Supplementary Material for: Fuel switching and energy stacking in low-income households in South Africa: A review with recommendations for household air pollution exposure research

Author and Publication Year:	Title:	Journal:	Location of study:	Aim/ Objective of Study (is stacking or switching part of the main aim?):	The main outcomes of the study related to fuel use patterns:
Vermaak et al. 2014	Developing an energy-based poverty line for South Africa	Journal of Economic and Financial Sciences	South Africa as a whole	This study aimed to quantify the incidence of energy poverty in South Africa (i.e., for a given energy poverty line, the proportion of households below that line was identified).	Among electrified households, energy poverty rates were highest in the following provinces: Limpopo province (66%); Northern Cape (53%); Mpumalanga (43%); Eastern Cape (40%); KwaZulu-Natal (36%); North West (32%); Free State (28%). The lowest energy poverty rates were noted in: Gauteng (21%); Western Cape (20%). In the case of non-electrified households, energy poverty rates were highest in the Free State (86%) and lowest in the Western Cape (47%). Expanding access to modern energy sources was seen as one of the keys to reducing energy poverty.
Musango 2014	Household electricity access and consumption behaviour in an urban environment: The case of Gauteng in South Africa	Energy for Sustainable Development	Gauteng Province, South Africa	This study aimed to provide quantitative information about household energy use in an urbanised context and to investigate household energy use by fuel type for cooking and lighting purposes.	Respondents with no or low monthly income used risky and unhealthy fuels (e.g., paraffin and candles) for cooking and lighting, even though they had an electricity supply. Households with higher monthly income levels entirely shifted from risky fuels and only used electricity and gas for cooking and lighting.
Kimemia and Annegarn 2016	Domestic LPG interventions in South Africa: Challenges and lessons	Energy Policy	Atteridgeville Township, City of Tshwane, Gauteng Province, South Africa	This study aimed to evaluate the impacts of a subsidised LPG intervention in the Atteridgeville Township.	Years after the intervention, about 70% of the beneficiaries continued to use LPG and reported that the intervention had improved their welfare. Fast cooking was cited as the critical tangible benefit of LPG technology in households, followed by saving on electricity

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					bills. Electricity was still the most widely used cooking and heating energy carrier in the sampled households, possibly due to the FBE subsidy, which did not exist for LPG. The LPG intervention improved their socio-economic situation by providing households with a cost-effective, clean, and versatile cooking solution. Savings on electricity expenses reduced cooking time, and provision of an alternative power source during electricity blackouts were also mentioned as benefits. Those who previously used paraffin and solid fuels say that the introduction of LPG has improved indoor air quality. In addition, LPG has proved to be a convenient fuel when cooking in groups during community events.
Makonese et al. 2016	Energy use scenarios in an informal urban settlement in Johannesburg, South Africa	Conference paper	Vusimuzi, Madela Kufa Section 1 and Madela Kufa Section 2 (three informal settlements), Tembisa, Ekurhuleni Metropolitan Municipality, Johannesburg, Gauteng Province, South Africa	This study investigated the fuel use scenarios in a typical informal settlement in the Highveld region of South Africa and investigated factors affecting the residents' fuel choices and consumption patterns.	Coal was the primary energy source for cooking, water heating, and space heating, and kerosene was frequently used for cooking and lighting and less for water heating. Most informal dwellings were not connected to the electricity grid at the time of the survey, save for a few connected through petrol-powered electric generators or electricity obtained from a network of illegal connections. None of the households purchased LPG for domestic use; these communities consider the fuel unsafe. Factors such as seasonality, the availability and price of fuels, and socio-cultural aspects affect fuel choices and the quantity consumed.
Brown et al. 2017	eCook: What behavioural challenges await this potentially transformative concept?	Sustainable Energy Technologies and Assessments	South Africa as a whole	This study aimed to identify and understand the potential obstacles in expanding the proposed battery-electric cooking idea, eCook. This concept promised emission-free cooking, savings in time and money, and broader environmental advantages due	The socio-cultural barriers and drivers to the proposed eCook concept were identified, and it was found that with a strategic market-based approach focusing on the necessary supporting infrastructure, the uptake of this technology by specific market segments was likely. It was recognised that fuel stacking was inevitable in the beginning stages of implementation when households needed to

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				to decreased use of fuelwood and charcoal.	cater to higher demand as this technology did not outcompete flexible technologies, which provided for many people.
Harris et al. 2017	Aiming for a moving target: The dynamics of household electricity connections in a developing context	World Development	Agincourt, Mpumalanga Province, South Africa and South Africa as a whole	This study aimed to develop new insights into the energy transition process by examining the prevalence of ‘‘downward” energy transitions (i.e., connection losses) and their impact on aggregate electricity access. The links between the movements up the energy ladder and household well-being in South Africa added weight to the argument for an analysis that provided new insights into the details and processes behind electricity access dynamics. An analysis of the relationship between household electricity access and household formation dynamics in South Africa was considered.	While the number of electricity connections increased during 2008–2010, the higher proportional increase in the household population resulted in a net decline in the electricity access rate. A net reduction in connections of more than 100,000 among continuing households was evident. Given an average household size of four, this equates to more than 400,000 individuals losing access to electricity in their homes, likely because: (1) the number of households may have grown faster than the rate of growth in connections as a result of rapid household formation; (2) people may have moved out of connected households and set up new households in locations that lack access and; (3) specific connected households that survive from one period to the next may have lost their electricity connections.
Mbewe 2018	Investigating household energy poverty in South Africa by using unidimensional and multidimensional measures	A dissertation: Master of Philosophy in Energy and Development Studies	South Africa as a whole and at a province level	This study aimed to compute national-level estimates of household energy poverty and broke these estimates down by province, household income, poverty status, and household location (urban versus rural).	Overall, household energy poverty has reduced in South Africa between 2008 and 2014-2015. The lack of income in poor households led to using non-monetary energy sources such as firewood and animal dung. This effectively underestimates energy poverty, given that firewood and animal dung are not captured as a monetary expenditure on energy services. The Limpopo province had the highest rates of energy poverty in 2014-2015. This study also found that household energy poverty has been reduced in rural areas.
Tait 2017	Towards a multidimensional framework for measuring	Energy for Sustainable Development	Manenberg and Masilunge (two poor settlements),	This study aimed to determine how to best define, measure, and conceptualise "energy	‘Adequate’ energy supply configurations only exist for grid-connected electricity, LPG and potentially for solar electricity. Solar

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	household energy access: Application to South Africa		Cape Town, South Africa	access" at a household level in South Africa. This was done within a framework representing four key dimensions: fuel use, affordability, safety and reliability.	was, however, not used by any households in the sample and was scoped out. Candles, wood, paraffin and coal have negative implications associated with their use and do not provide a safe or modern energy service in South Africa. It was recommended that measurement frameworks need to consider local contexts.
Uhunamure et al. 2017	Driving forces for fuelwood use in households in the Thulamela municipality, South Africa	Journal of Energy in Southern Africa	Altein, Botsoleni, Makhovha and Thenzheni in the Thulamela Municipality, Limpopo Province, South Africa	This study aimed to understand the driving forces for energy preference in rural households while reassessing the energy ladder and multiple fuel use theories.	Household income, educational level and employment status, cultural norms and values were among the key determinants of energy preferences. Those with a high level of education were likely to be associated with a positive attitude towards conserving the environment by using a cleaner form of energy. Even educated people in this study, however, harvested and purchased fuelwood to supplement electricity for domestic use. The results showed that the respondents' education and occupation influenced fuel use. A high unemployment rate has shown an implicit effect on the environment, as most of the unemployed spend much of their time harvesting fuelwood. The employed and self-employed moderately relied on modern energy, while those in the unemployed category relied mainly on traditional energy sources. The survey revealed that low-income people spent much time harvesting fuelwood to meet their domestic energy needs. Unemployment pushed the community members towards using freely accessible energy sources such as fuelwood.
Baptista 2018	Space and energy transitions in sub-Saharan Africa: understated historical connections	Energy Research & Social Science	Sub-saharan Africa	This study reflected on how a historical and spatial perspective could improve future energy initiatives for sub-Saharan Africa.	This study showed substantive accounts of how urban environments and energy systems have co-evolved, mutually shaping each other, and need to be established. These historical and spatial accounts provided insights into the mechanisms and practices underlying the path dependencies that shaped

