

# **A GIS-based National Household Energy Surveillance System: Its Contributions to Health Promotion, Household Energy Safety and Security**

D Swart and G Prud'homme

The Paraffin Safety Association of Southern Africa, Cape Town, South Africa

## **ABSTRACT**

**Introduction:** The GIS-based National Household Energy Surveillance System (NHES) of the Paraffin Safety Association of Southern Africa (PSASA) is an effort to understand energy usage better as well as the nature, occurrence and frequency of harmful paraffin- and energy-related incidents in South Africa. It allows datasets to be analyzed with both geographical and time dimensions to determine trends and to assess the impacts of safety interventions, policy implementation and the energy crisis. Its outputs can facilitate an evidence-based approach for the development and implementation of effective household energy policy and it can also assist with the promotion of safe and healthy energy-related behavior.

**Methods:** Data is or will be collected on energy usage and consumer behavior, harmful energy-related incidents, energy safety educational campaigns and the energy system of paraffin. Nine healthcare institutions in five provinces are collecting energy-related injury data and data from external sources are incorporated in NHES.

**Results:** To date the system is comprised of: maps of paraffin sales, energy consumption; fires in informal settlements and over 1838 records on energy-related injury. Data, graphs, tables and maps are accessible to the public on the PSASA website.

**Conclusions:** Analysis of the data has enhanced household energy safety knowledge, providing evidence to counter prevalent energy safety myths which have influenced decision making and policy implementation. Geographical analysis coupled with correlations between the surveillance data and other relevant data have also generated valuable information usable for health promotion and the provision of health facilities. Additional GIS analysis would provide assistance in the enforcement of household energy safety policies.

## **INTRODUCTION**

Every household is dependent on energy for cooking, heating and lighting. Energy security and safety are important issues to be addressed in South Africa. Energy security in low income households is affected by unpredictable income, the relatively high capital outlay for electricity, the rising cost of paraffin, and it becomes a growing concern due to the current national energy crisis (1, 2, 3). Statistics South Africa (STATSSA) is collecting a few indicators on energy usages; however there is a need for a household energy surveillance system which would identify domestic energy trends to ensure that every South Africa household has access to energy now and in the future (4, 5). This system would also inform household energy policy development and enforcement using geographical analysis.

Unsafe energy distribution, storage, and use are threatening the constitutional right of all South Africans to “an environment that is not harmful to their health and well-being...” (6). This results in major causes of injuries (such as burns, asphyxiations and poisonings) in South Africa, especially in low income households due to:

- Overcrowded, cramped living conditions
- Poor maintenance of cooking and heating appliances
- Stresses and economic survival
- Substance abuse, particularly alcohol
- Domestic violence
- Leaving appliances unattended while in operation
- Leaving children, especially infants, unattended (7)

In 2003, burns was the first external causes of death in children under 1 year of age and third external cause of deaths among women (11%) and children from 1-14 years (4). However, little is known about the occurrence, nature, frequency and impacts of energy-related injuries and harmful incidents in South Africa. A household energy surveillance system using geographical analysis would address these gaps and assist in the implementation of energy safety educational campaigns, health promotion and healthcare accessibility.

### **The GIS-based National Household Energy Surveillance System (NHESS)**

In the absence of a repository of household energy data and information, PSASA is developing the NHESS in order to collate and analyse household energy usage patterns, consumer behaviour, safety education campaigns and harmful incidents as well as to monitor the paraffin system (production, distribution, storage, sale, usage, appliances). The surveillance system allows analysis to be performed at both geographical and time dimensions using GIS technology, which is priceless for the determination of trends. The system also allows for analysis to be performed with external datasets as fires, national census and paraffin sales. Therefore, the NHESS contributes to the evidence-based approach adopted by PSASA for promoting health and healthy behaviour, influencing policy development and enforcement as well as assisting disaster management.

Currently, the system includes information on household energy usage and harmful energy-related incidents. The collection of energy-related injury data started at Prince Mshiyeni Memorial Hospital in Umlazi, KwaZulu-Natal in April 2006 and has expanded to nine institutions in five provinces to date. Data from external sources are also included in NHESS.

