SOCIO- ECONOMIC BENEFITS OF ENERGY INITIATIVES ON THE WELLBEING OF RURAL HOUSEHOLDS IN HOMA BAY COUNTY, KENYA

BY

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DECLARATION

Declaration by the student

This proposal is my original work and has not been presented for any degree or academic award in any other university.

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This thesis has been submitted for examination with our approval as University supervisors.

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To my children; Jack, Eunice, Esther, Titus and Elizabeth who, more than anyone else, inspired me. My burning desire and humble prayer is for my children to grow and to reach higher levels in all spheres of life.

ABSTRACT

Access to energy is perceived to improve the social, economic and wellbeing of a society. However, there exists a challenge in ascertaining the actual benefits of energy initiatives introduced in the community. To a larger extent in the absence of tangible results most initiatives end up as a blessing in disguise to the society. The study sought to examine the effect of energy initiatives on people's socio-economic livelihoods in Homa bay County, Kenya. The specific objectives were to: Identify the energy initiatives in Homa Bay County; assess their socio-economic benefit on wellbeing; and examine the challenges encountered in the adoption and use of the energy initiatives. The study was based on capability theory and diffusion of innovation theory and utilized pragmatism philosophical underpinning. Based on mixed methodology, the study adopted ex post facto research design. The target population was 203,192 and using systematic and cluster sampling techniques, a sample size of 389 was selected for the study. Instruments of data collection were structured questionnaire, interview schedule and observation guide. Data was analyzed both descriptively and inferentially. Descriptive analysis employed frequencies, percentages; inferential statistics involved the use of chi square, while qualitative data was analyzed thematically. The study established two main sources of household cooking technologies; the three stone fire and the Kenya ceramic jiko. Additionally, the main sources of household cooking fuel were biomass, kerosene and LPG. Adoption of solar (126) and electricity (76) enabled homework and assignments to be done at night. Households (235) were also able to access educative programs on TV, radio or use their mobile phones for social activities. Chi square analysis revealed that adoption of kerosene (X^2 (2) = 4.305, $p<0.05$) and charcoal (X^2 (2) = 6.656, $p<0.05$) reduced the problem of chesty cough. Kerosene ($X^2(2)$ = 5.873, $p<0.05$) and charcoal ($X^2(2)$ = 9.101, $p<0.05$) also reduced eye irritation. However, Households reported indoor air pollution evidenced by presence of black carbon (83.4%) and smoke (69.2%) in the kitchen area. The challenges included high cost of fuels and appliances, low income and education level, lack of information and long distance to collection and purchasing points. The study concludes that biomass constitute an important fuel in Homa Bay County. Stoves with chimneys can reduce exposure to smoke and black carbon relative to traditional options. The study recommends awareness creation and promotion of clean and improved cooking solutions including modern fuels such as LPG and electricity; renewable solutions such as biogas, and solar; and advanced biomass gasifier stove technologies with the aim of reducing the cost of stoves and creating added economic incentive to replace old, inefficient cookstove models.

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AGECC	Advisory Group on Energy and Climate Change
ALRI	Acute Lower Respiratory Infections
BMU	Beach Management Units
CBA	Cost Benefit Analysis
CH_4	Methane
CIA	Central Intelligence Agency
CIF	Climate Investment Funds
CO	Carbon monoxide
CO_2	Carbon dioxide
COPD	Chronic Obstructive Pulmonary Disease
CSD-9	Commission on Sustainable Development
CSI	Clean Stove Initiative
DALY	Disability Adjusted Life Year
DANIDA	Danish International Development Agency
EAC-EASUP	EAC Energy Access Scale-Up Programme
ERC	Energy Regulatory Commission
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion

GACC	Alliance for Clean Cookstoves
GHG	Green House Gas
GIZ	Gesellschaft fur Internationale Zusammenarbeit
GoK	Government of Kenya
GTZ	The German Development Agency (GTZ)
GVEP	Global Village Energy Partnership
GW	Giga watts
HAP	Household Air Pollution
HIV/AIDS	Human Immunodeficiency Virus, Acquired Immunodeficiency syndrome
IAP	Indoor Air Pollution
ICS	Improved Cookstove
ICT	Information and communication technologies
IEA	International Energy Agency
IEP	Integrated Energy Plan
IISD	International Institute of Sustainable Development
INGO	International Non-Governmental Organisations
IRADe	Integrated Research and Action for Development
IRENA	International Renewable Energy Agency
KNBS	Kenya National Bureau of Statistics
KWFT	Kenya Women Finance Trust
kWh	kilowatt hours
lm	Lumen

LMIC	Low and Medium Income Countries
LPG	Liquefied Petroleum Gas
MDG	Millennium Development Goals
Mfi	Micro-finance Institution
MJ	Mega Joules
MOA	Ministry of Agriculture
MoE	Ministry of Energy
MSE	Micro/Small-Scale Enterprise
MWh	megawatt hours
NACOSTI	National Commission for Science, Technology and Innovation
NGO	Non-Governmental Organization
PAH	polycyclic aromatic hydrocarbons
PPEO	Poor Peoples Energy Outlook
PM	Particulate matter
PSDA	Private Sector Development in Agriculture
PSL	Photovoltaic solar lamps
RE	Renewable Energy
REC	Rural Electrification
RET	Renewable Energy Technology
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SEI	Stockholm Environment Institute

SEWA	Solar Sisters in Africa
SID	Society for International Development
SREP	Scaling-Up Renewable Energy Program
TOE	Tons of Oil Equivalent
UN	United Nation
UNEP	United Nation Environmental Programme
UNDESA	United Nation Department of Economic and Social Affairs
UNDP	United Nation Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nation Industrial Development Organisation
µg/m3	microgram per cubic meter
WHO	World Health Organisation
WRC	Women's Refugee Commission
WSSD	World Summit on Sustainable Development

OPERATIONAL DEFINITION OF TERMS

Biomass: Any plant matter (which includes wood, timber and pulp production waste, vegetal waste, crop residues) as well as animal waste or dung, used directly as fuel or converted into other forms such as charcoal before combustion

Energy: Energy is taken to include fuels such as petroleum products (kerosene, petrol, diesel) and biomass (firewood, charcoal, agricultural wastes, dung), power (electricity) which can be from a number of sources (fossil fuel based or renewable)

Household: A group of people who eat together regularly and/or who sleep under the same roof together

Improved cookstove: A stove that is more fuel efficient and releases fewer emissions as compared to a traditional "three stone" fire

Inefficiency: Use of cooking devices with high biomass consumption, low per unit energy production and increased emissions of smoke and particulates

Livelihoods: The resources and activities required to make a living, and have a good quality of life

Time poverty: the fact that some individuals do not have enough time for rest and leisure after taking into account the time spent working, whether in the labour market or at home.

CHAPTER ONE

INTRODUCTION

1.1 Overview

Transformation in the energy sector seems to be affecting people's livelihoods in rural areas in different ways. In this chapter, key issues forming the background to this study are critically analyzed. The background of the study, statement of the problem, study objectives and research questions are among the key issues that are articulated with an aim of generating a gap towards this study. In addition, it provides the justification, significance and the scope of the study.

1.2. Background to the Study

Energy provides services to meet many basic human needs, particularly heat, light and motive power (e.g. water pumps and transport). Industry, business, commerce and public services such as modern education, healthcare and communication are highly dependent on access to energy services. Indeed, there is a direct relationship between the absence of adequate energy services and many poverty indicators such as illiteracy, life expectancy, infant mortality and total fertility rate (IEA, 2000). Inadequate access to energy also aggravates rapid urbanization in developing countries, by driving people to seek better living conditions.

Biomass refers to organic materials, either plant or animal, which undergoes the process of combustion or conversion to generate energy. Currently, the largest source of biomass is wood. However, biomass energy may also be generated from agricultural residues, animal and human wastes, charcoal, and other derived fuels.

Biomass may be used either directly or indirectly. Direct use, more often termed as the traditional use of biomass, primarily involves the process of combustion. The energy that is generated is usually utilized for cooking, space heating, and industrial processes. Indirect use or the modern use concerns the more advanced processes of converting biomass into secondary energy. This includes gasification and electricity generation (Blauvelt, 2007).

While 1.3 billion people have no access to electricity, more than double that number, approximately 3 billion people, mainly in South Asia and Sub-Saharan Africa, are still relying on solid fuels for cooking and heating (IEA, 2012; IEA, 2014). Solid fuels in the form of traditional biomass (wood, animal dung, crop residues, and charcoal) are used by nearly 2.6 billion people, while solid fuels in the form of coal are used by about 0.5 billion people, mainly in China and to a lesser extent in India and South Africa. In Ethiopia, DR Congo, Tanzania and Uganda biomass accounts for as much as 93 percent to 95 percent of the total energy consumed. A similar pattern holds true in many countries in the region. 2 million people (mainly women and children) die because of the burning of biomass indoors. About 10 million people, mostly rural poor, have gained access to modern energy services through UNDP supported projects over the past decade (UNDP 2011, UNDESA 2010, IEA 2011, WHO 2011).While the use of traditional energy sources is not necessarily undesirable in itself, concerns have been raised over how they are currently being used.

In developing countries, use of traditional biomass stoves for household cooking require extensive local fuel collection and can create additional pressure on local forests and ecological systems. Even though the collection of fuel wood does not directly cause deforestation because the branches are mainly collected from agricultural lands or roadsides the production of charcoal from fuel wood burning has been proved to aggravate land degradation in sub-Saharan Africa (World Bank, 2011; GACC, 2015).Traditional stoves and open fires are inefficient at converting energy into heat for cooking; the amount of biomass cooking fuel required each year can reach up to 2 tons per family; local environmental problems can result where demand for local biomass outstrips the natural regrowth of resources (Ramanathan and Carmichael 2008; Venkataraman et al. 2010). Also, if fuel wood and charcoal resources are not adequately available, the use of animal dung and agricultural residues for fuel would have to increase, resulting in a reduction of soil fertility and direct competition with animals that rely upon crop residue and the shrubs for fodder (Kaale, 1990). While many local communities can and do manage their biomass supplies sustainably, tremendous amounts of time, a burden shouldered disproportionately by women and children, may be spent collecting and managing these resources (Kammen, 2002; Dutta, 2003; Clancy and Skutsch, 2003).

The consumption of biomass has vast implications both for deterioration of natural resources and the workload of rural women and girls charged with the responsibility of firewood collection. Women and children in Tanzania spend several hours a day collecting fuel wood for household use (IEA, 2006).This causes a dramatic opportunity cost in terms of lost education chances and limiting other possibilities of generating income. The poor combustion technology of traditional stoves has serious negative impact on the health of rural women and small children as cooking traditionally takes place inside houses with very poor ventilation (Yadama, 2013; WHO, 2014, 2016).Research has found that the domestic burning of wood contributes to health impacts such as eye diseases, respiratory infections and low birth weight

(Boy et al. 2002; Reddy et al. 2004; Rumchev et al. 2007; Smith-Sivertsen et al. 2004a, 2004b; Smith 1993; Smith et al. 2000).

Recent estimates have shown that IAP accounts for nearly 2 million deaths annually (WHO and UNDP, 2009; IEA 2010; WHO, 2014). This is more than the deaths from malaria or tuberculosis; it is estimated that by 2030 over 4,000 people will die prematurely each day from household air pollution (IEA, 2010; IEA, 2012; Lim et al., 2012). Low grade biomass and agricultural residues used as cooking fuel increase this exposure and the use of poor-quality kerosene ‘candles’ that generate a lot of soot is widespread in rural areas. Traditional charcoal stoves burning poor quality charcoal cause exposure to high levels of carbon monoxide (CO) (GACC, 2011), nitrogen oxides (NOx) and fine particulate matter such as $PM_{2.5}$ and PM_{10} which refer to particulate matter smaller than 2.5 and 10 micrometers, respectively (SEI, 2009). Particles less than 2.5 micrometers in diameter ($PM_{2.5}$) are referred to as “fine” particles and are believed to lodge deeply into the lungs (www.epa.gov). This is combined with small kitchens often in makeshift huts that offer little ventilation to dispel these toxic fumes.

With regard to wood collection there are reports of incidences of pregnancy complications such as miscarriages (Bryceson & Howe, 1993; Haile, 1989) and post-partum complications (Odimegwu et al., 2005) and degenerative spine changes, prolapsed and herniated discs among firewood carriers (Echarri & Forriol, 2002, 2005). In addition, women frequently experience injuries such as cuts, skin irritations, broken bones, snakebites and infections (Wickramasinghe, 2003) as well as threats of physical and sexual assault including rape (Abebe et al. 2003; Haile 1989, MSF 2005; Wickramasinghe 2003).

There is growing evidence that biomass burned inefficiently contributes to climate change at regional and global levels, suggesting that the climate change debate needs to take household energy issues into consideration. About 730 million tons of biomass are burned each year in developing countries amounting to more than 1 billion tons of carbon dioxide (CO_2) emitted into the atmosphere (Smith et al., 2009; Venkataraman et al. 2010). It is also estimated that cooking with traditional biomass accounts for 18% of current global GHG emissions (Bond, 2007). Unlike oil fuels, biomass not only emits typical greenhouse gases, but also produces black carbon remains. Black carbon remains typically lasts in the atmosphere for only a few weeks, thus reducing black carbon by controlling the use of biomass energy has the potential to diminish the warming effect on the atmosphere relatively quickly (Ramanathan and Carmichael 2008; Gustafsson, 2009; Bond et al., 2013). With better fuels and more efficient cookstoves, such emissions could be reduced. Under conditions of sustainable production and more efficient fuel use, biomass energy is renewable. However, in many regions, little attention is paid to this issue, and scant research is undertaken to assess whether biomass energy is being produced and burned in a sustainable way.

Several studies have shown that more than half of the world's population and more than 70 percent of the world's poor are found in rural areas and that access to modern energy initiatives have a substantial positive impact on rural growth and livelihoods (World Bank, 2004; Pachauri et al., 2012). The term livelihood is well recognized as humans inherently develop and implement strategies to ensure their survival. The hidden complexity behind the term comes to light when governments, civil society, and external organizations attempt to assist people whose means of making a living is threatened, damaged or destroyed. Livelihood activities according to Ellis (2000) are the activities, assets and access that jointly determine the living gained by the rural households. Carney (1998) explains that it is sustainable when it has the capacity to meet the immediate needs of the people while its ability to meet future needs is not jeopardized. A livelihood can be precisely said to comprise the capabilities, assets and activities required for a means of living and is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resources.

The sustainable development goals (SDGs) proposed by the Open Working Group of the General Assembly of the United Nations recognize the importance of the natural environment and its resources to human well-being. SDG 7—to "ensure access to affordable, reliable, sustainable and modern energy for all"—targets by 2030: to ensure universal access to affordable, reliable and modern energy services; increase substantially the share of renewable energy in the global energy mix; double the global rate of improvement in energy efficiency; enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology and to expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support. However, SDG7 is a challenge confronting every country and touches everyone. It is important that we unpack the statement of this goal in order to understand the necessity of meeting this goal and what it requires to do so (UN Chronicle, 2015).

The energy sector has a significant and productive role to play in achieving the goals related to income and poverty, education, health, and gender issues. In terms of economic development, it provides the basis for improving productivity by facilitating income generating activities and improving the business climate. In terms of human development, the energy sector can assist in reducing child mortality, maternal mortality, and other diseases by facilitating better health services. Furthermore, energy can encourage the development of higher literacy rates, gender equality, and women's empowerment. It is not surprising that a number of statistics show a very strong association between increasing commercial energy consumption and human welfare (Cabraal et al., 2005).

