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Comparative Studies of Cooking Fuels and the Need to Harness Induction Cooking: South Africa as a Case Study

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ABSTRACT*: This paper has discussed the use of induction cooking for the poor and has further ascertain that induction cooking technology is more efficient. Through comparison with other cooking fuels, this study has highlight that electricity is cheaper to cook but it has not worked in the past. Emphasis is on the challenges/barriers to induction cooking for the poor which has been discussed.*

KEYWORDS: *Cooking, Efficient, Fuels, Electricity, Induction, Technology.*

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I. INTRODUCTION

Residential energy use accounts for a substantial total energy consumption in both developed and developing countries(Wood & Newborough, 2003). The use of domestic appliances for lighting, cooking, refrigeration and airconditioning relies on electricity and consequently causes green house gases (GHGs) emissions(Wood & Newborough, 2003).

In South Africa, the residential sector is the third highest consumer of energy and accounts for 20% of the total national energy share for 2006 (DME, 2009). “Countries around the world are increasingly aware of the urgent need to transform the way they use energy” (IEA, 2014). Concerns over climate change, energy security and economic impacts of the use of energy have led many countries to put emphasis towards promotion of efficient use of energy (IEA, 2014).

1.1. Energy Demand Share by Sector

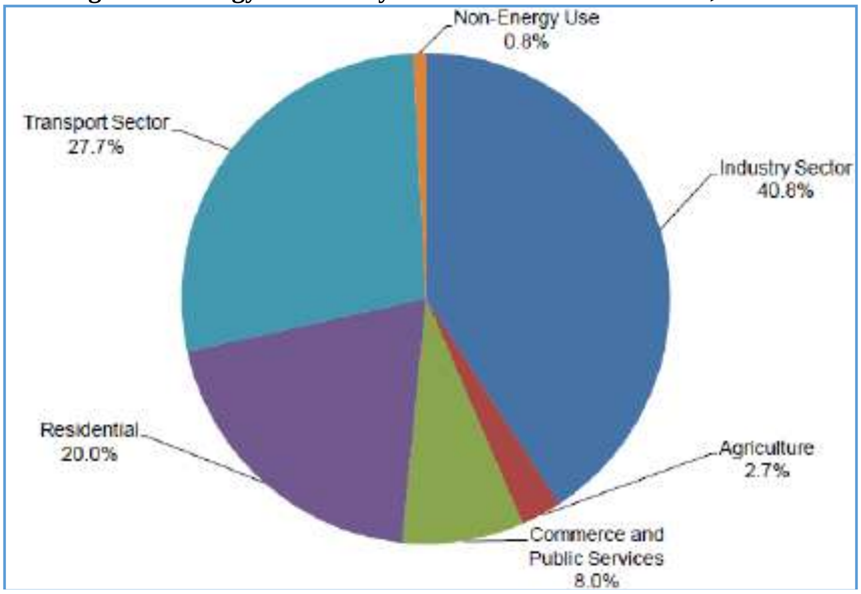
Energy is an important aspect of the economy of a nation(DoE, 2013). National objectives/goals can only be met when current and future energy service needs are determined in the most sustainable manner(DoE, 2013).

South Africa being a developing country needs to balance its development growth with social needs in an environmentally sustainable way. Therefore, the fact is not just to meet energy needs but also to integrate and/or align cross-sectorial impacts systematically(DoE, 2013).

Energy is an important component for human comfort and for attaining socioeconomic development of the nation(DoE, 2013).Sustainable social economic progress is determined by the choices of how energy is produced and consumed(DoE, 2013). Understanding energy demand drivers such as, population growth, economic growth and energy prices will determine the starting point for energy requirements in the sectors(DoE, 2013). South Africa’s energy demand and electricity consumption is shown below.

South Africa consumed 2,627 million Gigajoule (GJ) of energy in 2006 (DME, 2009). The consumption showed a considerable increase in energy demand in all intensive sectors. In 2004 the energy demand was 36.2%, 25.7% and 17.9% for industrial, transport and residential sectors respectively (Krueger, 2009).Figure 1 shows the 2006 energy demand by sector.