The data captured in the surveillance system databases is accessible to the public as raw data or as information in the form of maps, graphs and tables on the PSASA website (8). It has been structured in a way that any institutions wishing to contribute can log onto the online database to capture or upload energy-related injury data. This should facilitate greater collaboration and research opportunities. Although the NHESS has limited resources and has limited data sets, its value and the importance of geographical analysis cannot be undermined.

## **METHODS**

### **1) Household Energy Usage**

Currently, data on energy usage from STATSSA and on paraffin sales from South African Petroleum Industry Association (SAPIA) are included in the NHESS.

### **2) Harmful Energy-related Incidents**

PSASA in collaboration with burn specialists and health professionals has developed a data capture form on energy-related injuries which includes ingestion of liquid energy carriers, burns (from flame, contact, liquid and food), chemical burns and smoke inhalation/ asphyxiation. Data on the energy source involved, location of injury, activity when injury occurred, intentionality, clinical data and outcomes as well as patient demographic information are also being collected. Data is collected from nine healthcare institutions in five provinces using a variety of models. Due to limited resources some facilities provided existing databases, whereas others relied on doctors and other hospital staff to fill out the data collection forms. In some cases, trained volunteers from the community were used.

The completed data forms are submitted to PSASA and then captured in the MYSQL online database. Data quality checks are being performed and corrections addressed with the relevant institutions. When necessary, on-going trainings of the data collectors are carried out based on frequent gaps and misunderstanding of fields. PSASA is currently piloting cell phone data collection and capturing in Umlazi, Durban to assess its possibilities in order to reduce the human resources needed in the process. The energy-related injury data and fire data are available on PSASA website (8). A series of semi-automatic, user selected analysis including tables, graphs and maps are also available on the website. In the event that the user's information of interest is not published, additional analysis of data is possible upon online request.

Information on fires is also being collected from contributing municipalities as part of the NHESS. Data on fire location, date, causes, number of people and informal houses affected is being collected.

### **GIS Analysis**

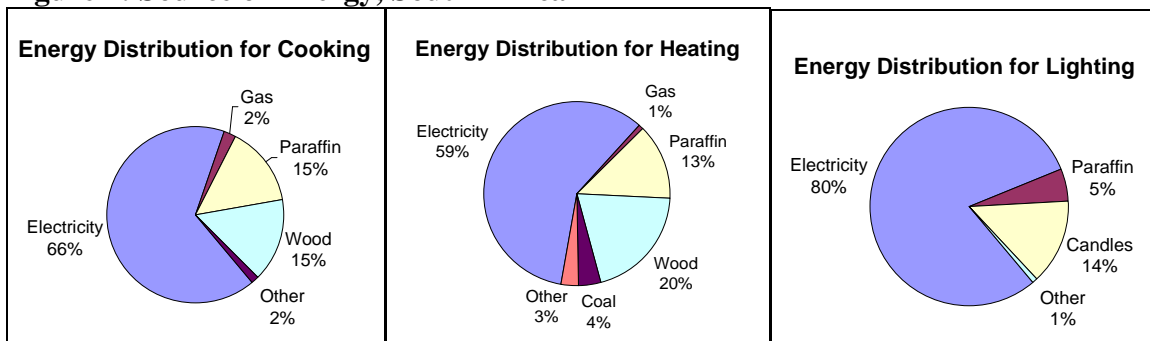
GIS analysis of paraffin sales, energy usage, fires and energy-related injuries have been performed at national, provincial or regional levels by Terry Richards-Hill from Mobility@Work using ArcView software. The basemaps were supplied by STATSSA, the healthcare institutions locations by the Department of Health of KZN and the Medical Research Council (MRC), the fire data from Buffalo City Disaster Management, the paraffin sales from the South African Petroleum Industry Association (SAPIA) and the energy-related injury data from PSASA.