The issue of energy poverty merited only a brief mention when the Millennium Development Goals (MDGs) were conceived in September 2000. Less than a decade later, it has gained its due importance and today is one of the most important issues in the international agenda, alongside climate change and the environment. Whereas there is no (MDG) specifically related to energy, the Millennium Project emphasizes the central role of energy services for development and it is clear that energy access is fundamental for achieving the MDGs (Havet, 2003). The UN Millennium Project commissioned in 2002 to develop concrete action plan for the world to achieve MDGs, called for adoption of the following target in preparation for achieving the MDGs: By 2015, enable the use of modern fuels for 50 percent of those who at present use traditional biomass for cooking. In addition, support (a) efforts to develop and adopt the use of improved cook stoves, (b) measures to reduce the adverse health impacts from cooking with biomass, and (c) measures to increase sustainable biomass production (UNDP, 2005, 2006).Meeting such targets poses a considerable challenge given the current trends in traditional biomass use in developing countries. However, the issue is urgent given the serious health and environmental impacts of high reliance on traditional biomass.

It is recognized that the energy system should help achieve the goals laid down at the 1992 United Nation Conference on Environment and Development (also called The Earth Summit) in Rio de Janeiro, and in other UN contexts. The Earth Summit led to greater awareness that development needs to be sustainable if it is to serve humanity's short- and long-term goals. More than 150 governments committed themselves to the protection of the environment through the Rio Declaration and Agenda 21. Government representatives considered that key commitments related to energy would be covered under the United Nations Framework Convention on Climate Change (UNFCCC), which was signed on this occasion (UN, 1993b).

Key energy issues were discussed in 2001 at the ninth session of the Commission on Sustainable Development (CSD-9). In 2002, at the World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa (UN, 2002), the international community reaffirmed that access to energy is important to the Millennium Development Goal of halving, by 2015, the proportion of people living in poverty (UN, 2000). The WSSD agreed to facilitate access for the poor to reliable and affordable energy services in the context of broader national policies to foster sustainable development. The summit also called for changes in unsustainable patterns of energy production and use.

The United Nations system has responded to the challenges and opportunities in the energy system with numerous programmes and projects. The Secretary-General established the Advisory Group on Energy and Climate Change (AGECC) in June 2009 to advise him on the energy-related dimensions of the climate change negotiations. AGECC is a prime example of a multi-stakeholder partnership bringing together the UN system, including the World Bank, with the private sector and research institutions. Its work has benefited from a unique mix of policy orientation, technical expertise and business experience of leading figures in the field of energy (AGECC, 2010).

The United Nation, in recognizing the importance of access to modern affordable energy services in developing countries, launched the Sustainable Energy for All (SE4ALL) initiative with three objectives: i) ensuring universal access to modern energy services, ii) doubling the global rate of improvement in energy efficiency and iii) doubling the share of renewable energy in the global energy mix by 2030 (UN, 2013). This initiative has also attracted world-wide attention on issues related to clean cooking fuels. Also initiated is a separate global alliance, known as Global Alliance for Clean Cookstoves (GACC), under a global partnership of public and private sectors to foster the adoption of clean cookstoves and fuels in 100 million households by 2020 (GACC, 2011). A number of regional clean cooking initiatives have recently been launched by the World Bank such as the Africa Clean Cooking Energy Solutions to promote enterprise-based, large-scale dissemination and adoption of clean cooking solutions and the East Asia and Pacific region’s Clean Stove Initiative (CSI) to scale up access to advanced cooking stoves for rural poor households through country-specific technical assistance and a regional knowledge-sharing and cooperation forum.

Besides these global initiatives, there are several initiatives to promote clean cooking. For example, in India, the government launched National Biomass Cookstoves Program in 2009 to provide 160 million ICS to households currently using solid fuels

(Venkataraman et al., 2010). In Paris in November/December 2015, at COP 21 Conference with 195 countries attending, including heavy representation from Kenya, the world concluded talks that would launch the SDGs for the next 15 years. Of the 17 SDGs none is perhaps as critical as SDG number 7 that targets to ensure access to affordable, reliable, sustainable and modern energy for all with a particular emphasis to "increase substantially the share of renewable energy in the global energy mix by 2030". A long side this is the stated goal to double the global rate of improvement in energy efficiency. We need to remember that Kenya is a signatory to the Kyoto Protocal, the agreement that underpins global action to avert climate change.

Millions of ICS have been successfully and sustainably disseminated in Asia, Latin America and the Caribbean, and Africa. Most of the international ICS programs were launched to conserve firewood or reduce the financial burden of households from fuel purchase for cooking and heating. Some programs also had the specific objective to reduce indoor air pollution (ESMAP, 2010). In China, the first phase of the National Improved Stove Program started with the objective of rapid dissemination of stoves in 860 counties through subsidies to households, counties, and technical institutions to meet energy shortages in rural areas by doubling stove efficiency. The program focused on commercialization of stoves by reducing subsidies, giving tax and loan benefits to rural energy companies, undertaking training, and offering administrative support in the second phase. The third phase centered on quality control by certification and standardization (IEA, 2010).

In Mongolia, the project of the Energy Sector Management Assistance Program (ESMAP), which was launched at the request of the Mongolian government, aimed to introduce improved G2 stoves to the ger (The ger districts of Ulaanbaatar are the poor peri-urban settlements that have sprung up on the edge of the city) population, which would reduce indoor air pollution and the amount of coal consumed by households for heating and cooking purposes. The project aimed at improving the stoves and developing retrofit kits, conducting comprehensive surveys of households and stove producers, and testing dissemination strategies, including a program for the private sector and relevant stakeholders to disseminate the retrofit kits (Cowlin, et al., 2005; ESMAP, 2010).

In Nepal, the National ICS Program started in 2000 as an activity of the Alternative Energy Promotion Center and ESMAP, supported by the Danish International Development Agency (DANIDA). The objective of the program was to install 50,000 ICS in households in the mid hills as a way to reduce firewood consumption. The objective of the second phase which started in 2007 as a biomass energy component was to install 434,000 improved stoves in the mid hills and Terai, disseminate 10,000 household gasifiers and 1,000 institutional gasifiers, demonstrate 5,000 institutional ICS, and install 50,000 metal ICS in the high hills (ESMAP, 2010). In Uganda, the ICS component under the Energy Advisory Project identified areas with extreme wood scarcity. Rocket Lorena cookstoves were first promoted as a pilot activity then later scaled up. The aim of the second phase of the Energy Advisory Project (2005–2008) was to install 300,000 ICS and in fact successfully installed around 500,000 stoves during this period (ESMAP, 2010; GVEP, 2013).

Biomass energy provides 68% of Kenya’s national energy requirements and it is projected to remain the main source of energy for the foreseeable future (Mugo and Gathui, 2010). Only 6% of Kenya's land is forest with large areas of these forest resources not being accessible due to legal or environmental restrictions, management issues, ownership, distances or infrastructure (GoK 2014). Kenyan’s fuelwood demand is 35 million tons per year while its supply is 15 million tons per year, representing a deficit of 20 million tons (GTZ 2007). The massive deficit in fuelwood supply has led to high rates of deforestation in both exotic and indigenous vegetation resulting to adverse environmental effects such as desertification, droughts, land degradation and famine among others.

Private Sector Development in Agriculture (PSDA)through collaboration with other Development Partners initiated Promotion of improved cook stoves in January 2006 in an effort to reduce these problems. Nevertheless, a high population share still uses firewood for cooking; more than 80% of the population use traditional three stones technology for the same. According to KNBS, (2019) the number of households consuming charcoal in Kenya is 55.1% while 11.6% consume charcoal. The distribution of households of households by firewood consumption is 84.1% rural and 9.2% urban. The households consuming charcoal are 7.7% in rural and 17.7% in urban. Consumption of LPG has increased to 52.9% in urban and 5.6% in rural households.

Kenya’s energy policy was formulated in 2004, but recently high oil prices and need for energy security have become more urgent drivers for alternative energy. This may necessitate re-assessment and update of the policy and strategy. For Kenya, high oil prices and the need to increase overall energy per capita supply are strong motivators for development of alternative forms of energy. Transportation fuels remain the most emotive of all energy segments, especially when prices are going up, as this is where lifestyles and livelihoods are visibly impacted. Alternative energy is not only focusing on economics alone, but also looks at security of supply and other social economic benefits to the country. There are technologies in the country that can reduce the consumption of biomass energy by almost 80%. They include the Kenya Ceramic Jiko (KCJ) which can save up to 50%, the improved wood stove that can also save 50% energy, fireless cookers that can save up to 50% and the improved charcoal kilns which can save up to 60% energy when compared to the traditional technologies. Investment in the development and promotion of other biomass technologies like biogas and woody crop residues should be considered.

Kenya, with more than 30 years' experience in cookstove activities and one of the largest ICS programmes in Africa, is at the forefront of cookstove development, marketing and distribution in the region (Winrock International, 2011). However, most Kenyans still do not have access to improved stoves (GoK, 2011). As in many developing countries, Kenya has experienced limited coordination among government agencies working on cookstoves. Until recently, the main actors involved in the development of and dissemination of stoves were international development agencies (most notably GIZ, Practical Action, and the Global Village Energy Partnership (GVEP) and local NGOs), which supported local artisans to develop and disseminate ICS.

The Kenyan Ceramic Jiko was designed in mid 1980s through collaboration between donors and local artisans. In 1990, efforts to promote firewood stoves accelerated, driven largely by GIZ, partnership with the Ministry of Agriculture and Practical Action, in conjunction with Ministry of Energy. In 2005, GIZ launched the Energizing Development Program which carries out activities in more than 20 counties with the aim of increasing access to modern energy for households, social institutions and small and medium sized enterprises. By the end of 2012, some 1.4

million stoves had been commercially disseminated around Kenya, serving 7 million people (GIZ, 2012). However, the situation in Homabay County is still wanting. About 6.2% of residents in Homa Bay County use liquefied petroleum gas (LPG), and 1.4% use paraffin, while 74.3% use firewood, 0.3% use solar and 17.0% use charcoal (KNBS, 2019).

Though these developments are promising, the road to larger-scale transformation of livelihoods is not without challenges. Scaling up will require strong and sustained support in a number of areas. These are: promoting sustainable biomass harvesting through innovative and efficient exploitation and utilisation technologies while at the same time providing policy triggers to shift rural energy consumption to cleaner fuels like liquefied petroleum gas (LPG) and kerosene; national institutions promoting ICS; financing institutions that can administer energy funds to support ICS; development of performance standards and benchmarks on safety, (energy) efficiency, emissions, and durability; technical research and development; monitoring and evaluation (M&E) mechanisms; intelligent financing mechanisms that can target subsidies and grants; awareness raising, business development, and consumer research; adapting cookstoves and programs to country contexts; and taking account of consumer preferences and behavior.

The provision of clean and affordable household energy should be an integral part of scaling up energy access for the pro-poor. The social and economic consequences of reducing the hours women spend collecting biomass fuel, improving their health, and freeing up their time for more beneficial activities might well result in raising the living standards of an entire generation of children and households. At the global and regional levels, ICS could contribute to a reduction in greenhouse gases and other climate forcers attributed to biomass burning. Consequently, the study examined effect of energy initiatives on socio-economic livelihood of rural households in Homa Bay County. The research identified the various sources of energy in two sub-counties of Homa Bay County and their benefit to rural households. It also assessed the challenges encountered in the adoption and use of the energy initiatives and the possible strategies for enhancing their applicability.

1.3. Statement of the Problem

The main emphasis of many stove programmes in the 1970s was to address the supposed problem of fuel shortage in rural areas resulting from extensive deforestation (Eckholm, 1975). Assessment of biomass available at national and regional level approximates that demand for firewood will be higher than long term supply. This perceived gap in firewood prompted efforts to both decrease demand for firewood and step up its supply thereby resulting in a wave of high efficiency cookstove projects. Several nations implemented community-based programs aimed at reforestation, joint management of forest resources and agroforestry (Schreekenberg et al., 2006; Ravindranath et al., 2011). The chief aim of the stove projects was to minimize use of fuelwood and at the same time reduce emission of particulate matter (Kshirsagar and Kalamkar, 2014). These efforts realized different result with performance and adoption of high efficiency cookstoves falling below published potential. However, critiques suggested the need to examine real-world conditions and practical measures of consumption through field tests in households. Approximations of availability and use of biomass have also been limited (Kajisa et al., 2009; Jain et al., 2014).

Bearer et al., alludes that the disparity between regional evaluation and activities at household level may lead to underestimation of ecosystem responses. Furthermore, regional and local variations call for studies across scales. A study by Bailis et al., (undated) examined the proportion of fuelwood use relative to annual productivity; the results revealed extensive variation in the sustainability of fuelwood use across India and in particular between nations. Hence, attention has shifted from resource availability to ecological impacts such as deforestation. The consequence is a shift in methodology with preferences given to mix method approaches to understanding household dynamics.

Promotion of adoption of ICS was done by several governments and international development agencies with the goal of reducing environmental and health impact linked to traditional use of solid biomass. The design was meant to promote efficient use of biomass as well as reduce IAP and emission of black carbon (Bardouille, 2012; Venkataraman, 2010). In spite of the many intervention programs, the anticipated significant uptake and sustained use necessary to effectively address environmental and health problems have not been achieved (SEI, 2015).

While environmental and health benefits of nontraditional stoves is supported by massive body of literature, there is scanty literature on factors affecting demand for nontraditional cookstoves (ESMAP, 2010). Very few studies address the drivers of clean cookstove adoption mostly by applying qualitative approaches and non-experimental evidence. Since major international efforts have been launched to disseminate cleaner cookstoves (GACC, 2015), there is an urgent need for research on the demand for new varieties of cookstoves and effective delivery plans (Smith, 2010).

At the start of the cookstove adoption programmes, it was thought that cookstoves would be automatically adopted on large scale. Yet technological efficiency alone proved to be an inadequate driver for adoption (Barnes et al., 1994; Sesan, 2014; Tafadzwa & Bradnum, 2017). Shankar et al., (2014) warns that purchase of ICS should not be treated as synonymous with adoption but rather an initial step towards adoption. Mitigation of energy poverty demands that people transit to clean and modern energy. Traditional energy ladder theory posits that households switch from solid biomass and agricultural residues to modern fuels (electricity and LPG) with increase in income. The theory assumes that traditional cookstoves and fuels would be substituted automatically once households adopt modern fuels and technologies. However, empirical evidence suggests that household energy transition is complicated and that stacking is more common in many occasions than direct switching (Masera, et al., 2000; Hiemstra-van der Horst & Hovorka, 2008, Van Der Kroon et al., 2015). Many households who use traditional fires rely on traditional cookstoves for end uses associated with both cooking and non-cooking including space and water heating. However, ICS are designed in such a way that they do not allow for the heating of large volumes of water. They also don't sufficiently accommodate space heating (Ruiz-Mercado & Masera, 2015). Traditional stoves unlike ICS, are embedded in cultural rituals and customs often serving varied social functions (Ruiz-Mercado & Masera, 2015).Shanker et al., (2014) adds that very few studies have been done to determine suitability of stoves for particular cooking tasks. The outcome of such studies would help design cookstove that are not only fit for the purpose but also suitable for end-user cooking preferences.

(Ruiz-Mercado & Masera, 2015) argue that, even though the prevalence of stove and fuel stacking has been approved, the rationale for stacking has not been thoroughly examined. Moreover, it is assumed that improving energy security is a strong driver of household's fuel and stoves stacking (Pachauri & Spreng, 2012; Ruiz-Mercado & Masera, 2015). They also allude that greater flexibility about fuel choices is achieved through fuel stacking, allowing households to be more resilient and less vulnerable to variables such as unreliable energy services, fluctuating fuel prices and changes in the availability of fuels.

Clean cookstoves and fuels have received increased attention in the past years through an agenda put forward by Global Alliance for Clean Cookstoves to disseminate clean cookstoves. GACC also made efforts to understand the difficulties related to adoption and sustained use of clean fuels and cookstoves (Debbi et al., 2014; Rehfuess et al., 2014; Ruiz-Mercado & Masera, 2015). The conclusion drawn from these studies was that realizing the goal of sustained adoption of ICS is an intricate process which requires that a range of factors be deliberated on at national, regional, community and household levels. Factors which influence adoption at household level include socioeconomic (cost, availability, access, income, seasonality, education, awareness and family size), cultural (lifestyle, taste preference, food choices), behavioural and external factors (regulatory environment and policy) (Malla & Timilsina, 2014; Rehfuess et al., 2014). A reflection on this led Debbi et al., 2014 to recommend qualitative evaluation of effectiveness, alongside qualitative studies to assess factors affecting uptake with emphasis on equity to enable future ICS programmes to draw lessons from previous interventions and build on existing studies. This study responds to this call and reports on a quantitative and qualitative study assessing the effect of energy initiative on socio-economic livelihood of households in Homa Bay County.