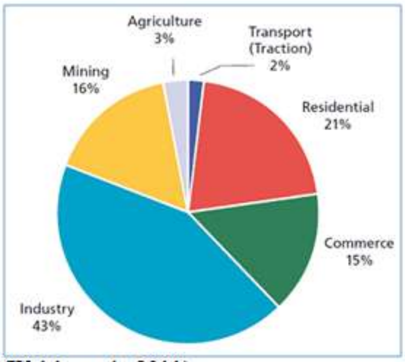
Figure 1: Energy demand by economic sector for 2006: 2,627 PJ



(DME, 2009)

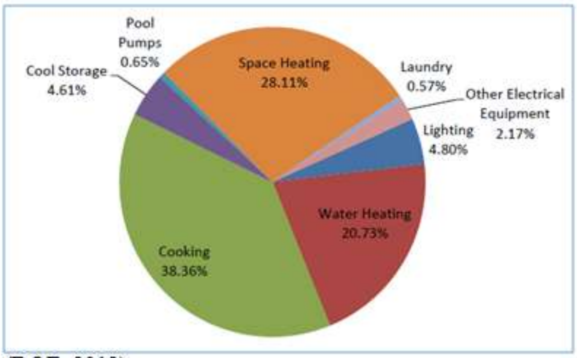
Electricity consumption by sectors also shows a relative increase in consumption in some sectors, comparing 2000 and 2011 consumptions. In 2000, industrial sector consumed 49%, mining and residential consumed 18% each and all other sectors (agriculture, transport and commercial) consumed 16%(Krueger, 2009). While in 2011, industrial, residential, mining and other sectors consumed 43%, 21%, 16% and 20% respectively(Walsh, et al., 2011)**.**

Figure 2: South African electricity consumption by sector



(Walsh, et al., 2011)

Figure 3: Residential Energy End-use



(DOE, 2013)

1.2. Residential energy demand share (high, medium and low income households)

Residential household's energy demand has shown gradual increase from 18% in 2000 to 20% in 2006 as it is shown above. The sectors increase in energy demand has become more evident in the demand by fuel type. Electricity consumption in the residential sector increased from 18% in 2000 to 21% in 2011, which shows an increase of above 14%. This trend can be attributed to increased households electrification and urbanisation.

More than 75% of households were electrified in South Africa at the end of 2012, bringing the total number of electrified households to 9,809,136 households and 86% of these are situated in the Western Cape(DoE, 2013).The most use of energy in households comes from cooking.as shown in Figure 3**.**

II. ENERGY EFFICIENCY

This section will briefly discuss the need for energy efficiency, its definition/importance will be discussed, especially as it affects South African economy and it will close with a brief review of energy efficiency policies in South Africa.

2.1. What is energy efficiency all about?

According to EIA (2014), in 2012, South Africa's total primary energy consumption share was 72% coal, 22% oil, 3% natural gas, 3% nuclear and less than 1% renewable sources(EIA, 2014).About 90% of electricity generation is from coal(EIA, 2014). This has led to South Africa being the highest emitter of greenhouse gases (GHGs) in Africa, and the 14^{th} globally(EIA, 2014). South Africa's general energy environment is constrained, its installed electricity capacity is about 45,700 megawatts (MW) and its peak demand in 2013 was forecasted to reach 44,005 MW according to South African Power Pool (SAPP, 2013). EIA described South Africa as an energy intensive country; this is as a result of its heavy reliance on coal intensive economyIt has now become imperative to change this trend.

In many countries, the era of cheap energy has become a thing of the past and it is becoming more costly and environmental degrading to access energy(UNIDO, 2014). Therefore, the trend has moved to reducing energy consumption, its cost and GHGs emissions(UNIDO, 2014).

Energy efficiency is defined as "a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input. For example, when a compact florescent light (CFL) bulb uses less energy (one-third to one-fifth) than an incandescent bulb to produce the same amount of light, the CFL is considered to be more energy efficient"(IEA, 2014)

2.2. Importance of energy efficiency (especially in SA)

South Africa as a developing country keeps planning and readjusting its developmental pathways. In its recent National Development Plan (NDP), South Africa outlined development priorities which includes, poverty and inequality reduction, job creation, provision of basic amenities (housing, health, electricity, water), emissions reductions, energy mix for electricity and education (NPC, 2011).The government of South Africa needs sustainable energy production and consumption in order to achieve its development goals.

The benefits of energy efficiency cannot be overemphasised as evidenced by the IEA study. The study shows thatenergy efficiency has the potential to support economic growth, enhance social development, advance environmental sustainability, ensure energy-system security and help build wealth(IEA, 2014). Energy efficiency can be quantified, challenged the IEA's study(IEA, 2014). For instance, the report shows that in the residential sector: energy efficiency measures can effectively improve health and well-being, when homes are made warmer, drier and healthier(IEA, 2014).