## DISCUSSION

### 1) Energy Usage Mapping

In South Africa, 81.5% of households are connected to a main electricity supply (4). Most connected households use electricity for lighting, but only 66% of all households use electricity for cooking: 15% rely on paraffin and another 15% on wood (1, 4). For heating, 59% of all households rely on electricity, 13% on paraffin and 20% on wood (1, 4).

**Figure 1: Source of Energy, South Africa**

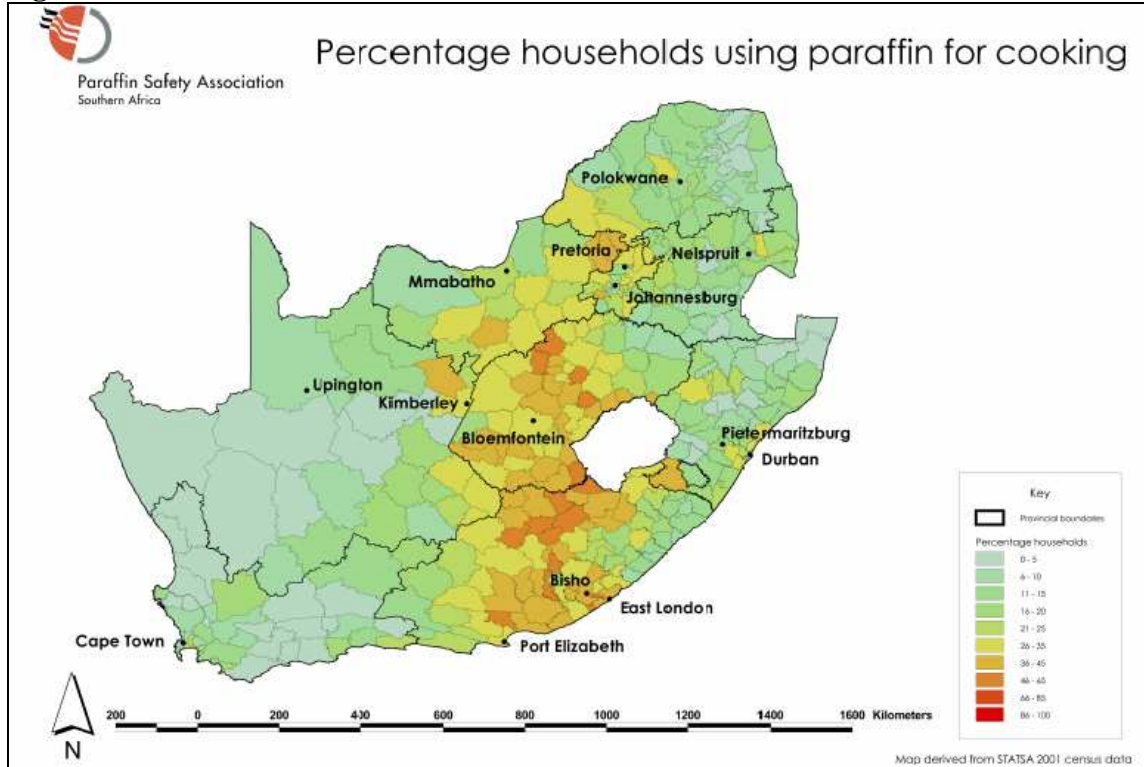


Source: 2007 Community Survey (9)