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					contemporary energy systems in the African sub-continent.
Bohlmann and Inglesi-Lotz 2018	Analysing the South African residential sector's energy profile	Renewable and Sustainable Energy Reviews	Across the country of South Africa	This study aimed to analyse and understand the South African residential sector's energy characteristics, considering energy-use profiles and other characteristics such as geographical distribution and demographic characteristics. It further aimed to evaluate the trends, evolution and characteristics of energy consumption in the South African residential sector.	Despite poorer households connected to the national grid receiving 50 kW/h of free electricity per month to help them cover their basic energy needs, South African households – particularly low-income households – still used various energy sources, including wood and paraffin, to satisfy their basic energy needs. Solid fuels were predominantly used in rural areas. Low-income households consume between 5% and 10% of their energy in lighting; space heating and cooking account for the remainder. The proportion of households with access to electricity is lower in households in which the head is 'Black African', or male or over the age of 60. Poorer households were less likely to be electrified than wealthier households. Formal dwellings were more likely to be electrified than informal dwellings. Electricity access increased over time. Over time, more households spent money on electricity and fewer households spent money on other energy sources. South Africa has a typical energy ladder where households progressively move away from low-quality energy sources such as wood and paraffin towards convenient and versatile modern sources of energy such as electricity and gas as income rises.
Israel-Akinbo et al. 2018	The energy transition patterns of low-income households in South Africa: An evaluation of energy programme and policy	Journal of Energy in Southern Africa	Large national panel study (the whole of South Africa)	This study investigated whether the energy transition patterns in low-income households in South Africa followed the energy ladder or energy stacking models for cooking, heating and lighting energy services.	Energy ladder "behaviour" exists for cooking activities, while energy stacking takes place for space heating, and the pattern for lighting tends towards energy stacking. Dwelling type, household size and geographical location were among the key determinants of the energy transition patterns. Even in South Africa, where most people have access to electricity, some households still demonstrate

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					energy poverty. Rural low-income households have greater access to wood than urban ones and could use fuelwood for energy security or for some cultural preferences (especially cooking). The type of dwelling and geographical location could aid the adoption of modern energy carriers by low-income households.
Pailman et al. 2018	Experiences with improved cookstoves (ICS) in Southern Africa	Journal of Energy in Southern Africa	Gauteng, North West and KwaZulu Natal Provinces, South Africa	This study aimed to examine fuel and stove preferences, experiences with ICS, the rationale for fuel and stove stacking after their initial uptake, and aspirations for energy and fuel use and then to add an ICS end-user perspective. The study also considered broad household experiences with modern fuels such as natural gas and electricity stoves and user experiences with traditional biomass cookstoves.	Among the sampled households, 60% had electric stoves, while only 13% had traditional three-stone stoves. The ICSs used biomass briquettes, charcoal and wood. Many households indicated that they would like to cook with electricity because 'it has multiple uses with many modern appliances and is convenient. Cost savings were an essential benefit of ICSs. A range of problems and defects was also highlighted (e.g., difficulties with cleaning, post-use cooling, requirements for suitably cut wood, and smoke indoors; the time involved in preparing the fuel was considered a major drawback). The prevalence of stove-stacking indicated that a single modern or improved stove does not necessarily serve all the functions of a traditional stove concerning preparing specific meals, water- and space-heating requirements.
Buthelezi et al. 2019	Household fuel use for heating and cooking and respiratory health in a low-income, South African coastal community	International Journal of Environmental Research and Public Health	Umlazi Township in the City of eThekwini, KwaZulu-Natal Province, South Africa	This study aimed to determine whether respiratory health status in a coastal, low-income community differed according to the fuel used (i.e., electric versus non-electric for heating and cooking).	There were statistically significant effects of non-electric sources for heating (adjusted OR = 3.6, 95% CI (confidence interval): 1.2–10.1, $p < 0.05$) and cooking (adjusted OR = 2.9, 95% CI: 1.1–7.9, $p < 0.05$) on the prevalence of URTIs. There was a statistically significant effect of electric sources for heating (adjusted OR = 2.7, 95% CI: 1.1–6.4, $p < 0.05$) on the prevalence of Lower Respiratory Tract Infections (LRTIs), but no evidence for relations between non-electric sources for heating and LRTIs, and

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					electric or non-electric fuel use type for cooking and LRTIs.
Hohne et al. 2019	A review of water heating technologies: An application to the South African context	Energy Reports	South Africa as a whole	This study aimed to survey the most frequently used domestic water heating technologies and critically analyse and summarise recent advancements in renewable and non-renewable water heating technologies in South Africa. Examples included electric storage tank water heaters, solar water heaters, heat pump water heaters, geothermal water heating, photovoltaic-thermal water heaters, gas-fired tankless water heaters, biomass water heaters and oil-fired water heaters.	Conventional water heaters may consume half of a regular household's total energy. People should be able to implement a system that suits their geographical and hot water requirements, with suitable financial support from the governing body, to reduce the use and dependency on fossil fuels. The amount of solar radiation the country receives makes it an ideal water heater system for all provinces. Provinces where temperatures are likely to reach freezing point should use an evacuated tube collector system to avoid damage to the collector (anti-freezing properties). Low-income households may benefit from Eskom rebates when these systems are implemented.
Kasangana and Masekameni 2019	Determinants for adoption and non-adoption of clean energy alternatives in low-income households: The case of South Africa	Conference: Domestic Use of Energy 2019 Cape Town, South Africa	Numerous studies in South African provinces, towns and settings	This study investigated the factors influencing the adoption or non-adoption of clean energy and ICS in South African low-income households.	Whether consumers invest in clean energy is influenced by: • Their household characteristics and preferences; • The device characteristics and performance; • Social and cultural norms; • The awareness of the risks of using traditional fuels or stoves; • The benefits of ICS and clean fuels; • Affordability; • Availability; • Accessibility; • The supply chain of the fuel or promoted clean cookstove or technology; • Increasing safety awareness campaigns of traditional stoves; • the benefits of ICS and increasing access to and making clean fuels;

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					• Making ICS and other energy technologies more affordable. It was suggested that if these factors are taken into acount it could lead to widespread diffusion.
Lusinga and de Groot 2019	Energy consumption behaviours of children in low-income communities: A case study of Khayelitsha, South Africa	Energy Research & Social Science	Khayelitsha, Cape Town, South Africa	This study aimed to investigate the energy consumption behaviour of primary school children in a low-income community in South Africa.	It was found that many children cooked for themselves or their families. It was found that children primarily used electricity (it is important to note that age makes a difference in energy use patterns). Using electricity for lighting was undoubtedly the most reported energy behaviour by children. Children reported various heating activities at home, predominantly focused on space- and water heating.
Mulumba et al. 2019	Determining the optimal energy use mix in a low-income household	Proceedings of the 27th International Conference on the Domestic Use of Energy, DUE 2019	KwaZamokuhle Town, Mpumalanga Province, South Africa	This study aimed to optimise the energy use mix in a typical low-income household on the Highveld for the lowest cost, lowest (CO2), and PM_{10} emissions.	It was found that using coal for cooking, space and water heating, and electricity for lighting and appliances was the cheapest option. For the lowest CO_2 and PM_{10} emissions, LPG is most suitable for cooking, space heating and water heating, and electricity is preferred for lighting and appliances.
Shupler et al. 2019	Household, community, sub-national and country-level predictors of primary cooking fuel switching in nine countries from the PURE study	Environmental Research Letters	International study, which took place in numerous countries. In South Africa, the study occurred in Potchefstroom, North West Province and Cape Town, Western Cape Province.	This study evaluated fuel switching within households across diverse household and community settings in a longitudinal study.	In South Africa, 54% of households reported changing their primary cooking fuels between baseline and follow-up surveys. Of these, 34% switched from polluting to clean fuels, 6% switched between different polluting fuels, 8% switched from clean to polluting fuels, and 6% switched between different clean fuels. Community-level factors (e.g., more significant population density) were the strongest predictors of polluting-to-clean fuel switching. South Africa experienced the highest rate of clean-to-polluting fuel switching (8%), with ~60% of households switching from electricity to wood and nearly 20% switching from electricity to kerosene fuel. The move away from electricity may be due to frequent power outages. The importance of community and