1.4. Research Questions

The study was guided by the following questions:

i. What are the sources of household energy in Homabay County?

ii. What effect do the energy initiatives have on people's social-economic livelihoods in Homabay County?

iii. What challenges are encountered in the adoption and use of the energy initiatives in Homabay County?

iv. What intervention strategies can be put in place to enhance the adoption and efficient use of the energy initiatives in Homabay County?

1.5. Study Objectives

The main objective of this study was to examine the effect of energy initiatives on people's socio-economic livelihoods in Homabay County.

1.5.1 Specific Objectives

i. To assess the sources of household energy in Homabay County.

ii. To assess the effect of the energy initiatives on people's social-economic livelihoods in Homabay County.

iii. To examine the challenges encountered in the adoption and use of the energy initiatives in Homabay County.

iv. To examine appropriate intervention strategies for enhancing adoption and efficient use of the energy initiatives in Homabay County.

1.6. Justification of the Study

In Kenya, biomass is the largest form of primary energy in use (KNBS, 2019). However, inefficient firewood production and consumption technologies and practices are still prevalent leading to massive wastefulness. Besides, the penetration and use of improved efficient kilns and stoves is also low and unsatisfactory. Even though it is known that more efficient and clean cooking solutions help families save money prevent deforestation and protect the climate, and in spite of its significance for development, the topic of cooking energy has continuously been sidelined. It is important to address this topic with the aim of changing the view point of many energy actors in donor and development organizations, developing countries and the private sector.

While cooking energy interventions in 1980s were government driven strategies based on financial support, these have recently turned into successful market-based approaches. These approaches are important for the sustainable introduction of clean cookstoves. The almost 3 billion people who still lack access to clean, accessible and affordable energy solutions present a viable market of individuals and households who need support from governments and international development cooperation.

Some of the key challenges facing the sector include lack of product standards, access to finance for both manufacturers and consumers, infrastructure and poor distribution channels for fuels and stoves and lack of awareness within the society. While there is huge potential for LPG in Kenya, more so in rural areas, the industry is facing the challenge of transporting the fuel to remote areas, dispelling fear of explosion and other biases against LPG. Development practitioners can address these challenges through support for the development of cleaner fuels and cookstoves, market information research, development and implementation of clean cookstove standards. Mobilizing investor and donor resources, research into benefits and impacts of cookstove issues and advocacy and raising awareness for moving to clean cookstoves and fuels (Practical Action, 2013). This study examined the challenges encountered in the adoption and use of the energy initiatives and options for more efficient use that will support human socio-economic development in Homa bay County, Kenya.

1.7. Significance of the Study

This study is significant to various stakeholders with the main ones being those in development programs, RE, rural households as well as policy makers. The study helps development practitioners to come up with sustainable livelihood programs that will not only aim at transforming people's lives but also take on board the concerns of both male and female members of the society and incorporates them in their programmes as a means of transforming people's lives. For those dealing with RE, the study provides a basis for understanding how energy initiatives affect men and women and be able to come up with energy programmes that addresses the energy concerns of both. It also helps them to come up with programmes that reduce energy scarcity in rural areas as well as look at how use of biomass can continue sustainably and efficiently. Policy makers can use the findings of this study to come up with RE policies that are relevant, non-conflicting and those that could see a transformation of the lives to improve livelihoods.

Moreover, findings of this thesis could enable Kenya to harmonize its energy policies and regulations at both the national and regional levels, as well as formulate its up-scaled energy investment program aligned to EAC-EASUP. Kenya could start laying the requisite energy sector capacity foundation for both the private and public sectors and to build coordination and programme management frameworks, including relevant data, information and knowledge sharing and networking systems. All these are critical ingredients to success of the regional scaling-up strategy for access to modern energy initiatives in order to fulfill the MDGs.

The information obtained could be used to enhance current efforts of improved cookstove adoption and determine where additional resources should be applied in order to have the greatest impact on the cookstove market. It could provide insight on how capacity building to create the platform scaled up delivery of energy services to the poor can be done through training and organizing the supply chains; targeted market awareness campaigns; needs assessments; capacity building of institutions; training service providers, mainly off-grid and training of community groups.

Furthermore, at national level, the findings help the government to undertake the following interventions; i) Mainstreaming energy access into national development planning and budgeting, ii) Developing pro-poor and gender-responsive energy policies, iii) Strengthening national capacity to deliver energy services for the poor, and iv) Targeting investment in proven systems and develop new 'business models' to scale up energy access. It was also necessary to do this research since there has been little research of this type done in Kenya where both social and economic issues are studied together extensively, and where gender issues are also incorporated in the study. This thesis strengthens Kenya's research and development work in this area.

1.8. Scope of the Study

The study was carried out in Homabay County from which two sub-counties were sampled. Two locations were chosen from each sub-county to form the area of study. As regards content scope the study was limited to effect of energy initiatives on people's socio-economic livelihoods. It was defined within the following bounds. The study focused on residential cooking needs of households rather than those of institutions or small businesses; the full spectrum of ICS which includes all stoves that improve on the traditional open fire and an analysis of the use of other cooking solutions including kerosene and LPG and solar energy.

1.9 Delimitation of the Study

1. The scope of the study may not have allowed the investigation of the entire spectrum of effect of energy initiatives on people's socio-economic livelihoods. For instance, the study did not investigate effect on businesses and public buildings that are crucial to economic and social development, i.e schools and hospitals. Focus on different tiers of ICS had the potential of increasing errors and variations in data reporting from households. In order to narrow down the focus of the research the study only investigated effect of energy initiative at household level.

2. Trust is a major issue in Homa Bay County in particular in relation to demographic data. There was wide spread fear among residents that their personal details may be used to recruit them into secret societies or to solicit for funds from funding organizations. Respondents were assured of confidentiality of records where identities and records of individuals remain confidential and

   not identifiable even in publishing or disseminating results

3. The other limitation would be the generalization of the findings. This is because it is well documented that socio-cultural and belief systems of different communities are known to influence cooking practices. Therefore the

communities studied are different from other communities that were not studied. The findings are likely to apply to Homa Bay County than to other Kenyan communities not residing in the study area. This was resolved by using probability sampling to generate a representative sample. Probability sampling basically eliminates bias from the selection of a sample by using a process of random selection.

4. Another major limitation of the field research reflects the time constraints of participants in Suba North since the local men and women were always occupied with activities at the lake. It was hard to catch up with their time and I had to be very flexible to be accommodated according to their convenience.

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview

The aim of this study as discussed in the previous chapter is to explore the issues surrounding energy initiative on people's socio-economic livelihoods. This chapter reviewed the relevant literature as it related to the research study. The chapter is organized into the following sections: energy and development, common energy services in the community, household cooking fuels and technology, energy initiatives on people's socio-economic livelihoods, challenges facing the use of energy initiatives and the interventions for enhancing the use of energy initiatives.

2.2. Energy and Development

Scholars have debated for decades on the subject of relationship between "energy" (defined as "the ability to transform a system" (Smil, 2008a)) and "development" (also defined as a "process of material improvement" or "improvements in well-being, living standards, and opportunities" (Edelman and Haugerud, 2007)). Some scholars trace the link between energy and development back to some 5000 years ago (Carbonnier, 2011). Some of these scholars, belonging to the development school of thought, tried to establish the link between energy and economic development and human wellbeing by analyzing the relationship between the exploitation of the various sources of energy and the economic development. They concluded that human history could be divided into periods based on the kind of energy used (Wilk, 2002).

They argued that the establishment of modern societies began when humankind started employing their own energy (human energy/muscles) for their own development. As time advanced humankind began to domesticate fire, animals and plants and harnessed their energy for development. Humankind also harnessed water, wind, solar energy and developed steam engine and nuclear fission after several thousands of years for the benefit of humankind. Discoveries and inventions that tapped larger sources of energy were noted by Netting (1993) to be the prime engines of change providing not only more material goods but a higher standard of living. This line of thought presents humankind employing two strategies in their quest to develop. First, they harnessed powerful forces of nature, brought them under their control, and made them to work for them. Second, they harnessed energy using new technologies and also by improving the efficiency of old ones (Wilk, 2002). Some scholars of development school of thought believe that the differences and diversities in societies across the globe can be attributed to the use of technology for exploitation and utilisation of energy for development (Carbonnier, 2011).

Some other scholars, belonging to the development economics school of thought, tried to ascertain the link between energy and stages of a country's development by analysing the relationship between the exploitation of the various sources of energy and the development that is associated with it. Schurr (1984) and Toman and Jemelkova (2003) who are members of this school have made efforts to advance the concept of energy and development arguing that energy development (referred to as increased availability of energy in quantity and quality) is central to the theory of economic development. In their theory of energy and development Toman and Jemelkova (2003) assert that an increase in availability of energy is a key stimulus of economic development at every stage of the development ladder. They point out that, at the lowest level of economic development, energy sources tend to come from biological sources (wood, dung, sunlight for drying). Economic activities carried out by humans also tend to be humanly powered. At this level energy remains abundant and cheap in terms of cost. At the intermediate stage of economic development, the sources of energy tend to come from processed biofuels; charcoal, biogas, animal power, and some commercial energy. Energy production begins to undergo stages of development aided by technology which helps to deliver energy in the form desired by industry. At the more advanced stage of economic industrialization and development commercial fossil energy in the form of gas, coal, oil, nuclear and ultimately electricity become the predominant source of energy.

Development theoretical strand argue that energy is central to human society and therefore lack of it is seen as a problem that has to be overcome for a country and its people to make progress. It is alluded that all things being equal, development or societal transformation is impossible to take place or will face uphill task if there is little or no access to energy (Omorogbe, 2011). Empirically, the origin of the industrial revolution in the 19^{th}century unquestionably sealed the relationship between energy and development (Carbonnier, 2011). A closer look at what Grinevald (2007) has called “thermo-industrial revolution” the developmentalists argue from socio-epistemological and anthropological standpoint that the industrial revolution would not have occurred without the twin pillars of energy and technology (Carbonnier, 2011). They argue that the development of the steam engine powered by coal or wood mounted on wheels and metal rails, marked the turning point in human progress especially in Western Europe and North America. Moreover, the steam engine revolutionised land and sea transport, compressed space–time just as air travel has reduced space–time in the 21st Century and eventually opened up Africa, Asia, and North and South America for colonisation (Carbonnier, 2011). In the early part of the 20th century, the processing of crude oil on an industrial scale and the development of engines that could run on refined oil added new momentum to the human experience. The development of complex technologies combined with oil, gas after the Second World War, has further deepened transformation of societies and brought the entire human race into one global village.

Critiques of the energy and development concepts have questioned the role of energy in national development. For example, global energy market is highly dominated by the rich consuming nations like U.S, Japan, Canada, and the E.U. Due to the size of their economies, its dependence on oil and gas and the need to ensure energy and economic security, the global energy market is influenced greatly by the actions and behaviour of the big energy consumers sometimes to the detriment of the poor countries. For example, WHO (2005) notes that 10 per cent of the world's richest population receives 54 per cent of global income. This wealth enables them to build strategic oil and gas stocks and reserves that can last for about 114 days and therefore shields them from any negative impact as a result of price increases. The poorer consuming countries cannot afford such strategic stocks and reserves and therefore seriously bear the consequences of any price hikes. Furthermore, speculative activities of oil and gas traders from the rich consuming countries (London and New York) and intense competition between them for energy resources always make prices volatile putting off gear planned budgets of the poor countries. The poor consuming countries cannot fairly compete with the rich countries in paying for energy. Some countries in the global south spend huge chunk of GDP on oil and gas imports, a problem that has led to trade imbalances and huge debts. The debts and trade imbalances have often resulted in small quantity of oil and gas being imported for energy generation. This further creates economic problems for the poor countries. Thus, the existence of a world energy market dominated by few rich countries and their multinationals unfairly limits the capacity of the poor consuming countries to meet energy needs of their people. This partly accounts for the huge energy poverty in such countries

The role of technology in eliminating fuel poverty has been acknowledged worldwide (Toman and Jemelkova, 2003). However, like oil and gas, most of the technologies in the energy sector are developed and the market controlled by countries in the global north particularly the U.S., E.U., Canada, Japan, and recently China. For example, the development and production of wind and solar technologies, that could potentially help to reduce energy poverty in the global south, is dominated by major companies in the global north. These companies hide behind patent rights to demand higher prices and make the dissemination of the technologies to poor but needy countries impossible. Similarly, most of the world's major oil and gas companies are based in the global north. They include the giants like Shell, British Petroleum, Chevron, ExxonMobil, Total, and Statoil among others. They use their immense financial, information and technological superiority to lobby their governments and the World Trade Organisation to support global energy policies that work to their advantage but which unfairly make it difficult for energy companies in the global south to operate. They for example dominate energy exploration, development, extraction, distribution and marketing not only in the global north which is their traditional domain but also in the global south.

At the same time the existence of fuel subsidies in rich consuming countries and the removal of such subsidies in the poor countries, at the insistence of the World Bank and the International Monetary Fund (IMF), increase fuel prices in poor consuming countries. This makes fuel a luxury for the few rich and explains why large populations in countries of the global south do not have access to fuel for lighting and cooking. Given the little access the people have with regards to fuel, biomass has become the main source of energy for many households leading to over exploitation. WHO (2014) indicate that the over exploitation of firewood and charcoal and the endemic poverty levels has led to scarcity of wood resources which has in turn led to agriculture residues being used as alternative to charcoal and other commercial fuels.

2.3 Energy Consumption Trends

2.3.1 Global Energy Situation

One common characteristic of developing countries is very limited access to modern, cleaner and affordable energy options. Moreover, the majority of developing countries are characterized by inequitable access to cleaner energy options, where the rural poor suffer similar deprivations. Overall, there are 1.4 billion people worldwide (1.2 billion in rural areas) who do not have access to electricity (IEA, 2010b). Of those who have access, several million more lack affordable and reliable supply of electricity. In addition, over 3 billion people cook and heat their homes with solid fuels in low-efficiency stoves (UNDP and WHO, 2009; IEA, 2010b). The United States consumed over 4 billion megawatt hours (MWh) of electricity in 2013. The leading source of electricity generation was coal, with 91% of the domestic production comprising 39% of U.S. demand (EIA, 2014a).

The second leading source was natural gas, providing 28% of electricity needs to the residential and commercial sectors (EIA, 2014b). New technologies, like hydraulic fracturing, allowed the U.S. to produce 93% of the gas it consumed in 2012 (Chen et al., 2014; EIA, 2014a). The remaining 35% of electricity generation was split between nuclear power and renewable energy sources. In 2013, domestic nuclear power generated 22% of the nation’s electricity (EIA, 2014i). Renewable energy provided

13% of electricity demand, consisting of 53% hydropower, 32% wind, 12% biomass, 3% geothermal and 2% solar (EIA, 2014b). The United States' challenge is to improve energy efficiency and reduce fossil fuel combustion for electricity generation.

The EIA, (2012) a quantitative study that projects long-term annual trends in energy supply, demand, and prices to the year 2040, had the following projections for the United States' electricity demand. Renewable technologies are expected to grow 67%, comprising only 16% of national electricity generation in 2040. However, further research shows renewable capacity has been growing consistently since 2005 (EIA 2015). A linear trend suggests that the 2040 market share is 20.5%, however, exponential growth may occur in a favorable legislative and economic climate. Natural gas is anticipated to surpass coal to become the largest share of electricity generation at 35% due to ample reserves, low-cost extraction methods and low natural gas prices. However, fluctuations in natural gas prices may shift focus to other energy sources. Natural gas is also projected to compensate for the retirement of 19% of the coal-fired electricity generating capacity of 2012. 50 GW out of 310 GW of coal-fired capacity is planned to be decommissioned by 2020 (EIA, 2014i).