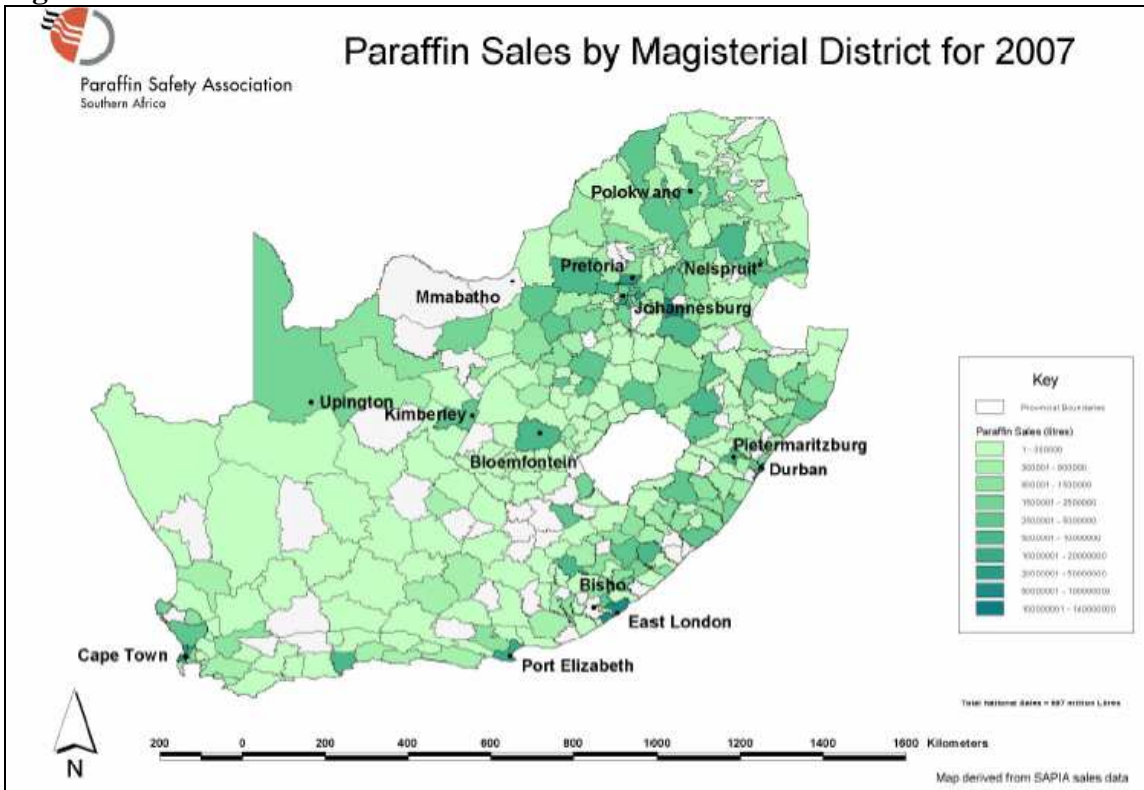
GIS analysis performed as part of NHESS has deepened current knowledge on usage of electricity, paraffin, wood, LPG and coal for cooking, heating and lighting by identifying the geographical distribution of users. As illustrated in Figure 2, paraffin is used for cooking mainly in Eastern Cape, Free State, North West and Gauteng (see in yellow-red). Similar maps for all five energy sources stated above and heating and lighting were created and are available on PSASA website (8).

The geographical distribution of paraffin sales was mapped using SAPIA's data (Figure 3). Equipped with this geographical information, priority regions for the enforcement of safe energy safety policy and implementation of energy safety education campaigns could be identified.