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					sub-national factors relative to household characteristics in determining polluting-to-clean fuel switching varied dramatically across the nine countries examined. These findings highlighted the potential importance of national and other contextual factors in shaping large-scale clean cooking transitions among rural communities in LMIC.
McCarron et al. 2020	Solid fuel user's perceptions of household solid fuel use in low- and middle-income countries: A scoping review	Environment International	Numerous countries, including South Africa	This study aimed to understand solid fuel users' perceptions of HAP and solid fuel use in LMIC. It further explored and summarised knowledge of solid fuel users' perceptions of solid fuel use and collection for cooking, heating and lighting in LMICs (perceptions of solid fuel use in terms of health, family and community life, home, space, cooking and cultural practices, environment and practice and policy development).	Participants emphasised the short-term health impacts of HAP instead of the longer-term health benefits of interventions and prioritised household security over improved ventilation. There was also a socio-demographic gendered disconnect as, although women and children generally have the most exposure to HAP, their decision-making power about the use of solid fuels is often limited. The review identified the importance of community norms and cultural traditions (including taste) in policy and practice.
Naidoo 2020	The socio-economic impacts of Solar Water Heaters (SWH) compared across two communities: A case study of Cato Manor	Renewable and Sustainable Energy Reviews	The Cato Manor community is located within Cato in Durban, KwaZulu Natal. Manor had two targeted communities, namely Wiggins and uMkumbaan.	This study aimed to examine the socio-economic impacts of using SWHs in low-income households and their attitudes and perceptions of using SWHs.	SWHs had a variety of socio-economic impacts, such as providing additional monetary savings that could be used towards livelihood strategies and benefits, allowing households to spend more time on productive activities. Socio-economic characteristics of residents (e.g., household income, size and gender) played essential roles in determining the energy profiles of the households as well as the reasons the use of the SWHs has improved these characteristics. The attitudes and perceptions of using SWHs were mixed. It was found that damage, negative experiences, technical difficulties, and disadvantages of using the SWHs brought about negative perceptions of the device due to its poor performance. However, larger proportions of respondents indicated that

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					SWHs had more benefits, and thus, residents comprehended a greater overall positive perception and attitude. Overall, SWHs provided socio-economic benefits to the residents of low-income households. These benefits had a holistic impact on their energy use in both communities. Residents have had an overall positive attitude and perception since receiving the technology.
Gill-Wiehl et al. 2021	What's in a stove? A review of the user preferences in improved stove designs	Energy Research & Social Science	Numerous countries, including South Africa	This study aimed to analyse the stove functions, characteristics, or features that households value in their cookstoves and to isolate and better understand the stove features that households require and prefer to ensure the adoption and consistent use of clean(er) cooking.	Overall, it was found that households needed a stove that met their significant cooking demands and could perform various cooking functions and cooking speeds. Preferences ranged across seven dimensions, but all related to the perception of ease of use, usefulness, or social influence. Households primarily wanted versatility; they had significant cooking demands and wanted a clean, durable stove (or stoves) that could meet that demand and perform various cooking functions at various cooking speeds. It was suggested that stove developers need to design and policymakers need to promote stoves (and perhaps stove bundles) that are versatile in size and function (e.g., can perform a range of cooking functions at a range of cooking speeds) in order to meet all of the household's cooking needs. If the stove designs fail to meet both technical and socially acceptable standards, low uptake and unclean stove stacking will continue.
Manyatsha et al. 2022	The determinants of households' energy fuel choice in Limpopo Province the case study of Boshega Village	Conference: National Association of Clean Air 2021; South Africa	Ga-Molepo, Boshega Village, Polokwane Local Municipality, Capricorn District South Africa	This study aimed to investigate the preferred biomass fuels in Boshega Village, identify the traditionally preferred tree species for fuelwood, and determine the driving forces for fuelwood consumption.	It was found that most respondents preferred fuelwood as the significant energy source for cooking, space and water heating. Electricity was the least preferred energy source for those same energy needs. Many sampled households preferred an energy mix for cooking and space heating, whilst none of the respondents preferred an energy mix for water heating. Most of the respondents used electricity for lighting since most households

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					are electrified. At the same time, only a tiny proportion used other energy sources such as candles and kerosene. It was concluded that age, monthly income, and employment status are among the key determinants of households' energy fuel choice required for cooking and space heating and whether they conformed to the "Energy Ladder Hypothesis" propositions. At the same time, gender, education level and family size did not necessarily influence the choice of energy sources.
Adeeyo et al. 2022	Determinants of solid fuel use and emissions risks among households: insights from Limpopo, South Africa	Toxics	Lulekane, Majeje and Makushane villages, Phalaborwa, Ba-Phalaborwa Local Municipality, Mopani District, Limpopo Province, South Africa	This study aimed to report factors influencing the choice of dominant solid fuel for cooking and sought to determine the emission risk from such solid fuel in three villages of Phalaborwa, Limpopo province, South Africa.	Wood was the predominant cooking fuel in the three villages, with 76.8% of participant households using it during the summer and winter. Variables such as low monthly income, education level, and burning system were revealed as strong predictors of wood fuel usage. Moreover, income, water heating energy, wood types, and cooking hours significantly influenced emissions from wood fuel in the community. Emissions from these wood fuels appeared to be a significant possible hazard for asthma and other respiratory diseases among households and represented demographics.
Pauw et al. 2022	The use of dirty fuels by low-income households on the South African Highveld	Clean Air Journal	The Highveld, Mpumalanga Province, South Africa	This study aimed to describe dirty fuel use by low-income households in the Highveld, including changes over time. The study aimed to describe which fuels were used, who used them, and for which utility. Emerging patterns shed light on possible avenues and prospects for ending dirty fuel use on the Highveld.	The complexities of household-level determinants of fuel switching and stacking patterns in low-income households on the Highveld were identified and unpacked in detail. These factors were placed within the context of more overarching determinants such as country-wide economic growth, the path of South Africa towards the Just Energy Transition, climate change, and the slow phasing out of coal in the country. "The enduring end of dirty solid fuel use will come from large societal transformations related to income, acceleration of formalisation through land rights and provision of services."

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Phogole et al. 2022	The effectiveness of household energy transition interventions in a coal-using community on the South African Highveld	Energy for Sustainable Development	The Highveld, Mpumalanga Province, South Africa	This study aimed to research the effectiveness and satisfaction of installing four clean household energy interventions implemented in KwaZamokuhle, a low-income coal-using community in the South African Highveld.	LPG and electric devices led many households to shift from coal. An electric stove was preferred for cooking, and 70% of households used the LPG heater five years after the intervention. Successful interventions to move households from coal should reduce energy demand and align natural preferences for electricity and fuel stacking when choosing alternative energy sources and appliances.
Roomaney et al. 2022	Estimating the burden of disease attributable to household air pollution from cooking with solid fuels in South Africa for 2000, 2006 and 2012	South African Medical Journal	South Africa as a whole	This study aimed to estimate the disease burden attributable to HAP for cooking in SA in 2000, 2006 and 2012.	Loss of healthy life years comprised 208 816 DALYs. An estimated 17.6% of the South African population was exposed to HAP in 2012. In the same year, HAP exposure was estimated to have caused 8 862 Deaths. HAP exposure due to cooking varied across provinces and was highest in the Limpopo, then Mpumalanga and KwaZulu-Natal Provinces. The burden of disease from HAP due to cooking in South Africa is of significant concern.
Gelo et al. 2023	The causal effect of income on household energy transition: Evidence from old age pension eligibility in South Africa	Energy Economics	South Africa as a whole	This study aimed to identify the causal effect of income from the discontinuous age-based eligibility for the Old Age Pension (OAP) benefit in South Africa on fuel choice and expenditures.	It was found that the eligibility for pension in a household increases reliance on electricity while reducing dependence on biomass and other polluting fuels. It was further shown that expenditure on electricity and other commercial fuels also increased, indicating that household demand for energy services generally increased with income. Moreover, it was shown that the effect on electricity demand was twice as large as that on demand for other fuels. The study highlighted the understudied benefit of cash assistance programs to people experiencing poverty in an essential and populous middle-income country and, more generally, provided important new causal evidence on income's role in facilitating household energy transitions.

Table A1: Generic overview of articles included in the main literature search (green indicates the study set out to investigate energy transitions, energy stacking or fuel switching).

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Matinga et al. 2014	Explaining the non-implementation of health-improving policies related to solid fuels use in South Africa	Energy Policy	South Africa	To understand why policies on solid fuel use have not been fully implemented.	The study found that the policies' symbolic meaning was the largest factor in why the 1998 energy plan regarding solid fuels was not followed. This is because, during Apartheid, Black communities were denied electricity. After the end of Apartheid, there was a significant focus on providing electricity to all Black communities, and policies such as the solid fuel policy did not receive attention. It was overlooked that many households continued using solid fuels even after electrification.	• Culture • Access to electricity • Rural/Urban • Economic • Social • Cultural • Income • Race
Ismail and Khembo 2015	Determinants of energy poverty in South Africa	Journal of Energy in Southern Africa	South Africa	To estimate the energy poverty line using the expenditure approach for South African Households. To estimate the determinants of energy poverty of these households.	Household expenditure patterns, race, education level, household and dwelling size, location of the household and access to electricity were essential factors in explaining the state of energy in South African households.	• Expenditure on transport, food and school • Race • Household size • Connection to the national energy grid • Rural vs urban • Geographical location
Nel et al. 2016	Energy perceptions in South Africa: An analysis of behaviour and understanding of electric water heaters	Energy for Sustainable Development	South Africa	To examine user awareness and knowledge about Electric Water Heater energy-saving measures.	Generally, participants underestimated their power consumption. Participants were open to switching off their EWH to reduce energy consumption but were less willing to do so if it resulted in a behavioural change (e.g., a change in the time they would shower). It was also found that participants older than 45 were more likely to have a SWH installed.	• Above/below 45 years old • Belief whether behaviours can reduce energy consumption • Convenience