China secured electricity access for almost 700 million people in two decades, enabling it to achieve an electrification rate of more than 98% in2000.From 1985 to 2000, electricity generation in China increased by nearly 1,000 TWh, 84% of it coal-fired, most of the rest hydroelectric. China's transformation and distribution networks still need very large investment to meet modern standards. Electricity services are unreliable and of poor quality. Wiring and meters in homes and offices are undependable, even unsafe. Usage is low, especially in rural areas, where consumers tend to restrict their electricity use to lighting their homes. Coal dominates current energy consumption in China, accounting for 66.0% of the total energy consumed in 2013 (National Bureau of Statistics of China, 2013). China is the world's largest coal producer, with Chinese coal production, as proportion of global output, growing from 16.2% in 1981 to nearly 50% in 2013 (BP, 2014); however, growth in consumption since 2003, when China was a major world coal exporter (second only to Australia), has meant that since 2009, China has become a net coal importer.

Oil accounted for only 17.8% of China's total energy consumption in 2013, far lower levels than those of the OECD countries, lower even than the world average. However, China's oil consumption in absolute terms is the second largest in the world with the degree of dependence on foreign oil reaching 58% in 2013. The largest oil fields in China (Daqing and Shengli) have already reached their peak production (Tang et al., 2010; Höök et al., 2010) leaving only limited possibilities for increased domestic oil production. Natural gas makes up only a few percent of China's energy system, even though gas demand is growing rapidly (Li et al., 2011; Lin et al., 2012), and studies indicate that China's domestic gas resources cannot be developed rapidly enough to match this surge in demand (Lin et al., 2012). This will lead China into future reliance on gas imports and competition with the EU and other international actors for available exports.

Energy production and consumption have become one of the main reasons for environmental deterioration in China. In recent years, serious haze has become the dominant environmental issue for not only the government, but also the Chinese public (Li and Zang, 2014). Most air pollution in China results from coal combustion, which is the source of 90% of SO_2 emissions, 70% of dust emissions and 67% of NOx *emissions (Chen and Xu, 2010). A coal-dominated energy structure is the major reason for this atmospheric pollution (Boden et al., 2013). Anthropogenic global warming is perhaps the most important global issue of the 21st century (IPCC, 2007), and nearly 72.5% of China's total CO_2 emissions were from coal in 2010 (Boden et al., 2013). Coal will continue to dominate China's energy consumption and production system in the foreseeable future, challenging the government in its pursuit of a greenhouse gas abatement policy in the short-to-medium term (Bloch et al, 2012). On the international stage, this makes China appear to be one of the main perpetrators of anthropogenic global warming and places the nation's diplomats in a tough position caught between demands to decarbonize and domestic calls for more energy to sustain economic development. Developing alternative energy is certainly an option in theory, but will take time and significant investment to realize the benefits (Höök et al., 2012).

Grid electricity is used by 39% of Peruvian rural households. A tiny fraction of households, 0.6% (13,100 households) have generators, and 0.8% (16,700 households) has solar home systems (SHS)(EIA, 2014a). Households without access to grid electricity often use small generators and SHS. SHS is particularly used for lighting and communications (radio and TV)(EIA, 2014b).Car batteries are commonly used as off-grid electricity sources, especially in the Coastal region of Peru, where households have more income and car battery recharging is relatively easy due to the presence of good roads. It is estimated that 18% (240,000) of off-grid rural household uses it for lighting and running TV`s (EIA, 2014a). Nevertheless, in rural households without electricity the most common source of energy for lighting comes from kerosene (80%) and candles (65%)(EIA, 2014a).Rural households in-grid connected areas consume less than 30 kWh per month (70%), and between 21% and 39% of their total electricity consumption is used for lighting. The remaining electricity consumption is due to the use of domestic appliances such as TV, irons and others. Less than 1% of these households own appliances such as domestic water pumps, electric pump irrigation systems or any other devices which are directly used for income-generating activities (EIA, 2014b).Domestic small appliances such as radios and flashlights are powered by dry cells (74%) in both types of households, with or without access to grid electricity(EIA, 2014a).

However, access to grid-based rural electrification is hampered by insufficient financial resources for investments in grid extension and installation of mini-grids and the difficulty to operate mini-grid profitability due to the low purchasing power and the low energy demand of rural clients. Obstacles for off-grid energy technologies and services on the other hand include insufficient financial resources to carry out dissemination programs for off-grid technologies, insufficient availability of micro-finance schemes for energy technologies in rural areas and lack of a marketing and maintenance structure for energy technology devices in rural areas(EIA, 2014a)

2.3.2 Regional Energy Situation

Africa is one of the few places considered to be dominated by energy poverty. The literature on energy indicates that Africa is the second continent after Asia where huge populations are without access to electricity and modern cooking services in spite of abundant renewable and non-renewable energy resources including coal, crude oil, natural gas, solar, wind, hydro, bitumen, and uranium (Omorogbe, 2010). Boden et al., (2013) asserts that eighty percent of the Sub-Sahara Africa's population still cooks with woodfuels on open fires because they have no access to modern fuels or cannot afford them. This represents 24% of people worldwide who cook with woodfuels.

In addition, two-thirds of SSA population has no access to electricity (WEO, 2010; Boden et al., (2013)). This totals to about 41% of the world's total population who are without electricity. For example, in 2009 it was identified that about 587 million people in Africa had no access to electricity. Two million of those identified resided in North Africa while 585 million resided in SSA (WEO, 2010). It is projected that 700 million people in SSA will be without access to electricity by 2030. Compared to other regions, by 2030 SSA will remain the only major region with a substantial number of its population who will still be without access to electricity and modern cooking facilities, a problem that will present challenges to development aspirations and poverty alleviation efforts in the region (WEO, 2010; EIA, 2014i).

An average of 31% of the population in SSA has access to electricity (WEO, 2010). -However, when South Africa is excluded, electricity access in the region falls to 28%, a level that is approximately equivalent to electricity consumed in the city of New York, U.S.A. This situation stands in contrast with what exists in other developing regions. For example, East Asia and the Pacific has electricity access rate of 90 percent, South Asia 65 percent, Latin America 93 percent, Middle East 91 percent, and North Africa 99 percent (WEO, 2010)

A breakdown of the population into urban and rural indicates that 46% of those living in urban areas in SSA do not have access to electricity as against 89% of populations living in rural areas (UNDP and WHO, 2009). These figures lead to the conclusion that although more populations in rural areas lack access to electricity compared to urban populations, the fact still remains that huge propositions of both urban and rural populations lack access to modern fuel and electricity, which has implications for their welfare. Moreover, it is imperative to point out that SSA is not one homogeneous region since there are variations among the countries and also within the countries with regards to energy accessibility. For example households' access to electricity in 2008 stood at 70% in South Africa;100% in Mauritius; 56% in Ghana (Boden et al., (2013)); 11.1% in Ethiopia, Democratic Republic of Congo, and Tanzania (WEO, 2010); 5% in Central Africa Republic, Rwanda and Sierra Leone and 3% in Chad, Burundi and Liberia (UNDP and WHO, 2009).

South Africa is a middle-income country that generates 90% of its electricity from coal-fired power plants. The remaining 10% of electricity supply is divided evenly between nuclear and hydroelectric dam generation (EIA, 2014h). Consequently, it is the largest emitter of carbon dioxide in Africa, and 14th largest in the world, according to 2011 estimates (EIA, 2014h). Approximations from the Central Intelligence Agency CIA (2012b) indicate that 82.7% of the population had access to the over 234.2 million MWh of electricity consumed in 2012. Moreover, reducing greenhouse gas emissions and stabilizing the electricity supply are two major goals for South Africa (EIA, 2014h). As a result, the country is planning to diversify its primary energy sources and expand total production by 20% by 2025 (EIA, 2014h). In addition, the goal of Integrated Energy Plan (IEP), launched in 2011, is to increase renewables, primarily wind and solar, from 203 MW to 18,200 MW of capacity in 2030. Furthermore, nuclear power would expand from 1,920 MW to 9,600 total capacity by 2030 (EIA, 2014h). According to South Africa's leading electricity producer, Eskom, current progress of these projects is not well documented, and ranges from initial planning stage to completed (Eskom, 2015).

Morocco, a developing nation, currently imports over 90% of their energy needs because the region lacks oil and natural gas reserves, and the strong solar and wind potential has not yet been utilized (CIF, 2013). The electricity consumption in 2012 stood at 25.4 million MWh and was composed of roughly 70% fossil fuels, 20% hydroelectric plants, and 4% renewable technology (CIA, 2012a; EIA, 2014e). In addition, 98% of the population has access to electricity (EIA, 2014e). However, Morocco's main challenge is weaning off foreign fuel sources, and supplying a reliable, domestic source of electricity production. Besides, relying on fossil fuel imports causes financial stress, an unpredictable energy supply, and substantial greenhouse gas emissions (IEA, 2014). Morocco has been emphasizing solar and wind energy owing to its prime location near the Sahara desert. In 2012, total electricity generating capacity was 6,763 MW (EIA, 2012), with less than 4% coming from renewable sources. Morocco has set a goal of 42% renewables by 2020 to be achieved by increasing each solar, wind and hydropower capacity by 2 GW each (Moroccan Investment Development Agency, 2014). Their National Energy Strategy which set into effect in 2009 established the following priorities for the energy sector: emphasize energy efficiency, expanding renewables and encouraging foreign investment (IEA, 2014). As of a report published in late 2013, Morocco is on time with these goals.

Mozambique is endowed with a variety of energy sources. Mozambique has large reserves of coal. Total coal reserves are estimated to be about 3 billion tons. There are exploitable reserves of natural gas that might be as high as 3 trillion cubic feet. Along with isolated fossil fuel resources Mozambique is rich in renewable energy resources. Biomass, micro hydro, wind, solar and geo thermal resources constitute some of the country's renewable energy resources. At the moment, most of Mozambique's primary energy consumption is met by traditional biofuels such as wood, charcoal and agro /animal wastes. In rural institutions that operate at night (e. g. health centres), kerosene is the main lighting fuel. Over the last few years PV solar energy has been gradually adopted in schools and health centres in rural areas and telecommunications business (UNDP, 2000).

In spite of these relatively abundant resources for opening up access to modern energy, Mozambique suffers from the consequences of the improper utilization of natural resources, which are distributed highly unevenly around the country, and access to energy in a sustainable manner remains extremely low. This situation is partly due to the high cost of extending networks and increasing the number of connections in remote and relatively low-demand areas using conventional technologies and design standards (WHO/UNDP, 2009; IRENA, 2010). Mozambique currently has a relatively low national electrification rate of less than 12%. While electricity has reached 21%of urban households, rural electrification lies at a very low level, 0.2%. Only 2% of the population has access to modern cooking fuel and more than98%from rural areas still use fuel wood for cooking (IEA, 2009). Access to electricity remains low, with only a small fraction of households in Mozambique relying on electricity as the main source of energy for lighting. They tend to rely on less efficient and poorer quality alternatives such as kerosene, candles or wood for lighting (EdM, 2013). Thus, it can be concluded that the government is facing three primary challenges, namely: (1) increasing access to modern energy, in particular electricity, and mitigating adverse environmental, livelihood and health impacts of traditional biofuels; (2) increasing the production and use of electricity; and (3) promoting and prudently managing export-oriented energy projects (MoE, 2004).

Tanzania is gifted with diverse energy sources most of which are untapped, these include biomass, hydro, uranium, natural gas, coal, geothermal, solar and wind. The primary energy supply includes biomass (90%); petroleum products (8%); electricity (1.5%), and the remaining (0.5%) is contributed by coal and, other renewable energy sources. More than 80% of energy delivered from biomass is consumed in rural areas; heavy dependence on biomass as the main energy source contributes to deforestation, while the importation of oil costs about 25% to 35% of the nation's foreign currency earnings. To-date only about 18.4% of the country's population has gained access to electricity. Extending the National Grid to many parts of the country, including rural areas, is not financially and economically feasible (IEA, 2009; IRENA, 2010).

Tanzania currently has a national electrification rate of 11.5%. While electrification has reached almost 40% of the urban households, rural electrification still lies very low at 2%. Only 2.8%of the population has access to modern cooking fuel while fuel wood is used for cooking by more than 77%of the total population and almost 94% of the rural population (IRENA, 2010). Biomass based fuel accounts for almost 90% of the current energy supply. Total installed electricity capacity (2011): 1,051 MW. (Hydro: 58.5% and Thermal: 41.5%)Droughts over the East Africa region have had severe effects on the electrical power supply in the country. Blackouts and power rationing as a result of low water levels in the hydro-electric dams have forced the Tanzania Electric Supply Company (Tanesco) to rely on gas-powered generators and to look increasingly at thermal projects for future capacity increases (WHO/UNDP, 2009).

The primary energy sources in Uganda consist of biomass, imported oil products and hydro. Total installed electricity capacity (2010) is 539.5 MW (Thermal 31.5%, Hydroelectric 65.4% and Biomass (bagasse) 3.1%)(Scarlat and Dallemand ,(2011);SNV, (2014)). Firewood (86%), charcoal (5.8%) and agricultural residues (7%) used for cooking constitute the bulk of household energy use. Because of the low access to modern energy sources Liquefied Petroleum Gas (LPG) (0.06%) and electricity (0.45%) make up a relatively small portion of overall household energy demand(MEMD, 2012b; Schlamann et al., 2013,).At less than 9%, Uganda currently has a remarkably low national electrification rate. While electrification has reached almost 43%of the urban households, rural electrification is still very low at 4%. Only 0.4%of the population has access to modern cooking fuel and almost 86%still rely on fuel wood for cooking (NPA, 2015).

Wood-burning “three stone stoves” found in rural Ugandan households have a low efficiency. Efficiency rates for such stoves vary widely; in lab tests thermal efficiency ranges between 20 to 30%, while in actual practice efficiency of as low as 5% can be experienced (ARC 2011). The stoves also expose family members to numerous pollutants causing health problems such as acute respiratory infections (WHO 2007; Jagger and Shively 2014). With droughts severely affecting the water levels in Lake Victoria and River Nile, Uganda’s overdependence on large scale hydro power may prove problematic (USAID, ADB, MRC and WWF (2010)). An estimated 200MW of Solar PV electrical capacity exist. There is also significant potential for Solar cooking with a large number of the population living in well insolate areas. There is hydropower potential for 3000MW in the country but only less than 10% has been exploited. There is an estimated geothermal resource potential of 450 MW and feasibility studies are recommended to promote its development. Wind power is insufficient for large-scale power generation but possible uses include water pumping and small-scale power generation in mountainous areas. There is also identified potential for biomass cogeneration from agricultural waste and the existing ‘peat’ resource (NPA, 2015).

2.3.3 Energy Situation in Kenya

Kenya is a developing country with 43.4% of its population below the poverty line. In 2012, only 18% had access to electricity, with the remaining population depending on biomass and waste combustion for heating and cooking (EIA, 2014c). The amount of electricity generated by Kenya in 2012 was 7.6 million MWh of which 68% was from renewable sources and 32% from oil. The country relies most heavily on hydroelectric and geothermal, with less than 4% of consumed electricity generated by wind or solar (EIA, 2014c). Kenya neither produces nor consumes natural gas, and her coal industry is not used for electricity generation. Electricity production is irregular, marked by frequent blackouts during peak times when demand outpaces supply.