**Figure 2**



**Figure 3**

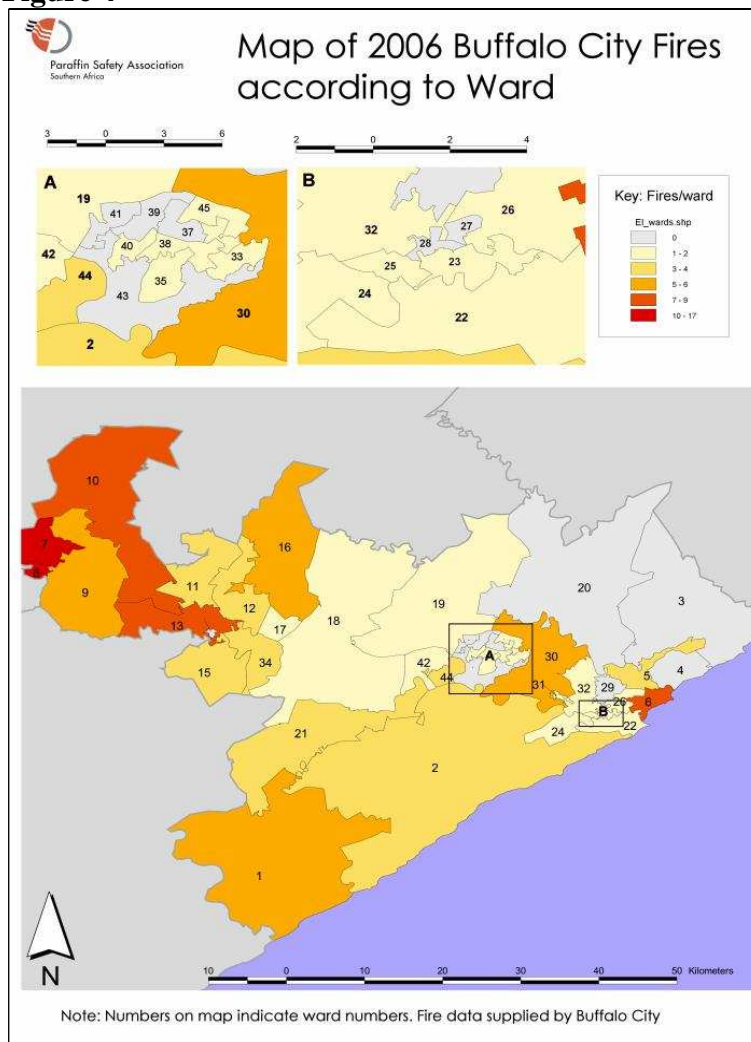


## 2) Harmful Energy-related Incidents Mapping for Health Promotion

As many energy-related harmful incidents occur due to consumers' unsafe usage practices (7), energy education campaigns are a priority. By gathering a wide variety of information on household energy in NHESS, PSASA has developed – and will constantly refine – IEC material appropriately addressing the gaps in energy safety practices. Being a small non-profit organisation, where limited resources can be used, it is necessary to identify areas where the need for energy safety campaigns is the greatest.

The NHESS has proven to be a useful tool in establishing targeted interventions. Using data provided by the Buffalo City Disaster Management in the Eastern Cape Province, a map was constructed illustrating the occurrence of fires. The majority of fires took place in Duncan Village, the wards in the top left hand corner of the map (Figure 4). As a result, a targeted safe energy safety campaign was initiated in this area.