2.3. Brief energy efficiency policy overview

South Africa recognized that its energy intensive economy needs to change by altering how energy is being utilized (DME, 1998). Therefore, the 1998 White Paper on Energy mandated the Department of Minerals and Energy to develop policies that would enhance efficient use of energy in the country (DME, 1998). In March 2005 the first efficiency policy was published, the National Energy Efficiency Strategy (NEES). Its goals were to reduce carbon emissions, environmental pollution, enhance energy security, and reduce the necessity of adding power generation capacity and also to satisfy governments existing development goals (DME, 2005). The strategy sets a target of 12% energy savings which will have potential monetary savings of over 6 billion Rand in 2015(DME, 2005). This target is set based on the estimated economic growth and energy demand which its priorities included saving energy from industry and mining (15%), commercial and public buildings (15%), residential (10%) and transport (9%) (DME, 2005).

In 2008 the Department of Energy (DoE) carried out a review of the NEES but it received unfavorable comments from stakeholders and the public. However, in 2011 a second review was carried out to address the comments from stakeholders in the first review. Consolidation of the comments was done in March 2013 (DOE, 2013).

During this review, a study was carried out in collaboration with SAGEN, SANEDI and GIZ. The output of this gave rise to the National Energy Efficiency Action Plan (NEEAP) (DOE, 2013).NEEAP will address the gaps identified in the 2005 NEES and other key deliverables, such as the finalization of establishment and implementation of the energy efficiency monitoring system, energy management regulations and plans, measurement and verification of the past energy savings, functional energy efficiency incentive scheme (DOE, 2013).

III. COOKING TECHNOLOGIES

Cooking is one of the most energy-intensive residential services in the globe and accounts for 2 billion tonnes of CO_2 equivalent emissions per year (Adria & Bethge, 2013). Most of the emissions are caused by inefficient cooking technologies in developing countries(Adria & Bethge, 2013).

There exist wide ranges of cooking stoves which are based on the type of fuel used. Such stoves include, LPG, induction, electric, microwave, paraffin and biomass (crop residual, charcoal, wood pellets and dung) stoves(Adria & Bethge, 2013).

Biomass technologies use organic matter as fuel, classified as traditional, improved and modern biomass technologies(Kerekezi, et al., 2004).Biomass is modified from the inefficient (14%) traditional 3-stone to improved modern biogas stoves with efficiency of approximately 60%(Kerekezi, et al., 2004). Table 1 below shows different cooking technologies with their characteristics such as, resource efficiencies, health/environmental effects, life cycle costs and convenience.

Table 1: Comparison of cooking technologies: ERC 2014 MScStudents'class presentation

Technology	Resource Efficiency	Health	Environment	Life cycle cost (R)	Convenience
LPG	39% - 59%	Less indoor pollution than paraffin, coal	Low GHG emissions	6985	Food takes little time to cook
Induction	31%	No emissions at point of use; no indoor pollution	Dependent on source of energy; high emissions from coal	6536	No need to go and buy fuel; electricity supply
Electric	27%			6147	
Microwave	18% - 21%				
Paraffin	18%	Indoor pollution, respiratory diseases	High emissions in household	9721	Readily available
Coal	25%			5422	
Biogas	15% - 36%		Low emissions	4764	

In addition to the above table, it is important to mention the various technologies' efficiencies, LPG stove (95%), induction stove (90%), electric stove (80%), microwave (55-62%), paraffin stove (46%), coal (nominal combustion 90%), biomass (15%) and biogas (60%)(Anozie, et al., 2007), (Kerekezi, et al., 2004), (Afrane & Ntiamoakh, 2012), (IJIRSET, 2014).Switching from inefficient traditional cooking technologies to energy efficient technologies can save energy, reduce cost and emissions (Adria & Bethge, 2013).

IV. INDUCTION COOKING

4.1. Working principles of an induction cooker

An induction cooker basically consists of a coil of copper wire and a round bottomed cooking pan (wok) (Meng, et al., 2009). An alternating electric current is passed through the coil to generatean oscillating magnetic field which causes eddy currents in them,and the iron molecules vibrate tens of thousands of times per second to create heat in the pot(Meng, et al., 2009).Dueto the inherent benefits of the induction cooker over other heating methods, it has been widely used in Asian and European residents (Lucia, et al., 2013).