The country is faced with the challenge of expanding the distribution of a reliable electricity supply to its citizens while maintaining and expanding current renewable energy capacity. Financial investments by the African Development Bank, International Finance Corporation, and World Bank aim to expand Kenya’s renewable energy sector though the Scaling-Up Renewable Energy Program (SREP) enacted in 2011 (ERC, 2011). As part of SREP and Vision 2030, the goal for generating capacity in 2030 is 23,000 MW. In 2012, Kenya had an electricity generating capacity of 1,840 megawatts (MW) (EIA, 2014g). To meet these goals, Kenya plans a 50-fold increase in geothermal capacity and small-scale distributions of solar, wind and hydropower to spread access to electricity within an efficient grid system (ERC, 2011).

2.4 Energy Initiatives

2.4.1The Kenya Ceramic Jiko

The Kenya Ceramic Jiko (KCJ) is one of the successful stove dissemination projects in Africa. The Kenya Ceramic Jiko was created after re-designing the Thai Bucket Stove and the Kenya Traditional Metal Stove (KENGO, 1991; Karekezi and Kithyoma, 2002, Coelho et. al 2004). Organizations such as CARE, UNICEF, The Bellerive Foundation, as well as the United Stated and German aid agencies all played a role in the development and promotion of the KCJ. The Kenya Energy and Environment Organization (KENGO) has played an active role in increasing awareness, and promoting the use of the Kenya Ceramic Jiko since 1982 (KENGO, 1991, Kammen, 1995).

A study carried out by Co2balance in partnership with the Global Alliances for Clean Cookstove and fuels revealed approximately 89% of rural and 7% of urban households regularly use firewood, giving a national average of about 70% of all households. Overall, about 21% of households use farm residues, but their use is mainly in rural areas with 29% households as compared to 0.5% in urban households. Only 2.5% of households use wood waste (sawdust, bark and small off-cuts). Use is mainly in urban areas by 3.7% of households as compared to 2.1% in the rural areas. Use of charcoal is about 47% at the national level with use of over 82% and 34% of urban and rural households, respectively. Per capita consumption is 156 kg in urban areas and 152 kg in rural areas (SCODE, 2012). This has implication for sources of biomass since cutting down trees for fuel has led to environmental degradation, including loss of forests, loss of biodiversity, destruction of habitats, and an increase in soil erosion. It also means that many people in the rural households especially women and children are exposed to indoor air pollution which is detrimental to their health thus the need for adoption of the improved stoves.

When used properly, the Kenya Ceramic Jiko has the ability to reduce fuel consumption by 20–50% (Smith et al., 1993), therefore reducing the demand for wood as a fuel resource. The stove may reduce 20% of emissions produced from incomplete combustion (Johnson et al., 2008). In addition, the Ceramic Jiko increases child safety as the ceramic liner prevents the stove from becoming extremely hot. Although most producers and dealers of the jiko stove have been men, many women in small urban areas have benefited immensely from the technology, significantly improving their standards of living through gains in time and income (Okello, 2005).

Figure 2.1 The Kenya ceramic jiko stove

Figure 2.2 The Kenya traditional metal

Source: https://www.aimspress.com/article/doi/10.3934/energy.2021005?viewType=HTML

2.4.2 SCODE Energy Saving Cookstove

SCODE (Sustainable Community Development services) social is a community-based organization started in the year 1996 with the aim of enabling people in Kenya especially the poor, to improve their quality of life by adopting technologies and approaches that are environmentally friendly and contribute towards sustainable development. SCODE's mission is to facilitate adoption of cleaner energy technology and sustainable land use approaches through capacity building and applied research for enhanced livelihoods with concern for the environment and sustainable development.

SCODE enterprise promotes a wide range of energy saving cookstoves (jikos) that are designed to reduce on fuel-wood consumption when used properly. The stoves are made from long lasting materials, high quality workmanship and are well insulated to minimize heat losses and come with a 6-12 months guarantee. Because of these qualities, there is reduced drudgery that women go through when fetching firewood, women cook more with less fuel-wood and time, reduce smoke emissions in the kitchen compared to the traditional three stone fireplace, the stoves last longer and reduce fire accidents among men and women in kitchens.

Figure 2.3: Jiko Star **figure 2.4 Kuni mbili jiko**

Source:
https://www.aimspress.com/article/doi/10.3934/energy.2021005?viewType=HTML

Figure 2.5: Jiko Kisasa **Figure 2.6: Rocket Stove**

Source:

https://www.aimspress.com/article/doi/10.3934/energy.2021005?viewType=HTML

Jiko Star is a charcoal-burning stove specially designed to reduce charcoal consumption, carbon monoxide emission and last longer. Kunimbili is a highly efficient wood stove which can also use charcoal. It's specially designed to reduce charcoal consumption, carbon monoxide emission and last longer. SCODE jikokisasa stove is a portable pottery cylinder (ceramic liner) that is installed by building a mud or concrete surrounding in the kitchen. It is suitable for use in households and institutions with a permanent fireplace. A Rocket stove is a firewood burning stove. There are three types: Mud, mud-brick and cement brick rockets. It cooks faster, fairly affordable and environmentally friendly. The sizes vary with each household and/or institution.

For SCODE the programmes have seen over 70,000 people in their respective areas become aware of the ICS and its benefits and install more than 25,000 jikos in their households. Consequently, these households have reported savings of between 40 and 50 percent on firewood use.

2.4.3 LPG Consumption in Kenya

The global focus on LPG is largely underpinned by the fact that LPG is the most efficient source of energy after electricity. Kenya signed the KYOTO protocol of 2010, which among other areas sought to promote modern energy usage to reduce pollution and more importantly, save the environment and promote health benefits. The use of biomass as the main energy in the Kenyan economy especially in the rural setting is over 80% on average. This unsustainable practice is a major health risk to the population. According to the report published by PIEA (2011) in the third quarter of 2016, the annual LPG consumption in Kenya stood at 148,800 MT. The reports available in the Petroleum Industry subsector in Kenya Even show that LPG consumption has increased by about 59% between 2003 and 2016.

Despite this rapid growth, LPG Consumption in Kenya still compares poorly with world statistics at 95.5Ktoe against a world average of 1434Ktoe and 384Ktoe in low-income economies (Ministry of energy report-MOE). Kenya's LPG per-capita consumption lags behind countries in Africa at 3.65 Kg in rural and 9.87 in urban areas compared to Senegal which is at 75Kg according to MOE reports. This consumption has however been rising at a steady pace. At an average growth of 14% annually (PIEA 2011) it is projected that the country will have 70% LPG penetration by the year 2030. However, this growth has mainly been concentrated in urban and peri-urban areas of Kenya. Even with an annual growth of 14% of LPG consumption, a lot more needs to be done to catch up with the rest of the world in promoting LPG.

The low LPG consumption prompted the government of Kenya to make an announcement to start an LPG subsidy program that targeted the low-income population especially in rural Kenya in October 2016. The total subsidy was reported to be upwards of 50% of cost on both accessories and the gas. In Kenya, and especially to the majority of the rural households living on less than a dollar a day, the initial cost of cylinder and accessories at an average of 400 dollars is unaffordable. It is not only expensive for the people at the bottom of the pyramid; it is unreachable competing with food and shelter at that basic level. The gap is widening and households would rather choose food over efficient fuel. This is the gap that the government perhaps hopes to bridge to aid in the upfront purchase of the cylinder, gas and accessories, through subsidy. Since it is estimated that over 97 percent of Kenya's nine million households rely on traditional sources of cooking energy (Dalberg, 2013), and that many households practice energy stacking, supplementing modern energy such as LPG with alternative sources of fuel such as wood, charcoal and kerosene. A deliberate effort has to be made to guide a household's hands to choose more efficient, more economical energy sources, LPG therefore should be at the forefront of this energy ladder.

2.4.4 The Kenya National Biogas Initiative

Kenya began to Plan for the implementation of a national domestic biogas programme on 23rd May 2007, when a number of stakeholders met and founded the Kenya Biogas Task Force. The spirit of this Kenyan initiative resulted from the May 2007 Biogas for Better Life Conference (KBFS, 2007; SNV, 2009). This was followed by a meeting of representatives from 27 countries in Africa in Nairobi to formally discuss how to carry forward the objectives of an Africa-wide biogas initiative with the support of the Directorate General for International Cooperation (DGIS) under the Netherlands Ministry of Foreign Affairs (SNV, 2009). The Kenya Biogas Task Force reconstituted into the current broad based Kenya National Biogas Initiative Committee (KENBIC), chaired by Kenya's Ministry of Energy (MoE) on 25th June

2008. Its main objective is realisation of a national biogas programme for Kenya (ABPP, 2008).

In the context of Biogas for Better Life (2007), the Shell Foundation commissioned and funded a feasibility study in 2007 to examine the potential for a national domestic biogas programme in Kenya. The study “Promoting Biogas Systems in Kenya” dated 18 October 2007 was carried out by ETC UK, in collaboration with ETC East Africa, ETC Energy, and local consultants Integral Advisory Ltd (KBFS, 2007). While recognising the potential to install an estimated 65,000 biogas plants in Kenya in just over 10 years, the Kenya Biogas Feasibility Study (KBFS) characterised the current market for biogas in Kenya as immature, with slow NGO and private sector-led sales, driven by a small number of pioneers. It was noted that the stakeholders have limited capacity to generate the level of activity that would spur absorption of the inherent but untapped demand. The market leader for household plants was estimated to install only about 30 systems a year, with total market activity at around 100 systems per annum and cumulative installations of about 2,000 (KBFS, 2007; DGIS, Hivos and SNV, 2008).

Despite this potent demand, development of a vibrant biogas market has been elusive. The operational status of existing biogas plants is believed to be average to poor, even though data on the same is incomplete. Research shows that 30% of biogas systems may not be in working condition, the notable causes being poor design and construction, low end-user awareness on system management, lack of standards to govern the sector, poor water supplies and poor development of the dairy industry. National and international organizations (both Government and NGO), as well as the private sector, have promoted, trained technicians, and given technical support to the biogas industry over the last 50 years though in a fragmented approach. Most biogas plants installed currently are on cash basis, even though some are supported by grants and/or financing by donors (SNV, 2009).

Figures 2.7: Other cookstoves that have been promoted in Kenya

Single pot Jiko Kisasa with a traditional pot

Figure 2.8: Single Pot Jiko Kisasa

Source: https://www.aimspress.com/article/doi/10.3934/energy.2021005?viewType=HTML

2.5 Benefits of Energy Initiatives on People's Socio-Economic Livelihoods

Several empirical studies identify different costs and benefits related with household's access to modern energy and ICS. For example, benefits from the viewpoint of users (demand-side), include health benefit through reduction in IAP emissions, economic benefit through time saved collecting fuels, and fuel and fuel cost savings, and other benefits such as aesthetic gains and improve social standings. Whereas costs include cookstove cost, fuel cost, stove maintenance and other related costs. Similarly, from the viewpoint of suppliers (supply-side), including international non-governmental organisations (INGOs) and the government, benefits include environmental benefit such as preservation of forest reserves, GHG and black carbon emissions reduction, economic benefit through market development and other benefits such as job creation and local skill development, while costs include market intervention costs such as subsidies, fuel cost and program cost.

Many of the studies identify health benefits, especially associated with smoke and safety, and other environmental benefits, from accessing modern energy and ICS. For example, using cost benefit analysis (CBA), WHO (2006b) discovered that it is potentially beneficial for human health as well as for local and global environment to invest in modern energy and ICS. Using similar CBA framework in Kenya, Sudan and Nepal, Malla et al. (2011) discovered that there is a direct health benefit from improved cooking system interventions due to reduced treatment costs and in time savings due to fewer days spent ill or having to care for sick child. Habermehl (2007, 2008) found that environmental benefits including preservation of forest reserves and reduction of CO_2 and CH_4 emissions from ICS program in Uganda and Malawi were significant. On the other hand, Madubansi and Shackleton (2007) found that most of the households in the villages of Bushbuckridge region of South Africa, who receive part of the electricity free, still rely heavily on firewood for cooking. In addition, the number of households purchasing firewood had increased most likely due to increased firewood scarcity in the local areas as reflected by increased firewood collection times and changes in firewood species preferences. Asaduzzaman et al. (2010) in Bangladesh and Garcia-Frapolli et al. (2010) in rural Mexico found switching to modern energy for cooking and ICS led to minimizing health risks associated with IAP. However, it is not always the case, as Mobarak et al. (2012) found that women did not consider IAP a high priority for switching to ICS.

Another factor associated with access to modern energy and ICS is economic benefit. For instance, Garcia-Frapolli et al. (2010) found that the ICS intervention in rural Mexico contributed substantial quantity of firewood savings, which constituted 53% of overall benefit. Malla et al. (2011) found that in Kenya, Sudan and Nepal, significant economic benefits from cooking system interventions were mainly due to fuel and cooking time savings. Similar findings are reported by Habermehl (2007) in Kampala, Uganda and Habermehl (2008) in Malawi. The study revealed that the economic benefit of the ICS programme from fuel savings and reduced cooking time were quite significant. In Maharashtra and Karnataka, India, Thurber et al. (2014) discovered that the highest rate of adoption of "Oorja" ICS, using pelletized biomass, came from households using LPG mainly because of reduced fuel costs. However, their study also found only 9% of households that purchased Oorja ICS were using the stove due to lack of fuel supply. Furthermore, in Vietnam ADB (2009) estimated that households saved roughly US$68 each year using biogas by substituting biomass, coal or kerosene fuels. In addition, women in northern Vietnam also saved on average1.8 hours a day by using biogas. Besides, Christiaensen and Heltberg (2012) found use of biogas among smallholder farmers in rural China led to decline in firewood and crop residues use for cooking, less time spent by women in collecting firewood, improvement in respiratory health and saving in fertilizers. Also, Djedje (2009) found that in western Kenya, both private and commercial users of ICS were able to reduce the cost of fuels (by using less firewood) and time for cooking. The study revealed that commercial users of ICS were able to save Euro 1.1 - Euro 6.6 per day.

In the case of costs associated with access to modern energy and ICS, WHO (2006b) found that fuel cost, stove cost and program costs are some of the main cooking system intervention costs. For instance, in rural Bangladesh, Asaduzzaman et al. (2010) found that cost of modern energy and lack of supply contributed to limited adoption of ICS. Based on life cycle analysis, Afrane and Ntiamoah (2012) found that firewood used in Ghanaian households for cooking has an annual environmental damage cost of US$36497 per household. Applying financial analysis in rural areas in India, Gupta and Ravindranath (1997) show that the ICS using firewood is the least cost option and biogas, which is the only quality fuel for rural areas, is the most expensive option. In addition, EAC (2006) reports that biomass collection time for rural households are as high as 4.5 hours in Kenya, 6 hours in Tanzania and Uganda. Households in rural Ethiopia spent on average between 11 and 12 hours per week collecting biomass (firewood and dung) fuels for cooking (Gwavuya et al., 2012). The responsibility for collecting these fuels lies on female household members between the ages of 18 and 59. Using the opportunity cost of labor which is estimated through the marginal productivity of own labor in farm activities, the study estimates that on average households lose US$0.06 for each hour spent on collecting firewood.

Basing on the economic evaluation of the ICS program in Uganda during 2005 and 2006, Habermehl (2007) estimated the opportunity cost (shadow wage) of firewood collection to be Euro 0.01 per kg. The study assumed that 50% of the time saved by the households are used for productive activities with average household income of Euro 0.1 per hour. Besides, Heltberg (2005) found that cooking labor scarcity (i.e., household size) translates into high opportunity costs of firewood collection in Guatemala; high share of females in the households are more likely to use multiple fuels, and higher level of education increases the opportunity cost of collection time. Also, in Himachal Pradesh, India, Parikh (2011) finds that there is a substantial physical and economic burden in collecting, processing and transporting biomass particularly for women. On average, women walk 30 km each month taking 2.7 hour per trip for firewood collection equivalent of 3 to 7 days per month of work days lost. Moreover, in Central American countries, men on average spend 10 hours per week collecting fuel and women on average spend 4 hours per day cooking (Wang et al., 2013).