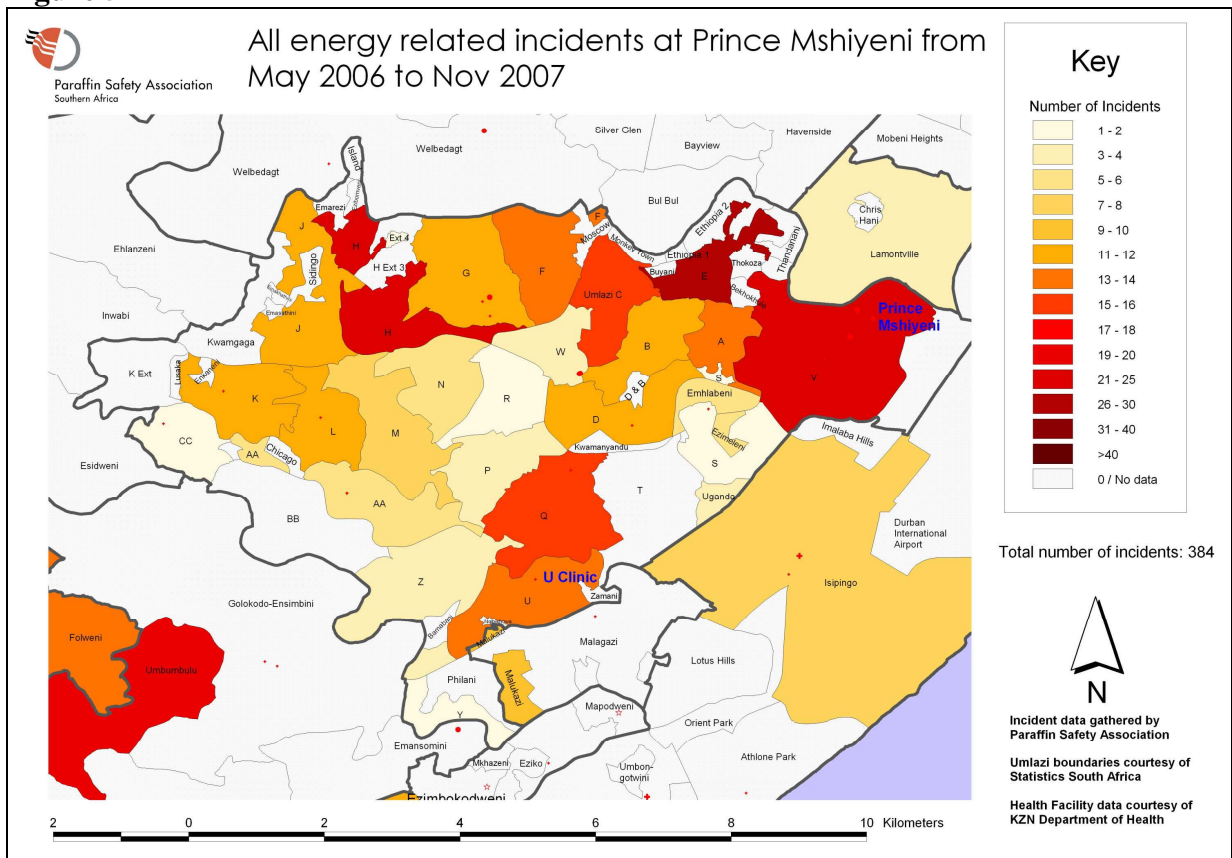
**Figure 4**



GIS analysis of energy-related injuries can also be used to identify targeted interventions areas. The map in Figure 5 demonstrates quite clearly that it is not viable to implement an intervention in the whole of Umlazi but it is advisable to implement interventions where most energy-related incidents are occurring such as sections V, E and H. By mapping energy-related injuries and fires before and after energy safety campaigns, the efficiency and impacts of the campaign could also be assessed. This could also be evaluated by correlating geographically the locations of educational campaigns and harmful energy-related incidents.

In order to evaluate healthcare accessibility, maps were created to show the distribution of energy-related injuries collected at the nine partnering hospital locations (8). This GIS analysis can assist health planners in their provision of health services. For example, it is evident from Figure 5 that patients travel long distances from high risk incident neighborhoods (e.g. Umbumbulu) to access health services at Prince Mshiyeni Memorial Hospital. This information can be used by the provincial Departments of Health to inform decisions on the provisioning of health facilities.

**Figure 5**



### **3) The Potential of Paraffin System Mapping for Household Energy Safety and Security Policy Development and Enforcement**

PSASA is planning to use NHESS for the collection and analysis, including GIS analysis, of additional energy usage and consumer behaviour data, energy safety education campaigns data and paraffin system data. The integration of data on energy usage and consumer behaviour from surveys conducted across the country is underway and a system for data collection on energy education campaigns and the paraffin system is being developed. Regional PSASA staff would collect the location of educational campaigns, paraffin sellers, paraffin storage tanks, paraffin appliances manufacturers and sellers using GPS coordinates which would be integrated in NHESS. Mapping this information would inform the development and enforcement of household energy safety and security policies.

Low-income households relying on paraffin are disproportionately affected by the rising cost of energy: the cost of paraffin increased by 54% in seven months this year. The “No VAT” policy on paraffin is not protecting poor consumers as they are being charged more than the wholesale price determined by the Department of Energy and Minerals (DME) (2, 10). The department has announced that pricing regulation mechanisms for paraffin will be investigated soon and that monitoring the spaza shop will pose a challenge to the implementation of such regulations as the department does not have the capacity to do so (10). The NHESS could be a useful resource in this regard as PSASA is planning to map the location where paraffin is sold. This would assist the DME in the enforcement of paraffin prices regulations to ensure household energy security in South Africa.