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Thondhlana and Kua 2016	Promoting household energy conservation in low-income households through tailored interventions in Grahamstown, South Africa	Journal of Cleaner Production	Grahamstown, Eastern Cape, South Africa	To evaluate the success of interventions aimed at reducing energy consumption.	It was found that small actions, such as closing windows, switching off lights in rooms that are not occupied, and switching off appliances that are not in use, resulted in noticeable decreases in energy consumption. It was found that providing continuous feedback on energy savings positively impacted the motivation to continue using energy-saving behaviours. It was recommended that more emphasis be placed on energy conservation interventions and education, as the changes in behaviour can result in considerable overall changes within the community.	• Number of bedrooms • Education • Number of members in household with jobs • Number of social grants
Curry et al. 2017	The potential and reality of the solar water heater programme in South African townships: Lessons from the City of Tshwane	Energy Policy	Tshwane, South Africa	To gauge the impact of the government's Solar Water Heater program.	Solar Water Heaters were installed to reduce the peak load of electricity, reduce Carbon emissions and improve the household's living conditions. Due to a lack of training in operations, maintenance, and the advantages of use, the solar water heaters were not fully utilised. Often, leaking parts resulted in higher water use, leading to the water heater being discontinued. Despite the guarantee being five to 10 years, it is the case that the manufacturers go bankrupt, lose their contract with Eskom or change their phone number to avoid complaints. Education sessions were provided but poorly attended. The SWHs were also poorly advertised; only 10% of the respondents had seen any advertisements. Finally, maintenance engineers were scarce and training to do maintenance by the equipment owner was not given.	• Nonavailability of maintenance • Increased water consumption • Lack of training • Lack of community support

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Kimemia and Van Niekerk 2017	Cookstove options for safety and health: Comparative analysis of technological and usability attributes	Energy Policy	South Africa	To evaluate cookstove options regarding safety and health, comparing their technological and usability attributes.	The study assessed various attributes of several stove technologies, such as firepower, energy efficiency, fuel toxicity, and fuel cost. LPG emerged as the fuel with the greatest potential to serve as a healthier alternative to solid fuels. However, the purchase price of an LPG kit is a barrier for low-income households. To address this, the author recommended a monthly subsidy to overcome this barrier and drive adoption. The study suggested phasing out kerosene as a household fuel in South Africa.	• Fuel type: kerosene, methanol, ethanol gel, and LPG • Food type being cooked
Runsten et al. 2018	Energy provision in South African informal urban Settlements - A multi-criteria sustainability analysis	Energy Strategy Reviews	South Africa, Cape Town	To identify alternative energy sources for informal settlements lacking access to electricity.	Various supply options for energy access were identified, including: • Illegal grid connections • purchasing from a neighbour who resells electricity-metered connections, • solar lanterns with LPG for cooking • solar home system, including batteries with LPG for cooking and heating • Community Energy Service Centre (recharging batteries and refilling LPG canisters) Off-the-grid solutions were seen as viable in the short and medium term. The paper recommended shifting focus from using only electricity to broader energy service access.	• Political will • Government policies • Subsidies • Community Engagement • Location
Ateba et al. 2018	The impact of energy fuel choice determinants on sustainable energy consumption of selected South African households	Journal of Energy in Southern Africa	Mafikeng, Potchefstroom, Pretoria, Johannesburg, Gauteng, South Africa	The research aimed to assess the determinants of fuel use for heating, cooking and lighting in South Africa,	The results of this study indicated that households with higher incomes generally utilised more advanced energy sources than those with lower incomes. This included electricity for cooking and heating. In contrast, low-income households used paraffin and significantly more wood for cooking and heating than high-income groups.	• Income • Household size • Education • Gender

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				drawing on the energy ladder and energy stacking hypotheses.	Coal was mainly used for cooking by low-income groups. The percentage of LPG use in high-income households was more than double that in low-income groups. Solar water heaters were predominantly used for heating by high-income households. Notably, all incomes used electricity for lighting. Household size had an impact on the choice of energy for lighting, cooking and heating. Larger households were more likely to use LPG for cooking than smaller ones. Household size had a limited influence on biomass use, with the exception of wood for heating, and did not influence the use of solar energy for water heating. The results suggested that education level correlates with household energy choices. Participants with higher educational qualifications, such as post-graduates and those with degrees, tended to use electricity more for lighting, cooking, and heating. Those with lower academic qualifications lean towards using more paraffin for cooking, while those with higher qualifications opt for gas. Education also influences the use of biomass for heating and cooking. A minor correlation exists between education level and the adoption of solar energy for water heating. Male participants generally used more electricity for lighting, cooking, and heating than female participants. Additionally, males tended to use more LPG for cooking, while females used more paraffin. No significant difference was found in biomass use between males and females, except for wood used in cooking. Male participants also	

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					more frequently used solar energy for heating compared to female participants.	
Kambule et al. 2019	Exploring the driving factors of prepaid electricity meter rejection in the largest township of South Africa	Energy Policy	Orlando East and Diepkloof in Soweto, Gauteng, South Africa	To explore the reasons behind the rejection of prepaid electricity meters.	The reasons for rejecting prepaid electricity meters in Soweto were found to be unique. The main reasons were: • Lack of training or consultation, • High electricity consumption, • Unrealistic promises made by political parties. The FBE policy is flawed and requires revision. These flaws included an increase in the monthly allocation, which is currently set at 50kWh. It has been found that households typically use 750kWh per month, so the FBE is insignificant.	• Lack of training • High electricity consumption • Unrealistic promises made by political parties
Kimemia et al. 2018	Burns and fires in South Africa's informal settlements: Have approved kerosene stoves improved safety?	Burns	Johannesburg, South Africa	To follow up on an intervention where kerosene stoves were provided to 150 households.	An investigation found that 43 kerosene stoves had operational defects, and 23 were still in use after 12 months. It was found that the stoves that failed after a longer period of use were more likely to continue being used despite safety concerns. These faults included flame control and failure of the mechanism for self-extinguishment. The study recommended that SABS kerosene stoves be designed to be more robust and longer-lasting. Education in the use of stoves and safer alternatives should also be provided. Lastly, separating the cooking space from the living space was recommended.	• Total duration of use • Robustness of stove • The financial cost of the stove • Speed of cooking • Clean cooking solutions

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Ye et al. 2018	Determinants of household electricity consumption in South Africa	Energy Economics	South Africa	To assess residential electricity demand in developing nations.	Several determinants were found that can be used to determine the fuel(s) used by a household. The major determinants were household income and electricity prices. It was found statistically that education was not a determinant.	• Income • Electricity price • Access to electrical grid • Other sources of energy available • Household composition • Lifestyle • Electric appliances owned • Building type • Building size • Building thermal characteristics • Building quality • Rural/urban • Property value • Prepaid electricity/monthly account • Rebates • Race
Adenle 2020	Assessment of solar energy technologies in Africa- opportunities and challenges in meeting the 2030 agenda and sustainable development goals	Energy Policy	South Africa	To assess solar energy projects and adoption in Ghana, Kenya, and South Africa using meta-analysis, interviews, and World Bank/Global	A significant challenge with the implementation of solar projects within Africa was identified as the lack of continuous funding and limited involvement from the government. This limitation has resulted in many projects being abandoned. Furthermore, the adoption of solar projects relied on the customer's ability to afford the end product. Many low-income households cannot bear the cost of various solar products, which slows the implementation process. This	• Not applicable

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				Environment Facility data.	issue should be addressed through subsidies for low-income households. One of the largest barriers identified regarding Africa's implementation of solar energy was the low-quality imported solar components. Establishing local manufacturing units and performing local R&D was recommended to combat these problems.	
Adesina et al. 2020	Contrasting indoor and ambient particulate matter concentrations and thermal comfort in coal and non-coal burning households at South Africa Highveld	Science of The Total Environment	KwaZamokuhle in Mpumalanga, South Africa	To measure PM4 in two households to gauge the impact of solid fuel combustion on indoor and ambient air quality	• The study found that PM4 measurements in both houses were similar during summertime. • Furthermore, when solid fuel is used extensively for heating in winter, the concentrations are much higher in the coal-burning (SFB) house. • The diurnal variations of indoor PM4 levels displayed a bimodal pattern. This indicated the community's cooking times during the morning and evening. • In winter, when high ambient pollution and meteorological conditions did not aid with pollutant dispersion, no correlation was found between PM4 indoors and outdoors for both SFB and NSFB houses. • The SFB house, lacking insulation and a ceiling, had notably poorer thermal comfort compared to the NSFB house. The SFB house frequently exceeded the WHO minimum temperature during winter and the WHO maximum temperature during summer.	• Coal burning, uninsulated house vs non-coal burning insulated house with ceiling • Time of year • Time of day