Cookstove burns from equipment explosion have been reported as a leading cause of severe house burns in women and children in Asia and Africa (Godwin et al., 1996; Peck et al., 2008). In a prospective study of flames and stove patient's admission in a Cape Town, South Africa hospital, 25% of those patients were injured in stove-related incidences, of which the majority (60%) was due to stove explosion (Peck et al., 2008). Poor manufacturing standards, low quality control, and lack of features define the cookstove in low- and medium-income countries (LMICs). Cook stoves which use paraffin may burst into flame, especially when the paraffin is contaminated. Malfunctioning cooking appliances are an important risk factor for fire burn injuries. Many LMICs do not have infrastructure in place to regulate fuel integrity, especially whether the fuel has been contaminated with another type of fuel (Peck et al., 2008).
The Global Alliance for clean cook stoves, led by the United Nations Foundation, seeks to encourage 100 million homes in LMICs to adopt clean cookstoves and fuels

by 2020 as well as support a clean and innovative cookstove industry (GACC, 2011). Efficient cookstoves that are affordable in the context of LMICs can dramatically reduce fuel consumption, exposure to harmful emissions and smoke, and reduce the risk of fire burns. Therefore, this study will seek to examine the effect of energy initiatives on people's socio-economic livelihoods.

2.6 Challenges Facing ICS programs

The traditional stoves have low thermal efficiency which means that a lot of energy is lost during cooking and harmful pollutants are also emitted. This translates to burning more biomass during cooking and hence more hours spent in fuel collection. Traditional stoves also produce a lot of particulate matter which include GHGs such as carbon dioxide and poisonous gases such as carbon monoxide (Mukhopadhyay et al., 2012). Households experience problems of poor air quality, the environment and climate. According to Barnes et al., (2012) the problems associated with burning biomass in traditional stoves are too important to be ignored.

International organizations, research laboratories, governments and NGO have advocated for a shift to different types of ICS as a way of mitigating these problems. The ICS have advantages such as free air flow unhindered by embers and ash, the flame is directed towards the cooking pot, increased in air supply results in complete combustion of wood, the size of the opening for fuel insertion has been reduced thereby reducing amount of fuel used and heat loss. These developments are based on combustion and air flow principles. Hence, looked at from a technological perspective only, other factors held constant, the ICS satisfy engineer's anticipated level of thermal efficiency and emission reduction. Moreover it would rationally follow that wide substitution of traditional cookstoves with ICS would automatically reduce health, environmental, economic (for example, time and money) and social challenges around the world.

Research on the way new technology is diffused shows that the creation and acceptance of technology is not just a function of need compelling unidirectional change; rather uptake of innovation is a multifaceted social process that entails critical change in culture and behaviour. The need for a shift in culture and behaviour may partially explain the minimal gains realized by ICS programmes.(Hana et al., (2012) reports that numerous ICS programmes launched in India have not met the anticipated level of adoption or goals of reducing respiratory disease, controlling rates of deforestation and addressing fuel shortages. Outstanding problems include low rate of initial adoption by households and consequent low usage rates. In cases where initial adoption is perceived as adequate, application declines over a period of time partly due to deterioration of the technology. Furthermore, users alter the ICS in a way that compromise the performance of the stoves (Barnes et al., 2012; Pallit and Bhattacharyya, 2014). Additionally, there is a lot of bureaucracy in ICS programmes controlled by government and other agencies whereby feedback from users is not a priority (Gifford, 2011).

Reduction in emission and fuel economy are key factors usually emphasized by ICS promoters (Palit and Bhattacharyya 2014; Mobarak et al., 2012). However, those who use biofuel stoves usually site other priorities, including ability to use different pot sizes, cooking speed, capacity to burn other types of fuel (crop residues, dung and coal (Gill 1987; Mobarak et el., 2012; Thacker et al., 2014). The early assumption that ICS are more efficient compared to traditional stoves were based on unreliable accounts. The most commonly emphasized challenge is that the performance of stove verified in a laboratory setting could not be replicated in the field (Smith 1989;

Johnson et al. 2008; Roden et al. 2009, Aung et al 2016). Most scholars highlight lack of basic design qualities that satisfy user needs (Gill 1987, Barnes et al. 1993, Kammen 1995, Bielecki and Wingenbach 2014, Thacker et al 2014, Palit and Bhattacharyya 2014). Shortcomings include possibility of tipping over, risk of burn, narrow openings and time needed to light the stove. Stoves may also under- or overcook food or break after repeated use and be costly or hard to repair.

In the event of successful adoption, it is rare that new stoves completely substitute existing technologies. It is common to find ICS being used alongside the traditional stoves. The two coexist because most ICS may not work well when cooking outdoor, when cooking for a large family and when food requires strong heating over a period of time (Ruiz-Mercado et al. 2011; Bielecki and Wingenbach 2014). Adopters easily make changes when they perceive that the ICS is compatible with the existing goals and cooking practices, offer actual advantages compared to the traditional stoves and is easy to understand and use.

Most ICS programmes ignore cultural and practical functions derived from traditional cooking styles (Muneer and Mohamed 2003; Bielecki and Wingenbach 2014; Thacker et al. 2014). Traditional stoves is also used for boiling water for bathing or as a primary source of light or heat. Regardless of health concern, the smoke may be suitable to cure food, dry hand-made ceramics or keep off insects and other pests. In addition to their spiritual and cultural value, traditional stoves are easily constructed and mended by women or a local craft person hence they are a source of independence.

Many programs implemented by international aid organization, governments and NGOs from 1970 have distributed millions of supposed efficient and/or cleaner cookstoves to rural areas across the globe. NGO led programmes have been criticized for lack of coordination and uneven distribution of investments from region to region or even village to village. There is little data to suggest that their efforts have resulted in significant rates of adoption or the promised improvements in health, household economies or local environments s (Agarwal 1983; Bhojvaid et al. 2014; Maniates 1990, 1992; Puzzolo et al. 2011).

2.7. Energy Policy

In Kenya there is a long history of plans, policies and programmes in the energy sector (Owen et al., 2012; UNDP, 2017). The Sessional Paper No 4 of 2004 expresses the principal energy policy framework to achieve economic growth in Kenya (GoK 2004). One of its chief components is the advancement of affordable, cost-effective and high-quality energy services nationally in the period 2004–2023. This policy has outlined numerous features of domestic cooking energy, as well as goals to catalyze the adoption rate of efficient charcoal stoves to 80% in urban areas by 2010 and to 100% by 2020. Respective adoption targets for rural areas were 40% for 2010 and 60% for 2020. In addition, the energy policy intended to achieve 30% adoption of efficient firewood stoves by 2020. Also, there were instructions to (a) offer training at community level to Jua Kali artisans to advance the manufacturing, installation and maintenance of renewable energy technologies (including efficient cookstoves) and, (b) educate on the proper use of biomass fuels to improve public health (Kituyi et al., 2001; Karanja and Gasparatos, 2019).

The Energy Act No 12 of 2006 revised and merged some of the disparate energy policies but failed to incorporate explicit provisions for the advancement of clean bioenergy cookstoves. However, Clean Cookstoves Association of Kenya (CCAK) intervened in 2013, and added various provisions connected to improved biomass cookstoves (Karanja and Gasparatos, 2019. This arrangement was thought to be vital for the development of the Sustainable Energy for All Action Agenda. It mainly gave regulations for the (a) accreditation of manufacturers, distributors, contractors, importers and technicians of improved biomass cookstoves, and the official use of biomass fuels for heating and cooking; (b) giving of service contract to customers, and (c) clearance of stoves in line with existing national environmental laws. This arrangement firmly defined improved biomass cookstoves stoves that conform with the Kenya Standard KS 1814-1:2005.

The 2013 National Climate Change Action Plan (NCCAP) set plans from the mitigation of (and adaptation to) climate change. The policy projected that introducing ICS and alternative fuels for cooking could save up to 5.6 million tonnes CO_2 equivalent annually. Additionally, NCCAP framed the Nationally Appropriate Mitigation Actions (NAMAs) that classify clean cooking as one of its Low Emission Development Strategies (Adkins et al., 2010). NAMA presumes that the advocating for manufacturing of clean cookstoves and developing delivery centres can improve trading in stoves, capacity building and licensing, having ripple effects for reducing poverty nationally.

Lastly, the Energy Bill of 2015 combines a series of energy laws and regulations. It creates a regulatory framework within the energy sector that regulates the functions and powers of national government agencies, and draft the tasks of it decentralized structure. The Energy Bill of 2015 differs from earlier energy policies in that it does not contain any plans for the promotion of clean bioenergy stoves (Karanja and Gasparatos, 2019).

The main drive for these energy policies is the wish to modernize the production, processing, distribution and consumption of energy, primarily biomass energy (Owen et al., 2012; GVEP, 2012). This was viewed at mostly as challenging in relative to the fast urbanization that has improved the demand for charcoal, and increased concerns over energy insecurity and degradation of resource (MEWNR, 2012; GOK, 2015; Ndegwa et al., 2016; Kiplagat and Wang, 2011; Daley, 2013). Other chief pushers include the need to fast-track growth of the economy, alleviation of poverty and income equality (Oduor, 2016; Owen et al., 2012; Nguu et al., 2014; Birundu et al., 2017; UNDP, 2004. To achieve these policy goals the policies stated above comprise numerous actions and interventions that attempt to facilitate energy transitions, expand sustainable supply of biomass, exploit present technical invention, and promote general enabling conditions (Kituyi, 2004; O'Keefe and Raskin, 1985)

2.7.1 Engendering Energy Policy

Women and men experience energy poverty in different ways, and they are affected by climate change in different ways linked to their gender roles. Regarding energy policy interventions, policy makers do not generally recognize the existence of gender needs in energy services, and as a consequence, women's energy needs tend to be marginalized in policy documents (Mensah-Kutin, 2006). Climate change initiatives where funds are available to promote energy access present a similar situation. A review of the Clean Development Mechanism concluded that only 5 of the 3864 projects listed in 2012 included gender considerations (UNFCCC, 2012). It is assumed that energy policies benefit women and men equally, so energy planning is implemented in a gender-neutral way. In reality, energy planning is gender-blind, and it fails to recognize that needs of men and women are different (Clancy and Feenstra, 2008). Such an approach misses issues that are of relevance to women. For example, a policy to promote the use of electricity by small enterprise neglects the fact that many of women's traditional income-generating activities use process heat (Woroniuk and Schalkwyk, 1998) for which electricity is not the cheapest option. In contrast, a more gender-aware policy would promote energy forms more compatible with process heat generation, such as LPG (Karlsson, 2004).

Two linked factors may explain why energy policy is gender-blind: women's social position and the attitude of energy institution to gender issues (Clancy and Feenstra, 2006). Gender relations indicate that men tend to dominate decision making within households, in community and organizations. Policy makers tend to be men and energy institutions and organizations, both in the public and private sector, as well as civil society (including NGOs dealing with energy), tend to be male-dominated, particularly in the professional posts. Women are universally under-represented in political decision-making bodies at the international, national and local level. As a consequence, the forums where the energy issues are identified and potential solutions are proposed tend to have an inadvertent male bias. Policy responses prioritize men's issues (for example, the need for irrigation pumps) whereas women's issues (for example, the need for drinking water) are overlooked. Gender issues appear not to be a high priority in the energy sector despite the existence of gender policies at the national level, based on international accords such as the Beijing Platform for Action.

Experience shows that there is a general lack of awareness among policy makers that women and men have different energy needs, and this can be attributed to the lack of sex-aggregated data related to energy (Clancy, 2011). The availability of good data is the basis of planning. If there's no data, then there is no visibility of problems and issues to create the interest necessary for policy-makers to take action. When data is collected, it tends to be from the head of the household, who is generally assumed to be a man. However, this lack of understanding of the gender issues in energy access is not unique to the energy sector, but among gender specialists, there appears to be a failure to understand the nature of the energy sector and its relevance to women. This is despite the fact that, in developing countries, energy at the micro-level is “women’s business.” In one sense, this lack of gender specialists’ engagement in the energy sector is surprising since the Beijing Platform for Action calls for mainstreaming gender in all sectors

2.8 Theoretical Framework

The thesis was based on the capability approach by Amartya Sen and Diffusion of Innovation Theory by Rodgers.

2.8.1 Capability Approach Theory

A Nobel economist Amartya Sen (1999) contends that poverty is more than having low income and is closely connected with deprivation of basic capabilities. Sen’s view is that people ought to be made equal in their capabilities or at least in their basic capabilities. For example, accessing modern energy initiatives can influence quality of life and livelihoods by improving education, health, information and technology, agriculture, gender equity and the environment. Sen (1999) argues that the correct focus for evaluating how well-off people are is their ability to live a life we have a reason to value, not their resource wealth or subjective well-being. But in order to begin to evaluate how people are performing in terms of capability, we first need to determine which functionings matter for the good life and how much, or at least we need to specify a valuation procedure for determining this. For instance, identifying the energy initiatives available in Homabay County and their effect on people’s socioeconomic livelihood was to reveal whether they are deprived of energy or not and how people are performing socially and economically and offer suggestions on how to improve their quality of life.

The capability approach in principle allowed questions such as ‘what capabilities does this person have?’ to be positively answered. This allowed an open diagnostic approach to what was going well or badly in people’s lives that could be used to reveal unexpected shortfalls or successes in different dimensions, without aggregating them all together into one number. For example, in this study examining the gains made in health, education, environment and economics revealed how the energy initiatives have contributed to quality of life and livelihoods. An examination of the challenges faced in accessing and using the energy initiatives exposed the existing shortfalls and made it possible for alternative options to be considered.

Sen’s Capability approach has received the following critics: Liberals identified the focus of the Capability Approach, ‘the ability to achieve the kind of lives we have reason to value,’ as problematic because it appears to impose an external valuation of the good life; Both capability theorists and external critics express concern that the content and structure of Sen’s Capability Approach is under-theorised hence making it unsuitable as a theory of justice; A third line of critique takes issue with Sen’s ‘thin’ agency based picture of persons as too abstract and rationalistic. It is said to be founded too closely in Sen’s personal dialectical relationship between economics and philosophy, and not enough in the perspectives and methods of anthropology, sociology, or psychology (Giri 2000; Gasper 2002). As a result Sen’s account is said to have a poor grasp, for example, of the centrality and complexity of *personal* growth and development.

However, despite the critics put forward, Capability approach still remains relevant to the study in that it supports the assessment of people's achievements which is what counts for improving quality of life and livelihoods. Since a capability is the ability or potential to do (e.g., cook a meal using clean energy) or be (e.g. to be healthy) something, more technically, to achieve a certain functioning (e.g. socioeconomic well-being) and functionings represent parts of the state of a person; in particular the various things that he or she manages to do or be in leading a life. The capability of a person reflects the alternative combinations of functionings the person can achieve and from which he or she can choose one collection. My view is that people ought to be made equal in their capabilities or at least in their basic capabilities. The concern should be with issues of social injustices that have created inequalities such as energy inequalities and thus focus on capabilities of people as the means of using energy initiatives to achieve socio-economic livelihoods.

2.8.2 The diffusion of Innovation Theory

According to Rodgers (2003) diffusion of innovation theory tries to explain the acceptance of new technologies and concepts. How and why they diffuse among people. And the speed at which they spread. Here the innovation refers to "cleaner" cookstoves that are a fairly new addition to the people in the study area. Diffusion is the process in which an innovation is communicated through certain channels over time among members of a social system (Rodgers, 2003).

The diffusion process is greatly influenced by communication channels. These can be divided into social networks and mass media. In social networks, information travels from individual to individual. While in mass media, information travels from a channel to an individual. Means of communication include face-to-face, mobile, written, broadcast media and electronic. Deroïan (2003) contends that a social network, considered as influence relationships, has to exert adequate level of influence in order to spread the innovation. Therefore, understanding the important characteristics of the communication network through the lens of current social ties could expose relevant aspects of the diffusion process. Another significant attribute of communication networks that social network analysts examine is how key individuals who hold position in the network influence communication. Opinion leaders and Key players, as identified by the structural properties of a network, can play an important role in technology diffusion. Whereas opinion leaders are proponents of a technology, who can communicate widely and encourage adoption of a certain technology via their position in the network (Valente and Davis (1999); Valente and Pumpuang (2007) Pine et al., 2011). Key players refer to individuals who are recognized as potential diffusers of a technology based on the network structures only.