4.2.FEATURES OF INDUCTION STOVE

4.2.2 Efficiency: Induction cookers have technology efficiency of 90% and resource efficiency of 31%. This high efficiency is due to the direct heat passed unto the pot which significantly reduces heat loose to the environment(Anozie, et al., 2007).

4.2.3. Safety: inducting stoves do not bring out flame or heat its element to red-hot where burns could be inflicted or fires caused like in other appliances(Meng, et al., 2009).

4.2.4. Cleanliness: the compact built of induction stoves coupled with its low surface temperature that prevents food from getting burned and stuck on the surface, makes it the cleanest appliance(Lucia, et al., 2013).

4.2.5.Pot detection: The ability of an induction cooker to detect the appropriate pot (with iron content), ensures proper power converter operation and provides additional security(Meng, et al., 2009).

4.2.6. Advanced control features: This feature allows induction stoves through addition sensors to control not only the power delivered to the load like other appliances but also the pot temperature. This also allows for implementation of specific temperature profiles during cooking process (Meng, et al., 2009).
4.2.7. Availability: Inductioncookerisaone-timeinvestmentthatdependsonlyonelectricity supply, unlike other appliances. For instance, LPG gas cylinder will need continuous refilling.

V. DISADVANTAGES OF INDUCTION COOKERS

5..1 Specific utensil requirements: Induction cookers use utensils that have iron content such as stainless steel and the right size of pot must be used for optimal performance.
5..2 Inducting cookers are expensive and may not be affordable by the low income earners.

VI. IS ELECTRICITY CHEAPER TO COOK ON?

Amongst the lowest in the world, SA's electricity prices have just started increasing from a low of 25c/kWh in 1987 to 52c/kWh in 2013 (Walsh, et al., 2011). It had become pertinent to increase electricity prices in order to raise funds for Eskom to expand its generation capacity and transmission infrastructure after numerous load-shedding in 2008 (Walsh, et al., 2011). The cost of electricity in SA still remains cheap compared to electricity prices globally.

6.1 Cost of Cooking

Bartels et al (1996), carried out a survey of Australian regions to obtain a comparative estimate of household's expenditure on cooking and water/space heating using LPG and electricity. Using the econometric approach, the results showed that the households using electricity for cooking spent more than those that use LPG and the reverse was the case for heating(Bartels, et al., 1996). Though the prices of electricity at peak were more than the LPG and prices were comparable at off peak, the all electricity households at overall spent less than the LPG households(Bartels, et al., 1996).

According to Gupta & Ravindranath (1997), in India, electricity prices are subsidised and have become cheaper than LPG(though also subsidised) at market prices. Efficiecy is a determining factor of total cost of the fuel device choice, the results are different when costs of converstion, distribution and transmission losses are involved(Gupta & Ravindranath, 1997). This is shown in both rural and urban situations where the inefficiency of the traditional wood stove makes it more expensive than other stoves in the urban areas and more expensive than paraffin in the rural areas (Gupta & Ravindranath, 1997).

In two separate researches carreid out by Anozie, et al (2007) and Afrane & Ntiamoakh (2012), the results show that electriciy is cheaper to cook on than paraffin and LPG. "This is a dangerous situation because of the pollution, deforestation and ecological problems associated with fuel wood burning. It is cheaper to cook with electricity than kerosene or gas" (Anozie, et al., 2007).

In comparison by energy source, gas hobs are more fossil carbon efficient (this depends on the source of electricity generation) (Eu, 2011). The energy consumption of these appliances depends largely on consumer behaviour, quantity of food prepared and the quality of the appliance used (Adria & Bethge, 2013).

In 2014,astudy was carried out to evaluate the potential for regional use of EastAfrica's large offshore natural gas finds to address underpinnings of economic development, electricity generation and clean cooking were considered among others(Demierre, et al., 2014). It was observed that for natural gas to be viable as a cooking fuel, its price must be competitive to the cheapest alternatives such as charcoal and electricity for residents at around $0.1/kWh or lower(Demierre, et al., 2014).

The researcher tends to agree with the results of the aforementioned authors that confirm that electricity is cheaper to cook on. This is more so based on South Africa's peculiarities such as the level of electrified households, cost of electricity and the efforts to increase generation capacity. Electricity will remain the cheapest cooking fuel in the immediate future because the investment needed to electrify the remaining approximately 20% residents would be negligible to compare with the investment in gas infrastructure from East Africa to residents in South Africa.