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Rasimphi and Tinarwo 2020	Relevance of biogas technology to Vhembe district of the Limpopo province in South Africa	Biotechnology Reports	Vhembe district in Limpopo, South Africa	To explore the potential of replacing solid fuels with biogas, its health implications, and barriers to adoption.	Biogas has been found to be a suitable candidate to replace solid fuels with some excess. The study showed that 80% of biogas a household would produce would replace solid fuels, and the remaining 20% would replace paraffin. Biogas was recommended for cooking, water heating and space heating but not advised for lighting due to the low efficiency of biogas lamps. Solar-powered lights were recommended for lighting. Making these changes would also help to reduce rates of deforestation. Additionally, the cost savings nationwide was estimated at R1 billion/annum. Users of digestors reported not having to manage the fire or collect fuelwood, which made much more time available. Based on the average number of livestock owned by communal farmers, a 5000 or 6350L/day digester can be installed when using cattle dung. Unfortunately, chicken waste (based on an average of 16 chickens per household) was found to be infeasible. When using human waste, a household of four people is also insufficient to feed a small biodigester, but in these cases, a community bio-digestor is recommended, with between 19 and 47 members.	• Livestock type • Number of livestock • Number of people in the household • Community/private biodigester
Strydom et al. 2020	Connecting energy services, carriers and flows: Rethinking household energy metabolism in Cape Town, South Africa.	Energy Research & Social Science	Cape Town, Western Cape, South Africa	To conduct a household energy assessment by income level, examining fuel use for 11 essential energy services.	By conducting a household energy metabolism assessment, it was found that all income levels have access to the 11 essential energy services. It can be concluded that wealth is not the only factor in whether these services are accessible. Electricity was the most used energy source by all income groups. Other studies have found that energy sources become less diverse with increased income, but this trend was not seen in	• Income group

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					this study. This is thought to be attributed to socio-cultural preference. It was suggested that low-income households should try to switch to more efficient energy sources to increase the sustainability of energy use, whereas wealthier households should decrease their total energy use.	
Dumont et al. 2021	The "yuck factor" of biogas technology: Naturalness concerns, social acceptance and community dynamics in South Africa	Energy Research & Social Science	Johannesburg, Gauteng, South Africa	To assess the social acceptance of biogas and factors reducing its adoption rate.	It was found that biogas was considered unnatural and disgusting and elicited some fear. Naturalness was the category that should be addressed, as the other two characteristics are found in other commonly accepted practices, such as wastewater treatment. It is also rejected due to the stigma of being used only by low-income people. It was proposed that biogas branding should change to indicate environmental friendliness.	• Naturalness • Fear • Moral and physical disgust • Indignity
Makonese et al. 2020	Performance evaluation of three methanol stoves using a contextual testing approach	Energy for Sustainable Development	Alexandra Township in Johannesburg, Gauteng, South Africa	To evaluate the performance of three alcohol-based stoves using the UCT and HTP testing methods	It was found that a stove could output more than 1kW into the pot when using methanol despite having been designed for Ethanol. In general, it was found that all three stoves emitted large amounts of CO and had possibilities for improvement.	• Ethanol vs Methanol
Sumbane-Prinsloo et al. 2021	The influence of particle size on the thermal performance of coal and its derived char in a Union stove	Energy Geoscience	Kwadela Township in Mpumalanga, South Africa	To study the influence of coal and coal-derived char particle diameter on combustion in a cast iron stove.	Several combustion parameters were investigated, and correlations were found: • 40mm char ignited faster than 15mm char; • Cooking time was similar between the fuels;	• Particle diameter

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					• Coal power output was above 10kW, while char measured between 8.5 and 10.7kW; • Coal efficiency was 66.4%, while char was 65.8%; • Char CO\CO2 ratio was higher, at 6.7-10.8, while coal was 4.9-5.3.	
Haque et al. 2021	Why do low-income urban dwellers reject energy technologies? Exploring the socio-cultural acceptance of solar adoption in Mumbai and Cape Town	Energy Research & Social Science	Joe Slovo in Cape Town, Western Cape, South Africa	To understand the socio-cultural acceptance of solar water heaters, compare Mumbai's and Cape Town's perspectives.	The top-down roll-out of solar energy use in Cape Town was less effective than the bottom-up approach in Mumbai. As SWHs were viewed as a low-income utility in Cape Town, the community resisted the roll-out despite the potential financial benefits. In contrast, the Mumbai community embraced the roll-out without this mindset. For both cities, a key factor was the visible demonstration of an affluent lifestyle.	• Social norms of the community • Roll-out technique
Ngarava et al. 2022	Gender and ethnic disparities in energy poverty: The case of South Africa	Energy Policy	South Africa	To identify gender and ethnic disparities in energy poverty, primarily focusing on female-headed households based on their race/ethnicity.	The study identified gender and ethnic disparities in energy poverty in South Africa. It found that Black/African female-headed households had the highest vulnerability to energy poverty. These findings could be associated with income and ethnic disparities, as Whites in South Africa generally have higher earnings compared to other ethnic groups. The study also suggested a review of policies like the FBE policy to address better and potentially eliminate energy poverty.	• Gender of household head • Race/ethnicity of the household when the head is female
Ojong 2021	The rise of solar home systems in sub-Saharan Africa: Examining	Energy Research & Social Science	South Africa	To investigate how societal factors, including age, gender, and location within	Several factors, such as gender, status and class, impacted the uptake of Solar Home Systems (SHS). Additionally, geographical location influenced status and, therefore, the acceptance of SHS. These factors should be considered by	• Gender • Age • Class • Culture

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	gender, class, and sustainability			Sub-Saharan Africa, influence the adoption rate of solar panels.	policymakers when rolling out interventions in order to maximise adoption rates.	• Daily routines and habits
Ye and Koch 2021	Measuring energy poverty in South Africa based on household-required energy consumption	Energy Economics	South Africa	To address energy poverty in South Africa using the Foster-Greer-Thorbecke-based poverty measures.	Using a semiparametric model, the energy poverty line in South Africa, which uses several inputs, was calculated. The model was used to quantitatively determine the extent of energy poverty within South Africa, which was found to be severe. This can be used to differentiate income poverty and energy poverty. Extreme poverty is found in the energy poverty group, and it was suggested that this group should receive focus first.	• Household expenditure • Household size • Household composition • Dwelling characteristics • Annual season • Household appliances
Monyai et al. 2023	Inequalities in access to energy in informal settlements: Towards energy justice in Gqeberha and Komani in South Africa	Water-Energy Nexus	Gqeberha, Komani, Eastern Cape, South Africa	To consider the energy needs and interests of marginalised communities in informal settlements.	This study found that many residents of low-income communities resort to unauthorised electrical connections due to the high energy cost. These connections pose safety risks. While energy is available in many of these settlements, affordability is a significant issue, leading residents to opt for illegal connections and potentially hazardous energy sources. This situation challenges South Africa's objectives of the National Energy Act of 2008. It is the incumbent of the government to address these inequalities and provide energy access to all, regardless of socio-economic status. Communities forced to reside on the outskirts of towns and cities must be granted development's social and economic benefits.	Problems accessing electricity due to: • Distance from informal settlements to the grid • Income poverty • Illegal connections

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Said and Acheampong 2023	Financial inclusion and energy poverty reduction in sub-Saharan Africa	Utility Policy	South Africa	To investigate the link between financial inclusion and energy poverty reduction. This was measured through access to electricity and clean cooking technologies and fuels across 23 Sub-Saharan African countries from 2004 to 2019.	The research established a positive correlation between financial inclusion and energy poverty reduction in most countries, indicating that decreasing energy poverty typically leads to adopting cleaner fuels. However, in Botswana, Rwanda, and Uganda, financial inclusion had a negative impact on energy poverty reduction.	• Sub-Saharan country • Financial inclusion • Energy poverty
Ye and Koch 2023	Towards accessibility or affordability? Multidimensional energy poverty across the South African urban–rural divide	Energy Research & Social Science	South Africa	To examine the affordability and accessibility of fuels among urban and rural communities.	The study revealed that energy affordability and accessibility vary in rural and urban households. It delved into the differences between energy usage patterns and poverty in these settings. Notably, rural households face more significant challenges with affordability than urban households. It should be noted that energy poverty is not synonymous with income poverty. Additionally, rural households that are extremely energy-poor tend to have much higher accessibility issues than urban households that are extremely energy-poor.	• Urban vs rural fuel use • Urban vs rural affordability • Urban vs rural accessibility

Table A2: Geographical location, main study design and study theme category, as well as fuel use determinants of studies included in the supplementary search.