Independent of the energy source, safe energy systems are crucial to prevent harmful incidents and ensure a safe environment to all South Africans. The production, storage and distribution of energy and its appliances standards must be regulated by a number of policies in order to protect its users. In 2006 and 2007, new safety standards were regulated for wick and pressure paraffin stoves (SANS1906:2006 & SANS1243:2007) (7). Mapping the location of paraffin appliances manufacturers and sellers could therefore contribute the enforcement of those new standard regulations. To ensure household energy safety in South Africa, such regulations and additional evidence-based energy safety policies need to be developed and properly enforced. GIS mapping of the energy systems would assist the enforcement of those policies. Additionally, mapping the location of paraffin storage tanks would also be useful for the management of disasters caused by fire.

### **4) Bringing GIS To Scale**

Developing NHESS is, however, fraught with challenges. Data gathering and capture is time and resource intensive. Its sustainability is difficult to achieve in all contributing institutions as the data collection process relies on remotely supervised volunteers. Errors must be managed. Personnel at partner institutions and regional PSASA staff are overburdened with responsibilities. Volunteers are constantly looking for opportunities for gainful employment and are seeking compensation. It is difficult to determine the cause of harmful incidents such as uncontrolled domestic fires.

Although nine disparate institutions have agreed to participate in the NHESS so far, their surveillance data is only beginning to come online – there are currently 1838 energy-related injury records. This means that caution must be exercised in the conclusions drawn from the limited data set that is available. The data currently captured in NHESS precludes fatalities that did not make it to the hospitals.

The surveillance system is an important tool for informing national health and energy policy and promoting health education. It is invaluable for collating, analysing and interpreting evidence. To ensure its sustainability and enhance its contribution to household energy security and safety, it is hoped that the South Africa National Energy Research Institute (SANERI) and the Department of Health will want to be partners with PSASA or possibly take over the project.

## CONCLUSION

The GIS analysis performed with NHESS data has enabled PSASA to understand energy usage patterns and to identify high risk populations so as to plan targeted interventions. It can also inform the Department of Health on the provisioning of healthcare facilities. Its foreseeable values would also contribute to the development and enforcement of household energy safety and security policy, and the evaluation of energy safety education campaigns. NHESS is used in conjunction with other research and datasets to enrich a sound base of evidence for health promotion, disaster management and energy safety policy. NHESS is facing sustainability challenges and would benefit from partnerships with key-players in the domain of energy and health. The expansion of this surveillance project will enable an ongoing systematic collection, collation and analysis of data on household energy safety and security, whereby results can be used for a wide range of purposes.

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## ACKNOWLEDGEMENT

The authors wish to thank all the institutions and personnel which have agreed to collaborate on the National Household Energy Surveillance System. We are very grateful to Terry Richards-Hill of Mobility@Work ([www.mobility.co.za](http://www.mobility.co.za)) for her amazing dedication and skill in the construction and development of the geographical information system.

## AUTHORS

**Author:** Dehran Swart has a BSc (Microbiology and Biochemistry), a BSc (Med) Hons in Community Health, and a HDE (PG) Sec diploma from the University of Cape Town as well as a MPH in Public Health from the University of the Western Cape. He is the Senior Project Manager for Education and Research at PSASA.



**Co-author:** Genevieve Prud'homme has a B. Sc. (Hons) in Environmental Health from the University of McGill in Montreal, Canada. She is a Project Assistant for Research and GIS at PSASA. (Presenter – MAF08PN63)



Paraffin Safety Association of Southern Africa  
 Tel: +27 21 671 5767  
 Fax: +27 21 671 0233  
 Email: [dehran@paraffinsafety.org](mailto:dehran@paraffinsafety.org)  
 PO BOX 232, Clareinch,  
 Cape Town, South Africa, 7740