Diffusion of innovation adopts an exceptional approach in comparison to other theories concerning change (Smith, 2004). The theory does not aim at converting people to change instead, it views change as an important rule about evolution or reinvention of product and the reason why certain innovations spread faster than others? In addition, why do other innovations fall? Diffusion scholars distinguish five attributes that influence the success of an innovation. Characteristics such as complexity, compatibility and adaptability influence the probability for adoption. Another important characteristic is trialability which denotes to the ability to try out ideas on a partial basis. Innovations that can be tried out in installments will gain adoption faster. Finally, there is observability which the extent to which the outcome of an innovation is visible to others.

Rodgers (2003) defines social systems as a set of interrelated units which may be individual people, organizations or groups. Members of a social system work together towards a common goal and can accelerate or hinder adoption. Only innovations which are compatible with the cultural norms succeed. Furthermore, innovations are adopted within a period of time, analysis of time for diffusion begins with the first opinion. The outcome is the decision to adopt or reject and a final confirmation of the choice made. People who are likely to adopt are exposed to communication for a long period of time.

Diffusion of innovation (Tabak et al., 2012) identifies strategies to increase the speed and effectiveness of innovation transfer to the end user and examines key stages in this adoption process: Knowledge, persuasion, decision, implementation, and confirmation. According to Rodgers (2003), the rate of adoption is used to categorize end users into groups: innovators are people who are willing to try out new ideas and technology. Because of their motivation to be agents of change, they explore and take risks. Most of them are financially stable and operate in multicultural social circles. Innovators include approximately 2.5% of the population.

Early adopters are people who hold leadership positions in the social system and are approached by other members for opinion and information about the technology. They play a key role in the innovation from initiation to implementation, especially in organizing the resources that carry innovation forward. Early adopters comprise roughly 13.5% of the population. Rodgers explains that even though early majority lack leadership role, they are very social, have good interaction with peers and readily change their behaviour as long as it improves their wellbeing. They are approximately 34% of the population.

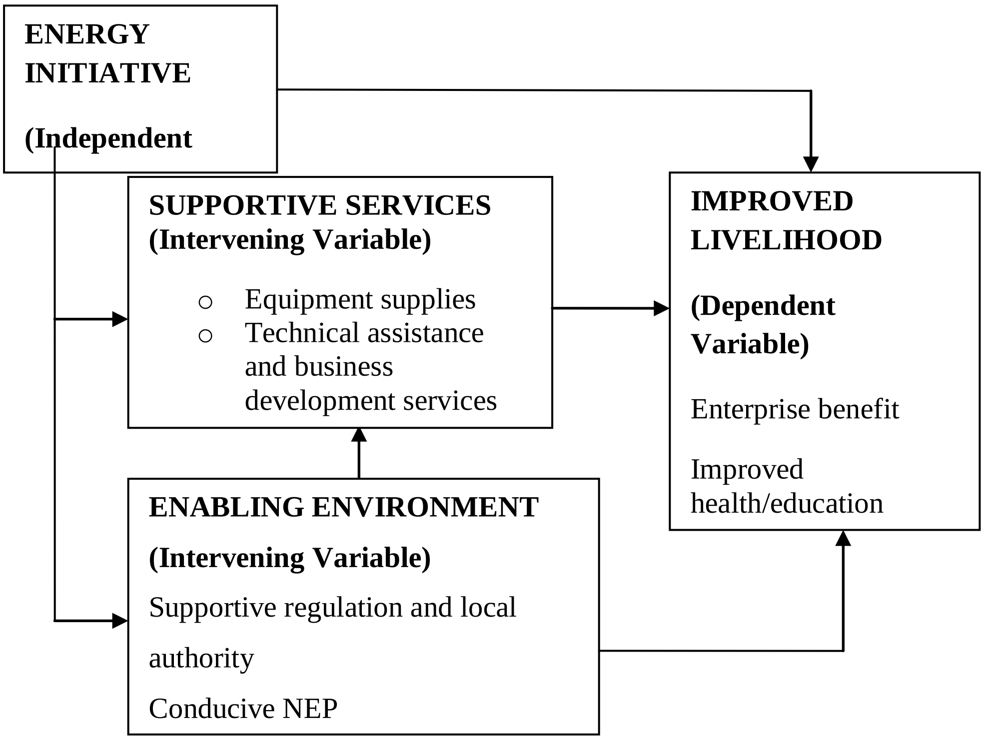
The late majority are characterized by waiting until the innovation is adopted by most of their peers. Even though they are doubtful about the innovation and its end result, they still adopt because of social or economic necessity. They form about 34% of the population. Laggards tend to be old people with limited social networks and hence not under pressure to adopt the innovation. They tend to decide after looking at how successful the adoption has been and comprise about 16% of the population.

Rodgers (2003) identifies four elements of diffusion of innovation: innovation or technology refers to a field of knowledge, such as rural energy, or to specific products, such as cookstoves (Carlsson et al., 2002). A technological innovation system can cut across national, regional and sectoral boundaries (Markard and Truffer, 2008; Hekkert et al., 2007)

2.9. The Conceptual Framework

This study was guided by the following conceptual framework derived from literature review.

Figure 2.9. The Energy Livelihood Framework



Source: Literature Review

2.10 Summary

The scope of the first part of the research is to analyze the energy in Homabay County, which is the first quantification of the box energy initiatives. The second part of the research will assess the benefits gained from the energy initiatives and how they contribute to the socio-economic wellbeing of the people of Homabay County, hence the box improved livelihoods. The third part of the research will examine challenges people face in the adoption and use of the initiatives and leads to the fourth part which will then examine the supportive services and enabling environment available as options to enhance adoption and use of the initiatives.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

The chapter discusses the research design and the methodology adopted by the study. It begins with the discussion of the sequential, explanatory, mixed methodology research design adopted by the study and the underlying philosophical assumptions. Details about the target population, the sampling technique and sample sized are discussed. Instrument construction, pre-testing and revision procedure are then discussed and methods of instrument validation and measures of reliability explained. Finally, the chapter presents details of the data collection techniques and mode of analysis and the ethical considerations.

3.2 Research Design

The study adopted post positivism philosophical orientation since for mixed method research it opens the door to multiple methods, different philosophical worldviews, and different assumptions, as well as different forms of data collection and analysis. Post positivism helped to develop subjective meaning out of peoples' experiences with energy initiatives. That was achieved through the use of structured interview, observations and focus group discussions hence, allowing the researcher and respondents to interact in their natural settings. The study employed*ex post facto* research design. *Ex post facto* research design was used because it was appropriate for investigating possible cause-and-effect relationships by observing an existing condition or state of affairs and searching back in time for plausible causal factors. In addition, it allowed the researcher to explore the answers to questions such as what factors seem to be associated with certain occurrences, or conditions, or aspects of behavior (Cohen et al., 2007).

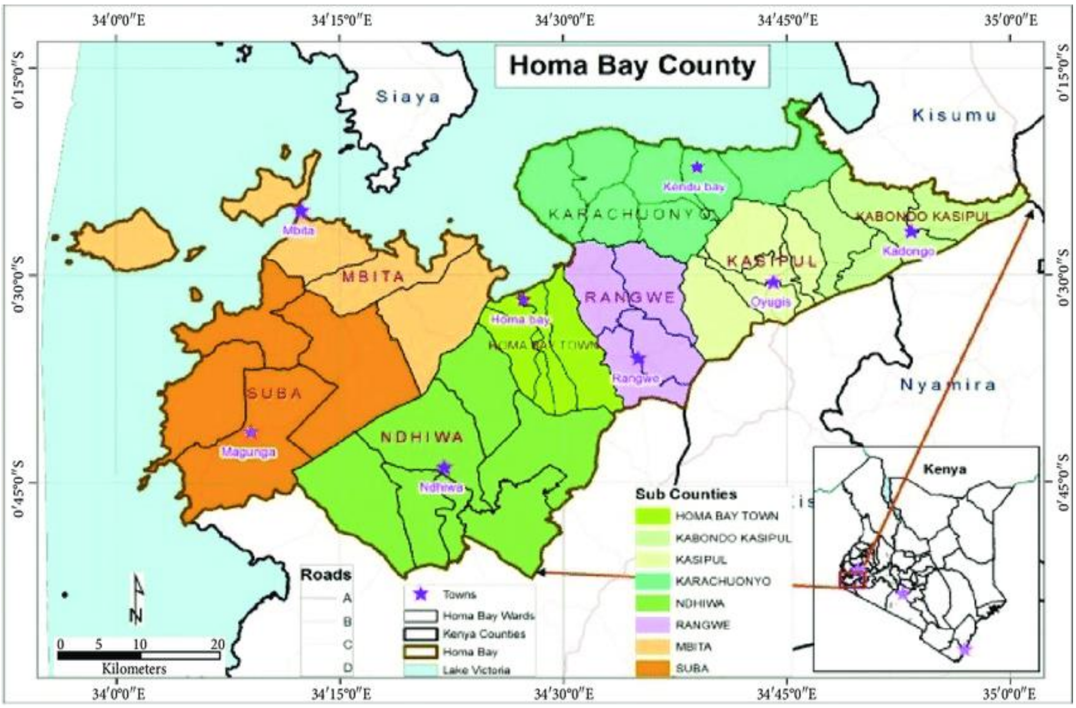
Mixed method research was used as it allowed collection and analysis of both qualitative (open-ended) and quantitative (closed-ended) data in response to research questions since the two forms of data were integrated in the study (Creswell, 2014). Mixed method research was used in order to draw on the strengths of both qualitative and quantitative methods together in one study. The core assumption of this form of inquiry was that the combination of qualitative and quantitative approaches provided a more complete understanding of the research problem than either approach alone (Creswell, 2013). In addition, the following abilities or qualities of mixed method research, according to Bryman (2012), were also considered in this study: completeness (provides a more comprehensive account of area of inquiry), triangulation (a means of seeking convergence across qualitative and quantitative methods) and explanation (one of the two methods can be used to explain findings generated from the other method).

3.3. Research Area

Homa Bay County lies between latitude $0^{o}15'$ South and $0^{o}52'$ South, and between longitudes 34^{o} East and 35^{o} East. The county covers an area of 4,267.1 Km^2 inclusive of the water surface which on its own covers an area of 1,227 km^2. The county is located in South Western Kenya along Lake Victoria where it borders Kisumu and Siaya Counties to the North, Kisii and Nyamira Counties to the East, Migori County to the South and Lake Victoria and the Republic of Uganda to the West (Homa Bay County Development Profile, 2013).

According to the Kenya National Housing and Population Census conducted in 2019, Homa Bay County has an estimated population of 1,131,950 persons (539,560 males and 592,367 females) (KNBS, 2019). This population was projected to be 963,794consisting of 462,794males and 501,340females in 2009 (KNBS, 2009).

Figure 3.1 Location of Homa Bay County



Source:https://www.researchgate.net/figure/Subcounties-in-Homa-Bay-County-source-GoK-13_fig1_343900176

According to the 2019 Kenya Population and Housing Census, the county's labour force is projected to stand at 970,400 persons, comprising 85.7% per cent of the total projected population of 2019. The employed population in the county stands at about 419,128. That is about 43.2% percent of the labour force. Those seeking employment are 27,424 while the number of people who are outside the labour force are 523,766 (KNBS, 2019).

Distribution of households' activities shows that 193,812 practice farming; 184,367 are engaged in crop production, 127,914 practice livestock production, 1056 practice agriculture while 17,770 are engage in fishing. The main crops produced in the county include maize (179,727), beans (111,932), sorghum (68,877), millet (18,769), kales (53,518), sweet potatoes (47,972), cassava (58,238), ground nuts (61,360) and bananas (56,152). The main livestock kept in the county include indigenous cattle (87,253), sheep (36,093), goat (43,402) and the indigenous chicken (106,788) (KNBS, 2019). Most of these livestock are bred for their sentimental value and are used only in emergencies to cover medical and transport costs, pay school fees, entertain guests and pay dowry.

Homabay County has two gazetted forests covering 29.6 km^2, namely Gwassi and Wire hills. There are eight non-gazetted forests covering about 128 km^2, namely Ngorome hills, Ruri hill, and Gembe hills, Mfangano, Homa Hills, Asego Hill and Kodera Forest. Destruction of forests and wetlands in the county, and the resultant biodiversity loss, is also identified as a key environmental challenge. Population growth, agricultural expansion, over-dependence on wood fuels, and low levels of afforestation has accelerated deforestation in the county. The loss of forests and wetlands can have consequences for ecosystems and food security.

The majority of Homa Bay's population depends on wood fuel for cooking. With estimates that at least 97 percent of households use firewood or charcoal for cooking and heating, population growth and associated increases in demand for farming and residential land will undoubtedly accelerate deforestation and exacerbate the effects of climate change in the county. Homabay County has deposits of iron ore around the Homa Hills, Kendu Bay and Oyugis (Got Kanyango) and, limestone around Homa

Hills. Prospecting for Gold continues in areas of Ndhiwa bordering Nyatike. The county has two quarry zones in Sindo and Karachuonyo Kanyipir. Sand harvesting is also common along most rivers and a few beaches especially around Kochia and Sindo (Homa Bay County Government, 2013).

The choice of the area of study was motivated by the fact that these two sub-counties are among the sub-counties in Homa Bay County where ICS and solar electrification projects have been implemented and as such, they provide a ground for which to study effect of energy initiatives on socio-economic livelihoods. Furthermore, these people even though they received ICS and solar electrification have continued to use biomass, most especially firewood, for cooking. This then provided room for studying effects of biomass use on health, education and economic gains in the same area using the same data. It was also easy to compare biomass and solar energy in terms of accessibility, usage and problems. The sample wasmade up of 389 households, 5 key informants and 4 focus group discussions comprising 10 participants each. Ideally the study could have been carried out in the whole of Kenya but due to resources, time and logistics constraints the study was limited to Homa Bay County. This was because Homa Bay County hadbetter access factors which allowed for generalization of the results to the whole of Kenya.

3.4. Target Population

Homa Bay County comprises of eight sub-Counties with a total 203,192 households. All the households in the county formed the target population. The sub-Counties are as follows:

Table 3.1: The Sub-Counties in Homa Bay County

Constituency	Number of Households
Rachuonyo South	24,205
Rachuonyo East	22,003
Rachuonyo North	33,933
Rangwe	20,661
Homa Bay	21,309
Ndhiwa	36,524
Suba North	23,540
Suba South	21,017
Total	**203,192**

Source: KNBS and SID 2013

3.5. Sample Size

The sample size was determined by the following formula recommended by Nassiuma (2000) for determining sample size:

$$n = \frac{NC^2}{C^2 + [\![N-1]\!]e^2}$$

Where n = sample size, N = Population size, C = coefficient of variation and e = Standard margin of error. Nassiuma (2000) recommends a margin of error ranging from between 2%-5% and coefficient of variation ranging between 20%-30%. N was taken based on the total population for each location, C = 20%and e = 0.02 which gives a sample of 396 households. However, only 389 households were reached. A systematic random sampling procedure was used to select the number of households in each stratum. In all the categories, the sample selected was proportionate for each constituency as shown in table 3.2

Table 3.2: Summary of Population Accessed for the Study

Category of Respondents	Sub-county	Number of Households	Sample
Gem West	Rangwe	4,101	96
Gem East	Rangwe	4,770	98
Gembe	Suba North	3688	97
Rusinga Island	Suba North	5492	98
Total		**22,003**	**389**

3.6. Sampling Technique

The study used probability sampling technique. Probability sampling was used because it provided an efficient system of capturing in small groups, the variations or heterogeneity that existed in the target population. In probability sampling every sample of a given size in the accessible population had an equal chance of being selected. Moreover, probability sampling allows generalizability to a large population with a margin of error that is statistically determinable. It also allows the use of inferential statistics (Cohen et al., 2007). Due to the large number of the households (203,192) and wide geographical distribution of households cluster sampling was employed whereby Homa Bay County was clustered into sub-Counties. Cluster sampling was used because the population was large and widely distributed, thus gathering a simple random sample would have posed administrative problems (Bryman, 2012).