Theme	Questions asked/ information requested.	Answers provided/ information recorded.	Reference
Access to electricity	What type of electrical supply, if any, does this house have?	• None; • Electricity with conventional meter; • Electricity with a prepaid card; • Other electricity supply: solar or wind generators; • Other electricity supply: petrol/diesel generators; • Connection from neighbour's house; • Do not know.	Musango 2014
Access to electricity	Have you ever had an electricity supply cut off for non-payment?	• Yes • No	Musango 2014
Access to electricity	If you have an electricity connection in your house, do you receive an FBE/ PoP subsidy?	• Yes • No	Kimemia and Annegarn 2016
Access to electricity	If you receive FBE, how many units (KWh) do you receive per month?	…KWh	Kimemia and Annegarn 2016
Access to electricity	In your opinion, what is the quality/reliability of electricity where you live	• High quality • Acceptable quality • Poor quality • Very poor quality • I do not know	Kimemia and Annegarn 2016
Access to electricity	Access to electricity	• Yes • No	Shupler et al. 2019
Access to electricity	A question asking whether a household was connected to the "MAINS electricity supply" indicates electricity access.		Harris et al. 2017
Access to electricity	Households were asked various questions regarding their access to and use of electricity, including:	Whether they received free electricity (if connected to the grid)	Harris et al. 2017
Access to electricity	Utility data on service interruptions:	• Average frequency per year • Average duration (h)	Tait 2017
Access to electricity	Indicator for whether the house receives FBE	•	Vermaak et al. 2014
Access to electricity	Does this household have electricity even if it is currently disconnected	• Yes • No	Mbewe 2018
Access to electricity	Electricity access	• Yes • No	Gelo et al. 2023

Fuel use in general	The energy sources used	• Fuelwood; • Electricity; • Kerosene; • Cow dung; • Agricultural residue.	Manyatsha et al. 2022
Fuel use in general	What the energy was used for	• Cooking; • Water and space heating; • Lighting.	Manyatsha et al. 2022
Fuel use in general	Fossil fuel used for heating	• Coal; • Wood; • Paraffin; • Gas; • Fossil heating; • No fossil heating.	Vanker et al. 2015
Fuel use in general	What is your source(s) of energy in this household for cooking, heating and lighting?	Respondents could tick one or many of the following responses for each utility: • Paraffin; • Coal; • Wood; • Candle; • Electricity; • Gas; • Ethanol Gel; • Other: Specify.	Kimemia and Annegarn 2016
Fuel use in general	Fuel use	• No electricity access • Informal connection; • Metered connection + inadequate fuels; • Metered connection + adequate fuels.	Tait 2017
Fuel use general	Prevalence of traditional fuels and biomass consumption		Bohlmann et al. 2018
Fuel use general	Variables considered:	• Water heating energy; • Categories of wood; • Types of wood; • Sources of wood; • Wood prices; • Quantity of wood bought; • Wood use per day; • System of burning; • Number of burning days per week.	Adeeyo et al. 2022

Fuel use general	Questionnaire surveys were designed and administered to gather information on energy practices within the informal townships.	• Types of cooking devices and fuels used; • Factors influencing stove/fuel choices (socio-economic factors); • Ignition methods; • Amount and cost of fuel used daily primarily for cooking.	Makonese et al. 2016
Fuel use general	Frequency of fuel use in sampled households for 'cooking', 'heating' and 'heating & cooking' (multiple fuel use allowed)	• Coal • Wood • Kerosene • Electricity	Makonese et al. 2016
Fuel use general	Do you use fuel in your house?		Pauw et al. 2022
Fuel use general	General household survey; A detailed household energy survey; Direct monitoring of household fire-making cycles; Weighing of fuel in a sample of households; Coal samples from coal merchants were analysed for energy value, carbon content and ash content.		Pauw et al. 2022
Fuel use general	The main energy source (lighting, heating, cooking)	• Only electricity; • At least some gas; • Biomass; • Other and mixed.	Gelo et al. 2023
Fuel use general	Energy carriers	• Electricity; • Coal; • Wood.	Adesina et al. 2020
Main fuel use cooking	What energy source is most used for cooking in your household?	• Electricity; • Gas/LPG; • Paraffin; • Wood; • Coal; • Dung; • Solar energy; • Other; • Do not know.	Musango 2014
Main fuel use cooking	What is the primary source of energy for cooking?	• Electricity; • Wood; • Gas; • Paraffin; • Candles; • Other (Specify).	Naidoo 2020

Main fuel use cooking	What fuel do you mainly use for cooking?	• Electricity; • Wood; • Gas; • Electricity and gas.	Buthelezi et al. 2019
Main fuel use cooking	The primary source of energy used for cooking	• Electricity; • Fuel wood; • Multiple uses.	Uhunamure et al. 2017
Main fuel use cooking	Baseline primary cooking fuel	• Animal dung; • Ag/crop/shrub; • Wood. • Coal; • Kerosene; • Charcoal; • Electricity; • Gas.	Shupler et al. 2019
Main fuel use cooking	"What is your main source of energy for cooking, heating and lighting in this household?"	The answers were open-ended.	Kimemia and Annegarn 2016
Main fuel use cooking	The primary fuels currently used for cooking.	• Electricity; • Biomass briquettes/pellets; • Charcoal; • Firewood; • Ethanol gel; • Gas.	Pailman et al. 2018
Main fuel use cooking	What is the main source of cooking fuel for this household?	• Electricity from mains; • Electricity from a generator; • Gas; • Paraffin; • Wood; • Coal; • Candles; • Animal Dung; • Solar Energy; • Other (specify); • None; • Refuse.	Mbewe 2018

Main fuel use cooking	What type of energy/fuel does this household mainly use for cooking?	• Electricity; • Gas; • Paraffin; • Wood; • Coal; • Candles; • Animal dung; • Solar; • Other; • None.	Pauw et al. 2022 (from the National Census)
Main fuel use cooking	Main cooking energy source	• Electricity; • Coal; • LPG; • Biomass; • Other.	Gelo et al. 2023
Fuel use cooking	Energy choice for cooking	• Traditional energy carrier (less preferred) • Transitional energy carrier (moderately preferred) • Modern energy carrier (most preferred) • Modern energy carriers include electricity from the grid, gas, solar energy and electricity from a generator. • Transitional energy carriers comprise paraffin and coal. • Traditional energy carriers include animal dung and wood.	Israel-Akinbo et al. 2018
Fuel use cooking	Energy choice for cooking	• Electricity • Coal • Firewood • Animal dung • Paraffin	Bohlmann et al. 2018
Fuel use cooking	A question asks whether the household uses electricity for cooking.		Harris et al. 2017
Fuel use heating	Energy choice for heating	• Traditional energy carrier (less preferred); • Transitional energy carrier (moderately preferred); • Modern energy carrier (most preferred); • Modern energy carriers include electricity from the grid, gas, solar energy and electricity from a generator; • Transitional energy carriers comprise paraffin and coal. • Traditional energy carriers include animal dung and wood.	Israel-Akinbo et al. 2018

Fuel use heating	Do you use any of the following heating systems (Y/N).	• Wood/ coal stove; • Fireplace; • Gas heater; • Asbestos heater; • Portable electric heater.	Buthelezi et al. 2019
Fuel use heating general	Energy choice for space heating.	• Electricity; • Firewood; • Paraffin.	Bohlmann et al. 2018
Main fuel use heating	What type of energy/fuel does this household MAINLY use for heating?	• Electricity; • Gas; • Paraffin; • Wood; • Coal; • Candles; • Animal dung; • Solar; • Other; • None.	Pauw et al. 2022 (from the National Census)
Main fuel use heating	Main heating energy source	• Electricity; • Coal; • LPG; • Biomass; • Other.	Gelo et al. 2023
Main fuel use water heating.	What is the main source of energy for heating water?	• Electricity; • Wood; • Gas; • Paraffin; • Candles; • Other (Specify).	Naidoo 2020
Main fuel use water heating.	The main source of energy used for heating water	• Electricity; • Fuel wood; • Multiple.	Uhunamure et al. 2017
Fuel use water heating general	Energy choice for heating water	• Electricity; • Solid fuels; • Paraffin; • LPG.	Bohlmann and Inglesi-Lotz 2018