Having seen that it is cheaper to cook on electricity and based on the highest efficiency of the induction stoves, one could be right to assert that it is the cheapest cooking technology among the electric cooking technologies, therefore, should be encouraged.

VII. CHALLENGES/BARRIERS

This section will briefly discuss some challenges/barriers that are encountered in the choice of efficient cooking technologies.
7.1. Policies/Politics

There are no subsidies for environmentally benign appliances and technologies used by the poor, as though middle to high income groups are the only contributors to GHGs

The widely used paraffin wick stove has been declared unsafe and banned for both production and sale in SA [SANS 1906:2006](Kimemia & Annegarn, 2012). A study carried out in Alexander Township in 2012, shows that the prohibited paraffin stove is still mostly and widely used (34%), without any reproach, though government is promoting the use of cleaner cooking energy (LPG) in the township (Kimemia & Annegarn, 2012).

7.2. Funding

There are cook stove initiatives carried out by the aacademia such as the university of Cape Town and University of Johannesburg in conjunction with SeTAR, Germany(Accenture, 2011). Researches, design and testing of cleancook stoveare carried out to provide information to various stakeholders(Accenture, 2011). Funding of these programmes is a key challenge. The University of Johannesburg is planning to commercialize its invention of an improved coal-fired cook stove(Accenture, 2011).

7.3. Accessibility/ Availability

Inefficient sources of energy such as coal are widely used in SA as a cooking fuel, especially by residents located close to coal mines(Balmer, 2007). This is largely because it is readily available, accessible, dual utility (cooking/heating) and most a times at no cost, though it poses great health dangers to the users(Balmer, 2007).There is limited access to electricity especially by the low income earners (Kehrer, et al., 2008).

7.4. Perception

Balmer (2007), queried why government is putting more efforts on increased access to electricity of low income households instead of addressing the supplyof safe cooking fuels to the low income households "Increasing access to electricity will not alleviate cooking energy shortages since poor households do not use electricity to cook with"(Balmer, 2007). This kind of argument shows how electricity has been misconstrued by many as an energy source for only lighting but not cooking.

VIII. RECOMMENDATIONS

This section suggests programs that will encourage the uptake of induction hobs as a cooking technology for the poor in South Africa in addition to other interventions that government is already carrying out such as free basic electricity policy (FBE) and integrated national electrification programme (INEP).

8.1 .Subsidy on induction cooking stove

Government should provide rebate on induction stove and its utensils so that low com earners could afford it. Since 2009, government granted rebates on solar water heaters and pumps to encourage their use(IRENA, 2013). The same can be done to induction stoves. Trough government support (carbon credits), customer education and marketing campaigns, the "SEWA" improved stove, though more expensive strived in Mali.

8.2. Awareness and Training

One herculean task government faces is maintaining sustainable energy services provided for the shanty towns (informal settlements). Moreover, there are many improper connections done illegally by residents who use energy inefficiently and do not understand nor accept energy conservation (Kehrer, et al., 2008). Government could implement integrated energy centers in such settlements to serve as information centers. Dissemination of information and education of the community on sustainable use of energy could be done by a trained personnel attached to the center (Kehrer, et al., 2008). Users of inefficient cooking fuels especially paraffin in informal settlements have substantial higher risk of burns, injury and fires than those using clean fuels for cooking, especially electricity(Kimemiaa, et al., 2014**)**. Therefore, a pro-poor approach should be employed when designing programs that will reduce these risks in informal settlements(Kimemiaa, et al., 2014**)**.

8.3. Catalysts

Large scale energy users such as schools, clinics and agricultural producers could be used as stimulus to household adoption of modern fuels (electricity in this case) (Foella, et al., 2011). Experiences from other programmes in developing countries suggest that attention to be paid to these users so that they can act as catalysts in the establishment of an energy supply chain that could be a forerunner to sustainable household's energy systems (Foella, et al., 2011).

IX. CONCLUSION

There is need for South Africa to explore clean sources of cooking to replace the inefficient stoves that emit GHGs. This study showed that induction stove is an efficient cooking technology and that electricity is cheaper to cook on. This is more so based on South Africa's peculiarities such as the high level of electrified households, cost of electricity and the efforts by government to increase power generation capacity. Misconception, funding, accessibility and weak institution framework are the challenges militating against the use of electricity as a cheap and efficient cooking fuel. The researcher suggested subsidies, awareness campaign and the use of large energy users as catalysts as programmes that will encourage the use of induction cooking.

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