves or identifying synergies between innovations that benefit people, and the companies for which they work.

14.1 Do electric geysers drive a significant proportion of South Africa's aggregate electricity demand?

14.1.1 We have seen from two case studies on residential estates in South Africa that between 49% and 55% of residential household electricity usage is explained by electric geysers. Further, we have seen that residential demand explains up to 35% of peak aggregate electricity demand. Therefore, between 17.2% and 19% of the South African country-wide aggregate electricity demand is driven by electric geysers during peak hours.

14.1.2 Additionally, we have seen compelling evidence that there is a deep relationship between the shape of geyser demand and the shape of total demand. While a causal study has not been performed, we may combine the facts that aggregate demand increases significantly during peak hours, residential demand increases significantly during peak hours, and that geysers explain all the residential demand's bimodality to produce strong evidence that geysers explain the peaks on the aggregate electricity demand curve.

14.1.3 Finally, we have seen that it is only during peak hours that aggregate demand exceeds aggregate supply. It therefore seems clear that redistribution of geyser demand to other parts of the day may significantly reduce the loadshedding required and the case studies in this paper suggest that it could be eliminated.

14.2 Is there evidence to suggest that the inclusion of smart geyser devices is economically viable for insurance companies?

14.2.1 We have seen that the direct benefits to short-term insurers writing homeowner's insurance policies are pronounced – reduced claims severity and frequency are both expected in theory as devices which stop leaks and/or prevent bursts must certainly be tested, at least from a risk management point of view. There is thus a direct incentive for such insurers – at least in the short term – to investigate alterations of their product design to include such devices.

14.2.2 The inclusion of such a device incurs some form of an additional cost, and produces an additional expected claims reduction. The financial viability of a product design change can be assessed to the extent that the benefits exceed the costs. We saw that the typical cost for a single device is in the range of R3,779 and R6,415. Therefore, the direct benefit of administering such a device to homeowners' insurance policyholders should ideally exceed that.

14.2.3 We have also seen the plethora of benefits of reduced loadshedding and the benefits discussed in this paper are likely not exhaustive. While some of the benefits are more difficult to quantify, that quantification might sensibly be based on a projection of expected reductions in loadshedding as a function of a particular adoption rate and a given projection of new business volumes and/or claims.

14.3 If such inclusion is not immediately economically viable, what can be done to make it so?

14.3.1 In briefly investigating a few different financing options, it is clear that a spectrum of reliance may be placed on an insurance company alone to finance the acquisition of smart geyser devices. Where insurers fully fund such devices, a potential anti-selection risk presents itself, and may present itself acutely if other insurers are not following suit.

14.3.2 Insurers who are encouraged to investigate including smart geyser devices as part of their homeowner's insurance product design would ideally look to their own business and assess to what extent they may fund these products.

14.3.3 Industry funds, at least at a high level, provide an encouraging and unvisited framework for private sector involvement in solving societal issues. Where the design of actuarial products is typically underpinned by how that specific designing company benefits, and to what risks that particular company may be exposed, societal benefits operate differently and funds which facilitate transfers to and from multiple involved insurers might be a viable option.

14.3.4 Custom arrangements between insurers and providers of smart geyser devices could be negotiated which dictate that insurers pay marginally for the services they require only – leak detection, for example – and finance the remaining cost depending on the beneficiary.

14.3.5 As a final alternative, and while not explored in this paper, the extent to which insurance companies see environmental benefits associated with smart geyser device adoption may dictate that environmental, social and governance (ESG) budgets can be directed to the acquisition of such devices.

15. NEXT STEPS

15.1 This paper may be interpreted as a progress report on the project of studying the costs and benefits of implementing smart geyser devices in every household in South Africa which has an electric geyser, using homeowners' insurance as a carrier.

15.2 What will directly follow in the ensuing months is a co-ordinated piece of work with a willing short-term insurer to assess the costs and benefits of implementation. This will enable deeper and more accurate models to be built, and to provide a more meaningful case for the involvement of actuaries, insurance companies and perhaps the private sector as a whole in reducing the impact of loadshedding.

16. FURTHER AREAS OF RESEARCH

The preparation of this paper represents one step towards the use of actuarial skills to serve humanity. Further areas of research which fall along the trajectory of this project include:

— Projecting gradual improvements in loadshedding in South Africa given a profile of distribution of smart geyser devices
— Performing an actuarial analysis on the costs and benefits of providing smart geyser devices through insurance policies.
— Determining what we can learn from risk equalisation funds.
— Concluding whether an industry equalisation fund could be adopted to fund projects which have societal benefit.

— Concluding whether such a fund can add value if it is not a regulatory requirement.
— Determining whether the planet is a beneficiary of reduced loadshedding.
— Investigating whether centralised control of electric geysers is reasonable and viable.

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REFERENCES

Actuarial Society of South Africa (2015). 'Code of Conduct', Cape Town: Actuarial Society of South Africa, p. 5. Available at https://www.actuarialsociety.org.za/download/disciplinary-procedure/?wpdmdl=1576 (Accessed 24 July 2023).

Alant, EJT (2023). 'An actuarial perspective of South Africa's electricity system', Cape Town: Actuarial Society of South Africa. Available at https://www.actuarialsociety.org.za/download/Public%20Interest:%20South%20Africa%E2%80%99s%20Electricity%20System/?wpdmdl=20845 (Accessed 24 July 2023).