Main fuel use lighting	What energy source is most used for lighting?	• Electricity; • Gas/LPG; • Paraffin; • Wood; • Candles; • Solar energy; • Other; • Do not know.	Musango 2014
Main fuel use lighting	What is the main source of energy for lighting?	• Electricity; • Wood; • Gas; • Paraffin; • Candles; • Other (Specify).	Naidoo 2020
Main fuel use lighting	What type of energy/fuel does this household mainly use for lighting?	• Electricity; • Gas; • Paraffin; • Wood; • Coal; • Candles; • Animal dung; • Solar; • Other; • None.	Pauw et al. 2022 (from the National Census)
Main fuel use lighting	Main lighting energy source	• Electricity; • Candle; • Paraffin; • Other.	Gelo et al. 2023
Fuel use for lighting general	Energy choice for lighting	• Traditional energy carrier (less preferred); • Transitional energy carrier (moderately preferred); • Modern energy carrier (most preferred); • Modern energy carriers include electricity from the grid, gas, solar energy and electricity from a generator; • Transitional energy carriers comprise paraffin and coal; • Traditional energy carriers include animal dung and wood;	Israel-Akinbo et al. 2018
Fuel use for lighting general	Households were asked whether they use electricity for lighting	• Electricity; • Paraffin; • Candles.	Harris et al. 2017
Fuel use for lighting general	Energy choice for lighting		Bohlmann and Inglesi-Lotz 2018

Additional fuel use cooking	What are your additional sources of energy for cooking?	• Electricity; • Wood; • Gas; • Paraffin; • Candles; • Other (Specify).	Naidoo 2020
Additional fuel use water heating	What are your additional sources of energy for heating water?	(Multiple responses)- none provided	Naidoo 2020
Additional fuel use lighting	What are your additional sources of energy for lighting?	(Multiple responses)- none provided	Naidoo 2020
Economics	Thinking about the cost of electricity or other fuels such as paraffin, candles, water, waste and municipal rates; approximately how much does your household spend per month?	…ZAR	Musango 2014
Economics	How much do you pay for this energy source per month?	Open answer	Naidoo 2020
Economics	On average how much does your household spend each month on the following energy sources?"	Energy source…monthly quantity…monthly cost…for: • Paraffin; • Wood; • Coal; • Electricity; • Gas; • Generator fuel; • Candles; • Batteries; • Other.	Kimemia and Annegarn 2016
Economics	Expenditure/ income:	• 0-10%; • 10-20%; • 20-30%; • >30%.	Tait 2017
Economics	Energy use quantities and costs:	• Unit of sale; • Price/unit; • Market; • Weekly; • Monthly; • Yearly.	Makonese et al. 2016

Economics		• Availability; • Affordability; • Accessibility; • Supply chain.	Kasangana and Masekameni 2019
Economics	The survey records spending by the household on the following energy types:	• Paraffin; • Gas; • Candles; • Coal; • Firewood; • Solar; • Electricity; • Batteries; • Car Batteries; • Generators; • Other Energy.	Vermaak et al. 2014
Economics	How much was spent on electricity in the last 30 days?	• Amount; • Refuse; • Do not Know.	Mbewe 2018
Economics	How much was spent on other energy sources such as wood, paraffin, charcoal/coal, candles, gas, purchasing/charging batteries and diesel oil for generators in the last 30 days?	• Amount; • Refuse; • Do not Know.	Mbewe 2017
Economics	Energy expenditure (Rand/month)	• Electricity expenditure; • Other energy expenditure.	Gelo et al. 2023
Economics	Possession of appliance: • Fans; • Heaters; • Refrigerator; • Water heater; • Electric kettle; • Lighting; • Home electronics; • Geyser; • Clothes dryer.	• Yes • No	Thondhlana and Kua 2016
Economics	If yes, how many?		Thondhlana and Kua 2016
Economics	Which actions are taken to increase efficiency or reduce the use of electricity		Thondhlana and Kua 2016
Economics	Monthly household electricity consumption expenditure	ZAR	Ye et al. 2018
Economics	Electricity price	ZAR	Ye et al. 2018

Economics	Household has received free basic electricity	• Yes • No	Ye et al. 2018
Economics	Monthly household gas expenditure, including expenditures on gas supplied through either a public network or purchased in cylinders (including gas for heating purposes)	ZAR	Ye et al. 2018
Economics	Monthly household expenditure on liquid fuels, including expenditures on paraffin, petrol and diesel (petrol and diesel for household use, not transport)	ZAR	Ye et al. 2018
Economics	Monthly household expenditure on solid fuels, including expenditures on candles, firewood bought, coal, charcoal, dung and crop waste, not including fetched firewood and dung values	ZAR	Ye et al. 2018
Economics	Use of [fuel type] by income: Electricity LPG and paraffin Solar water heater Use of traditional fuels (biomass)	• Yes • No	Ateba et al. 2018
Fuel use behaviour	Why do you choose this as the main source of cooking?	(Multiple responses) Use codes – none provided	Naidoo 2020
Fuel use behaviour	Why do you choose this as the main source of heating water?	(Multiple responses) Use codes – none provided	Naidoo 2020
Fuel use behaviour	How do you heat your water when your SWH is not functional?	• Electricity; • Wood; • Gas; • Paraffin; • Charcoal; • Candles; • Other (Specify).	Naidoo 2020
Fuel use behaviour	Does your SWH replace any appliance in this household?	• Kettle; • Urn; • Electric geyser; • Heating water using an electric stove or other fuel sources.	Naidoo 2020
Fuel use behaviour	Why do you choose this as your main source for lighting?	(Multiple responses) Use codes- none provided	Naidoo 2020
Fuel use behaviour	If you do have a portable gas heater in your home, how often do you use it during the winter?	• About every day; • 2-3 times a week; • 2-3 times a month; • Seldom; • Never.	Buthelezi et al. 2019

Fuel use behaviour	If you do have a coal stove in your home, how often do you use it during the winter?	• About every day; • 2-3 times a week; • 2-3 times a month; • Seldom; • Never.	Buthelezi et al. 2019
Fuel use behaviour	If you do have a fireplace in your home, how often do you use it during the winter?	• About every day; • 2-3 times a week; • 2-3 times a month; • Seldom; • Never.	Buthelezi et al. 2019
Fuel use behaviour	Fuelwood collection	None provided	Manyatsha et al. 2022
Fuel use behaviour	Respondent's reasons for using fuelwood	• Electricity is expensive; • Abundant fuel wood; • Fuel wood is cheaper; • Taste.	Uhunamure et al. 2017
Fuel use behaviour	How fuel wood is obtained	• Wood harvesters; • Wood purchasers.	Uhunamure et al. 2017
Fuel use behaviour	Employed a questionnaire to explore energy knowledge and attitudes, domestic circumstances, household energy use and energy habits of both children and parents/guardians		Lusinga and de Groot 2019
Fuel use behaviour	Energy diary	Description of children's behaviour, motivation and knowledge in their own words The children reported: • Their energy uses; • How they save energy; • Their reasons for saving energy.	Lusinga and de Groot 2019
Fuel use behaviour	Focus group	To clarify and probe the themes that emerged from the questionnaire and in the diaries	Lusinga and de Groot 2019
Fuel use behaviour	There are many other energy-related question in the questionnaire, many are focused on understanding how the LPG intervention has worked in households or how it could be improved.		Kimemia and Annegarn 2016
Fuel use behaviour	Has the household fuel mix has changed over the last 3 years	If yes, please give detail	Kimemia and Annegarn 2016

Fuel use behaviour	What are the solid fuel users' perceptions of solid fuel collection and solid fuel use in the home (?) with respect to:	• Health; • Family and community life; • Home, space, place and roles; • Cooking and cultural practices; • Environment; • Practice and policy development.	McCarron et al. 2020
Fuel use behaviour	knowledge of and use of bottom—lit updraft and TLUD ignition methods:	• Know; • Do not know; • Use.	Makonese et al. 2016
Fuel use behaviour	Determinants of adoption and sustained use of clean fuels and ICS	Knowledge and awareness of traditional fuels and ICS Risk and benefits and clean fuels and ICS	Kasangana and Masekameni 2019
Fuel use behaviour	Cookstove preference	• Improved biomass cookstove; • Traditional; • Traditional, improved biomass + electric; • Electric; • Improved biomass + electric; • Gas.	Pailman et al. 2018
Fuel use behaviour	Reported benefits of cooking with ICS	• Cost savings; • Less fuel required; • Smoke reduction; • Cooks well (fast).	Pailman et al. 2018
Fuel use behaviour	Aspirational fuels cooking	• Electricity; • Biomass briquettes/pellets; • Charcoal; • Firewood; • Gas.	Pailman et al. 2018
Fuel use behaviour	Were you consulted or educated about the use of prepaid meter before installation phase?	• Yes • No	Kambule et al. 2019
Fuel use behaviour	If yes, Please rate the standard of consultation or education received?	• Good • Poor	Kambule et al. 2019
Seasonal/ temporal	Does your solar water heater provide hot water throughout the day?	• Yes • No	Naidoo 2020
Seasonal/ temporal	Does your solar water heater provide hot water throughout the year?	• Yes • No	Naidoo 2020
Seasonal/ temporal	Different cooking fuels used during wet and dry seasons:	• Electricity; • Wood; • LPG; • Wood and electricity.	Adeeyo et al. 2022