Bureau for Economic Research (2023). Powering growth: Electricity and South Africa's economic outlook. Research Note 2023 No. 1.

BusinessTech (2023) 'From bad to worse: Load shedding vs blackout hours in South Africa', *BusinessTech*, 17 April 2023. <https://businesstech.co.za/news/business-opinion/681001/from-bad-to-worse-load-shedding-vs-blackout-hours-in-south-africa/>. (Accessed 24 July 2023).

Comrie, S (2022). 'The collapse of old king coal (part 1)', *amaBhungane Centre for Investigative Journalism*, 27 September 2022. <https://amabhungane.org/stories/220928-the-collapse-of-old-king-coal-part-1/>. (Accessed 24 July 2023).

Daily Maverick (2023). 'Absa expects load shedding diesel costs of between R200m and R350m in the next year', *Daily Maverick*, 13 March 2023. <https://www.dailymaverick.co.za/article/2023-03-13-absa-expects-load-shedding-diesel-costs-of-between-r200m-and-r350m-in-the-next-year/>. (Accessed 24 July 2023).

Discovery (2021). 'Pothole patrol – Driving change on South African roads', *Discovery Corporate*, (November 2021). <https://www.discovery.co.za/corporate/good-driving-pothole-patrol-driving-change#:~:text=and%20WhatsApp%20Bot.-,Discovery%20Insure%2C%20in%20partnership%20with%20Dialdirect%20and%20the%20City%20of,enhancing%20and%20protecting%20people's%20lives>. (Accessed 24 July 2023).

Du Toit, S (2023). 'Eskom spends R3 billion burning diesel a month into 2023/24 fiscal year', *capetownetc*, 5 June 2023. <https://www.capetownetc.com/news/eskom-spends-r3-billion-burning-diesel-a-month-into-2023-24-fiscal-year/#:~:text=Gordhan%20provided%20the%20figures%2C%20stating,3%20billion>. (Accessed 24 July 2023).

Eskom (2023). Eskom data request form. Available at: https://www.eskom.co.za/dataportal/data-request-form/ (Accessed 17 August 2023).

Garro, F (2020). 'The function of an electric water heater thermostat', *Interplay Learning*, 8 December 2020. <https://www.interplaylearning.com/blog/the-function-of-an-electric-water-heater-thermostat/>. (Accessed 18 August 2023.)

Hughes, A & Larmour, R (2021). 'Residential electricity consumption in South Africa', Cape Town: University of Cape Town. Available at https://sanedi.org.za/data-and-knowledge-management/uploads/October%202022/Residential%20Energy%20Cosumption%20Study%20-%2021042021.pdf (Accessed 24 July 2023)

Illidge, M (2023). 'Bank branches where you can get your passport and smart ID', *MyBroadband*, 30 January 2023. <https://mybroadband.co.za/news/banking/477023-bank-branches-where-you-can-get-your-passport-and-smart-id-2.html>. (Accessed 24 July 2023.)

McNeil, MA, Covary, T & Vermuelen, J (2015). 'Water heater technical study to improve MPS – South Africa', In 8th International Conference on Energy Efficiency in Domestic Appliances and Lighting. Available at https://international.lbl.gov/publications/water-heater-technical-study-improve?page=21 (Accessed 24 July 2023).

Moodley, N (2023). 'Eskom spends R3 billion burning diesel a month into 2023/24 fiscal year', *capetownetc*, 5 June 2023. <https://www.capetownetc.com/news/eskom-spends-r3-billion-burning-diesel-a-month-into-2023-24-fiscal-year/#:~:text=Gordhan%20provided%20the%20figures%2C%20stating,3%20billion>. (Accessed 24 July 2023.)

Ossip, A (2022). 'Audited Results' [Presentation], Discovery Insure 2022 UBS SA Short-term Insurance Indaba, 1 Discovery Place. Available at: https://www.discovery.co.za/assets/discoverycoza/corporate/investor-relations/2022-ubs-sa-short-term-insurance-indaba.pdf (Accessed 24 July 2023).

Plentify (2023a). *Meet HotBot*. Available at: https://plentify.io/individuals/#meet-hotbot (Accessed 24 July 2023).

Plentify (2023b). https://plentify.io/ (Accessed 24 July 2023).

Plentify (2023c). Proprietary pilots.

Porter, ME & Kramer, RK (2011). 'Creating Shared Value', *Harvard Business Review*, February 2011. <https://hbr.org/2011/01/the-big-idea-creating-shared-value>. (Accessed 24 July 2023.)

SADAG press release (2023). 'SADAG's new load shedding survey results sheds some light on the impact on mental health in South Africa', *SADAG*, 5 March 2023. <https://www.sadag.org/index.php?option=com_content&view=article&id=3282:sadag-s-new-load-shedding-survey-results-sheds-some-light-on-the-impact-on-mental-health-in-south-africa&catid=149&Itemid=577>. (Accessed 24 July 2023.)

Stobierski, T (2020). 'What are network effects?' Harvard Business School Online: Business Insights, 12 November 2020. <https://online.hbs.edu/blog/post/what-are-network-effects>. (Accessed 24 July 2023.)

von Loessl, V (2023). 'Smart meter-related data privacy concerns and dynamic electricity tariffs: Evidence from a stated choice experiment', Institute of Economics – University of Kassel. Available at https://www.sciencedirect.com/science/article/abs/pii/S0301421523002306 (Accessed 24 July 2023).