Seasonal/ temporal	Fuel preference in summer and in winter	• Coal; • Wood; • Kerosene; • Electricity.	Makonese et al. 2016
Stoves	Type of stove	• Electric; • Paraffin; • Gas; • Wood; • Coal; • Fossil stove; • No fossil stove.	Vanker et al. 2015
Stoves	A questionnaire was structured with both closed and open – ended questions. The final questionnaire developed comprised twenty questions relating to:	• Stove Acquisition; • Cost; • Use; • Choice; • Durability; • Type; • Quantity Of Fuel; • Method of ignition for solid fuel stoves.	Makonese et al. 2016
Stoves	Number of stove devices used for cooking and heating (multiple devices in households allowed):	• Brazier; • Cast iron stove; • Non-pressurised kerosene wick; • Electric.	Makonese et al. 2016
Stoves		Device characteristics and performance	Kasangana and Masekameni 2019
Stoves	Cookstove combinations:	• Traditional biomass; • Improved biomass + traditional biomass; • Improved biomass, traditional biomass + electric; • Improved biomass, traditional biomass + gas; • Ethanol gel and improved biomass; • Ethanol gel, improved biomass, electric + gas; • Improved biomass; • Improved biomass + electric; • Improved biomass + gas; • Improved biomass, traditional biomass, electric + gas; • Ethanol gel, improved biomass + electric;	Pailman et al. 2018

Stoves	Types of cookstoves in households:	• Traditional biomass; • Improved biomass; • Electric; • Gas; • Ethanol gel.	Pailman et al. 2018
Stoves	Frequency of use of ICS:	• Daily; • Sometimes; • Special occasions; • Never.	Pailman et al. 2018
Stoves	Frequency of use of traditional biomass cookstove:	• Daily; • Sometimes; • Special occasions; • Never.	Pailman et al. 2018
Socio-economic circumstances for contextualisation	Demographic information and socio-economic characteristics:	• Age; • Sex; • Gender; • Education Level; • Employment Status; • Monthly Income Level; • Family Size.	Manyatsha et al. 2022
Socio-economic circumstances for contextualisation	Kitchen structural characteristics:	None given	Manyatsha et al. 2022
Socio-economic circumstances for contextualisation		• Education level; • Employment status; • Household income bracket.	Uhunamure et al. 2017
Socio-economic circumstances for contextualisation	Percent income spent on food:	• 1-33%; • 34-66%; • 67-100%.	Shupler et al. 2019
Socio-economic circumstances for contextualisation	Highest level of education in household:	• None; • Primary; • Secondary; • High School; • Trade School; • College; • University.	Shupler et al. 2019

Socio-economic circumstances for contextualisation	Household characteristics:	• The age group of head of household (35-44, 45-54, 55-70); • Electricity access (yes/no); • Number of family members (1-2, 3-4, 5+); • Number of working family members (1, 2, 3-5); • Number of rooms in the household (1-2, 3-4, 5+); • Roofing material [poverty indicator] (1. thatch/wood/ stone/ ‘other’ 2. concrete/cement/iron/zinc/asbestos sheets 3. tile);	Shupler et al. 2019
Socio-economic circumstances for contextualisation	Community characteristics:	• Travel time (minutes) to closest densely populated area in 2015 (0-5, 6-15, 15+); • Population density in 2010 (midway point of study) (people/km2) (1-300, 301-800, 801+); • Change in population density between baseline (2005) and follow-up (2015) (people/km2) (-10 – 30, 31-120, 120+); • Majority of shopping (food, household necessities) done > 15-minute walk (yes/no).	Shupler et al. 2019
Socio-economic circumstances for contextualisation	Variables considered:	• Education; • Household size; • Household in compound; • Income.	Adeeyo et al. 2022
Socio-economic circumstances for contextualisation		• Household settings and characteristics; household preferences; Social and cultural influences;	Kasangana and Masekameni 2019
Socio-economic circumstances for contextualisation	Does the household own at least one fridge?	• Yes • No	Mbewe 2018
Socio-economic circumstances for contextualisation	Does the household own at least one radio?	• Yes • No	Mbewe 2018
Socio-economic circumstances for contextualisation	Does the household own at least one television?	• Yes • No	Mbewe 2018
Socio-economic circumstances for contextualisation	Does the household own at least one computer?	• Yes • No	Mbewe 2018
Socio-economic circumstances for contextualisation	Does the household own a mobile phone?	• Yes • No	Mbewe 2018
Socio-economic circumstances for contextualisation	Does the household own at least one landline phone?	• Yes • Yes, but disconnected • No	Mbewe 2018

Socio-economic circumstances for contextualisation	Influence of household size on the use of: • Electricity for lighting, cooking, heating • LPG and paraffin for cooking • Biomass for cooking and heating • Solar water heating	• 1-3 • 4-6 • >7	Ateba et al. 2018
Socio-economic circumstances for contextualisation	Influence of education on the use of: • Electricity for lighting, cooking, heating • LPG and paraffin for cooking • Biomass for cooking and heating • Solar water heating	• Grade 12 and below; • Diploma; • Degree; • Post-graduate.	Ateba et al. 2018
Socio-economic circumstances for contextualisation	Influence of gender on the use of: • Electricity for lighting, cooking, heating • LPG and paraffin for cooking • Biomass for cooking and heating • Solar water heating	• Male • Female	Ateba et al. 2018
Behaviour general	Qualitative questionnaires were distributed randomly to test the prevailing fuel type and identify demographic factors, kitchen characteristics, types of cookstoves used, and other factors that influence emissions.		Adeeyo et al. 2022
Control variables	Demographics	• Average years of schooling; • Household size; • Black; • Coloured; • Asian/Indian; • White.	Gelo et al. 2023
Air quality/ health	Informal exposure assessment	NA	Manyatsha et al. 2022
Air quality/ health	Quantified the number of self-reporting polluting primary cooking fuel at baseline and how many of those switched	• From polluting to clean fuel; • From polluting to polluting; • From clean to polluting; • From clean to clean.	Shupler et al. 2019

Air quality/ health	• -Opening windows/ doors in winter • -Mold/ mildew growing in house • -Pets in the household • -Diet and exercise • -Health (especially pertaining to respiratory health, asking about asthma, phlegm, wheeze etc.))		Buthelezi et al. 2019
Air quality/ health	In your opinion, what factor(s) has the biggest influence on your respiratory health status?	Open question	Buthelezi et al. 2019
Air quality/ health	Do you perceive the air pollution in the KZN as serious?	• Yes; • No; • Not critical; • Unknown.	Buthelezi et al. 2019
Air quality/ health	If you do not live in......................... any more, do you perceive air pollution levels in the area where you currently live as serious?	• Yes; • No; • Not critical; • Unknown.	Buthelezi et al. 2019
Air quality/ health	What do you consider the most important source of air pollution in your area? (Mark one)	• Motor vehicles; • Industries and mines; • Cigarette smoke; • Open fires (from areas without electricity); • Other (Specify).	Buthelezi et al. 2019
Air quality/ health	Have you noticed unusual odours in your neighbourhood?	• Yes • No	Buthelezi et al. 2019
Air quality/ health	If "Yes" for how long have you noticed these odours? (Complete only one)	…Years …Months …Days	Buthelezi et al. 2019
Air quality/ health	Do you feel that these odours are affecting your health?	• Yes; • No; • Unknown.	Buthelezi et al. 2019
Air quality/ health	If "Yes" how severely do you feel these odours are affecting your health?	• A great deal; • Fairly; • Very little; • Unknown.	Buthelezi et al. 2019
Air quality/ health	Prevalence of risk and number of risk categories:	• Behavioural risks; • Electrical safety risks; • Lack of fire safety knowledge; • Indoor air pollution risk; • Unsafe fuels are used.	Tait 2017

Air quality/ health	Health of the oldest woman in household	• Past asthma diagnosis; • Persistent cough, past 30 days; • Persistent cough with blood, past 30 days.	Gelo et al. 2023

Table A3: Overview of questions asked and information requested in the reviewed articles.

Note: Not all articles are listed in this table, as some did not provide the necessary information. If a question is listed in the cell, then the question is available in the manuscript or the supplementary material; if there is a statement, no question was provided in the manuscript, and statements were extracted based on the gist of the information gathered. If no direct answer to the question was provided, or if the answer options could not be derived, the cell in the ‘Answers provided/ information recorded’ column remained empty.