In addition, it allowed the researcher to be far more geographically concentrated than would be the case if a simple random or stratified sample were selected. Simple random sampling was used to sample 30 percent of the eight sub-Counties in Homa Bay County (Stasch, 1990). Each sub-County was recorded on a piece of papers and placed in a container. The collection of papers was thoroughly mixed and then two pieces of paper removed from the container. The sub-County named on the two pieces of paper were included in the sample. This yielded Rangwe and Suba North. Simple random sampling was used to sample 50% of locations from each of the two sub-Counties thereby yielded four locations, Gem West and Gem East from Rangwe and Rusinga Island and Gembe from Suba North.

Table 3.4: Number of Households in Rangwe

Location	Number of Households
Gem West	4101
Gem East	4770
Kagan	5974
Kochia	5816
Total	**20,661**

Source: KNBS and SID 2013

Table 3.5: Number of Households in Suba North

Location	Number of Households
Mfangano Island	5510
Rusinga Island	5492
Gembe	3688
Kasgunga	4386
Lambwe	4464
Total	**23,540**

Source: KNBS and SID 2013

A simple random sampling technique was used to select households to be included in the study. The study intended to use village registers to construct household sampling frames but due to nonexistence of such registers the chief provided the information required to construct the sample frames. Using this method, 389 households were selected for the study.

The study was planned to have four FGDs, where each of the two locations of Suba North and Rangwe would have one each. One FGD was conducted in each location, giving a total of 4 FGDs for the whole study. Each FGD was made up of 10 participants with diverse personalities and attributes. Purposive sampling method was used to select members for focus group discussion since the method relies on the ability and capability of the participants to provide relevant information (Morgan. 1998). Through the guidance of the area chief, leaders of existing “chama” were contacted and the recommended 10 participants for the study. According to Krueger (1994) ten participants are considered large enough to gain a variety of perspectives and small enough not to become disorderly. The individuals selected had similar characteristics of the overall population and could therefore contribute to a greater understanding of the topic. Selecting from existing groups also took care of group dynamics and Synergistics relationship among participants to generate data for the study. Krueger and Casey (2000) posit that people tend to disclose more in a natural and comfortable environment. Members of the same group also trust each other and this increases willingness to fully engage in a group discussion. FGD adopted mixed method group as proposed by Freitas et al., (1998) with the aim of improving the quality of discussion. A convenient venue was selected for each discussion taking care into consideration participant comfort, access to the venue and minimum distraction during the session (Smith, 1972). The sitting arrangement ensured that participants had a clear view of each other and the facilitator. The meeting lasted for two hours as proposed by (Gibson, 2012; Heary & Hennessy, 2002).

3.7. Methods of Data Collection and Instruments

A mixed methods approach of collecting data from primary sources was used (Creswell, 2014). The following techniques were employed in this study.

3.7.1. Household Survey

To collect data quantitatively, the researcher administered 389 questionnaires to an adult member of the households which formed part of the sample for this study.

Questionnaire was chosen because of it being a cost-effective way of gathering massive qualitative data in a short period of time compared to approaches such as face to face or telephone interview. In addition, questionnaires provide anonymity which puts respondents at ease and encourages them to answer truthfully. Furthermore, questionnaires allow uniformity since each respondent receives identical set of questions (Bryman, 2012). Closed ended questions offer standardized responses which assist in interpretation of data from large numbers of respondents. The aim was to give all interviewees exactly the same context of questioning. This means that each respondent received exactly the same interview stimulus as any other. The goal of this style of interviewing was to ensure that interviewees' replies could be aggregated, and this would be achieved reliably only if those replies were in response to identical cues (Bryman, 2012). On average one interview lasted about 30 minutes.

The questionnaire for households was a combination of open-ended and closed-ended items made up of the following sections: demographic information; information of cookstoves; Energy used for cooking; information on cooking fuels; Energy used for lighting; Health related problems. These questions helped to gather data that helped to understand concepts, constructs, knowledge, attitudes and practices regarding effect of energy initiatives on people's socio-economic livelihoods. However, even though this was a questionnaire, other participants provided long responses explaining things which resulted into new insights being brought up. Some issues brought up were not on the questionnaire but proved relevant to the study. This information was not thrown away but treated as equally valuable and thus recorded in the field journal which was always kept handy.

3.7.2. Focus Group Discussions

The study conducted four focus group discussions (FGDs), where each of the two constituencies of Rangwe and Suba North had two. Each FGD was made up of 10 participants. According to Stewart et al., (2007) the principal methods of data collection during a FGD include audio and tape recording, note taking and participant observation. The study adopted note taking and participant observation methods. During these FGDs the researcher made it a point that every participant chipped in at one point or the other in the discussions. This prevented other members who are either very clever or good at public speaking from dominating the whole discussion and thus only their views on the matter being heard. The questions that were used in these FGDs were open ended. The researcher used a FGD guide which had a set of guiding questions reflecting the topics to be covered in the FGD. Additionally, a lot of follow-up questions were used during these FGDs to investigate further some of the responses which were provided.

3.7.3. Observations

In a research study, observations involve both seeing and listening. Creswell (2014) identifies four forms of observation in research as follows: *Complete participant* – where the researcher conceals role; *Observer as participant* – where the role of the researcher is known by the participants; *Participant as observer* – where the observation role of the researcher comes secondary to the participant role; and *Complete observer* – where the researcher simply observes without participating. Yin (2003), however, identifies *direct observation* and *participant observation* as two forms of observation in research. Bringing the two authors together, Creswell's first three forms of observation can be equated to Yin's participant observation, while

Creswell's last form would be equated to Yin's direct observation. For simplicity's sake, the study used direct observation and participant observation (Creswell 2014; Yin 2003).

Various approaches used to collect data through observation include: time interval which involves periodical observation of what is going on in the research area; event sampling which captures certain events that take place in a period of time, taking note each time, the event occurs; checklist whereby a list of possible activities that may be observed in a particular setting is captured. Checklist ensures that you focus on what actually occurs; rating scale which involves recording the degree to which something happens. The study adopted rating scale to observe type of ventilation, type of roof in the kitchen area, kitchen size and smoke and soot level in the cooking area.

Observation of the house was done while conducting interviews. These observations were done with consent from the chief and the participants and accorded the researcher an opportunity to collect additional information. Observation records were carefully kept as the interview progress. DeWALT, DeWALT, and WAYLAND (1998/2002) advise that field notes should be taken publicly to reinforce that the data being collected is for research purposes. The process of observation was selective as suggested by ANGROSINO AND dePEREZ, (2000) in that the observation focused on the kitchens and cooking places while conducting household interviews. This helped in understanding the conditions of their kitchens in terms of size, ventilation, cooking stoves in use, type(s) of energy used for cooking as well as building materials used. Another one was done when making the transact walks to check the immediate environment in terms of trees and other vegetation, facilities or social services provided as well as economic activities taking place in the villages. Besides, the researcher had informal conversations with some villagers and the issues that were relevant to the study were recorded as part of the observation. The researcher occasionally listened to what the villagers were saying amongst themselves and again recorded what was relevant in the journal. All these observations, either listening or seeing, brought in new insights that contributed toward an understanding of the issues under study.

3.8. Validity and Reliability

Validity and reliability are the two widely used criteria for assessing the quality of a social research. They are rooted in quantitative research (positivist approach) (Golafshan 2003), even though they are also used in qualitative research (naturalistic approach). However, even though reliability and validity are widely used in both types of research to assess research quality, other qualitative researchers prefer to use trustworthiness and authenticity. This study will use trustworthiness and authenticity to assess the quality of the research study.

3.8.1. Trustworthiness and Authenticity

In this study triangulation strategy was used to enhance credibility. The findings of this study were based upon various sources of information and data gathering methods. Interviews with participants were supplemented with observations, discussions with key informants, focused group discussions and documentary sources, which helped to triangulate data. The study used probability sampling which promoted generalizations because it sought representativeness of the wider population (Bryman, 2012; Cohen et al, 2007). It is hoped that by adopting this strategy for sampling, the research results would provide sufficient descriptive data to make transferability judgment possible.

This study adopted two methods to ensure dependability: audit trail and reflexive journal (Bryman, 2012). That entailed ensuring that complete records are kept of all phases of the research process (problem formulation, selection of research participants and data analysis decisions) in an accessible manner. Supervisors and other Lecturers acted as auditors, during the course of the research and certainly at the end to establish how far proper procedures had been followed (Bryman, 2012). In addition, as soon as the field work began, the researcher began a journal which was used throughout the research study. The purpose of this journal was to record the activities, ideas and decisions that were made during the research process. The intention was to use the journal as a master calendar of events as interview appointments were made, set deadlines, and identify the stages of the study progress. Moreover, the journal became the researcher's personal diary of notes regarding her own perceptions, feelings and interactions with participants. Furthermore, to enhance confirmability in this study the researcher ensured that the interviews, to the extent possible contained open ended questions and value free questions that allowed for gathering a more comprehensive view of the context.

3.8.2. Pre-testing of Instruments

The data collection instruments were pre-tested in Dhiwa Constituency to ascertain the reliability of the study instruments before the actual study was carried out. Pre-testing helped to determine whether the questions were acceptable, answerable, analyzable and applicable and to enable the researcher discern, alter or detect any questions which could have been misinterpreted or too sensitive to be asked without offending the respondents, thus coming up with a good final questionnaire. This study employed the test re-test reliability test. Tests were administered to the subjects for the first time then administered to the same subjects after two weeks. Mean scores from the two tests were then correlated using Pearson product moment correlation coefficient. Each instrument was expected to be reliable if it yielded to a correlation coefficient of 0.7 and above. Using Pearson correlation coefficient, the results were also found to be reliable. Pearson [$r=0.808$, with $p< 0.01$, $p=0.00$]. Thus, the responses based on the questionnaire were highly reliable. Questions were redesigned and put across explicitly and guides given on how to respond.

3.9. Methods of Data Analysis

Data for this study was analysed in two ways:

3.9.1. Quantitative Data Analysis

Quantitative data was obtained from the closed-ended items in the structured questionnaires. Data from the 389 structured questionnaires was coded, cleaned and errors validated and reconciled. Analysis involved analyzing one variable only at a time as well as examining the relationship between two variables (Bryman 2012).Analysis of single variables provided the basis for descriptive analysis and data was presented in the form of frequency tables and bar graphs. Data obtained from analysis of two variables was presented in the form of contingency tables which allowed two variables to be simultaneously analysed so that relationships between the two variables can be examined (Bryman, 2012).

3.9.2. Qualitative Data Analysis

The primary method of qualitative analysis in this study was the thematic analysis. In this study the interview schedule was adopted as the starting point since theoretical sampling was not used as a guide to data collection. Substantive statements in response to questions asked in interviews with participants were coded. Though the early part of coding was confusing, with a mass of apparently unrelated material, as coding progressed and themes emerged, the analysis became more organized and structured. There were no specific rules to define which segment of the text was to be coded; these segments were chosen based on the existence of clues for the presence of coding concepts (labels given to discrete phenomena). There was no restriction concerning the number of codes assigned to a segment of text. Most of the interview texts were considered useful data.

The study used both open and axial coding with the intension of deconstructing the data into manageable chunks in order to facilitate an understanding of the phenomenon in question. Open coding involved exploring the data and identifying units of analysis to code for meanings, feelings, actions and events and. The data, created new codes and categories and subcategories where necessary, and integrating codes where relevant until the coding was complete. Axial coding sought to make links between categories and codes, with the aim of integrating codes around the axes of central categories (Ezzy 2002); the essence of axial coding was to achieve interconnectedness of categories (Creswell 1998).

After coding the findings were summarized, formulated and restated to improve understanding and applicability to research questions. The pattern and relationships among the findings were identified and articulated in order to answer the research questions. The findings were then related to those of other studies in order to put them in perspective.

3.10. Ethical Considerations

This section looked at ethical principles that were used as guidelines in this study. The researcher obtained a research permit from NACOSTI authorizing her to collect data. After obtaining the research permit the researcher visited the research site to familiarize with the environment. The researcher sought further clearance from the chief of the area and the village elder.

Diener and Crandall (1978) quoted in Bryman (2012), pointed out four ethical principles that form guidelines in a social research and these are: *harm to participants, lack of informed consent, invasion of privacy* and *deception*. In addition to these four, other researchers identify *confidentiality* as another ethical guiding principle. The four ethical principles as outlined by Diener and Crandall (1978) were used as a guideline during the research. Since most of these principles are intertwined in that in pursuant of one principle you end up using one or several of the other principles, *confidentiality* was dealt with under *harm to participants* in this study. The researcher informed all possible respondents that they had been selected to participate in the study before conducting the research. In addition, they were also briefed on the nature and purpose of the study and also that whatever they said was safe with the researcher and no harm would be done to them for participating in the study. After giving them all this information, the researcher then asked if they were willing to participate in the study or not. This was done to obtain informed and voluntary consent from them as required in the guiding principle of *informed consent*. Once they had freely given consent to be interviewed then they were allowed to participate in the study. No form of inducement was used to obtain consent from these people to participate.

Secondly, the principle of *harm to participant* dictates that no participant should be subjected to any form of harm, physical or psychological, arising from their involvement in research. According to Bryman (2012), the issue of harm to participants also includes maintaining *confidentiality* of records where identities and records of individuals remain confidential and not identifiable even in publishing or disseminating results. All participants in this study were not subjected to any harm and their names were not mentioned to protect their identities and also save them from possible harm. In addition, the participants were assured of the confidentiality of information they provided and that it was not to be used in any other way, apart from the stated academic purpose, without obtaining permission from them.

The third ethical guiding principle was *invasion of privacy*. This principle entail that a researcher is not allowed to invade the privacy of the participant and that the participants reserve the right to refuse having their privacy invaded (Bryman 2012). Invasion of privacy took into consideration asking questions of a very personal nature that deals with a person's private life which they would not be comfortable bringing to the public. There was a limit to which a person's private life can be divulged to the public, beyond which cannot be condoned. The issue of privacy and informed consent are related in that the researcher obtains consent from the participant after full information about the nature of the research had been given to the participant, and the participant was aware of what they were getting into. However, this did not mean the participant should answer every question, and where they felt their right to privacy was being infringed upon they had the right not to answer such questions. The study did not involve such type of questions or information to maintain the participants' privacy.

Deception is the fourth ethical guiding principle. This principle requires the researcher to avoid use of any form of deception on the participants, for instance representing the study differently from what it actually is (Bryman 2012; Yin 2014). All participants in this study knew about the nature of the study and they were not deceived in any way at any point in the study. Furthermore, whenever the researcher made observations in the study area people knew what she was up to as she would have previously communicated to them to that effect.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, INTERPRETATION AND DISCUSION

4.1 Overview

The chapter presents the findings of the study based on the objectives. It presents the results on demographic characteristics of the household, analysis of cookstoves and fuels used by households, benefits drawn from the use of the ICS, challenges facing adoption and use of ICS and possible mitigation measures.

4.2 Demographic Characteristics of the Households

4.2.1 Household Characteristics by Sub County

Data was collected over two sub-counties with the numbers and frequencies for each sub-county shown in table 4.1.

Table 4.1 Household Characteristics by Sub County

Sub-County	Frequency	Percent
Suba North	195	50.1
Rangwe	194	49.9
Total	**389**	**100.0**

Source: Homa Bay County (2017)

Among the respondents 60.7% were female while 39.3% were men. Table 4.2 shows the results

4.2.2 Household Characteristics by Gender

Table 4.2 Household Characteristics by Gender

Gender	Frequency	Percent
Male	153	39.3
Female	236	60.7
Total	389	100.0

Source: Homa Bay County (2017)

Table 4.3 shows that majority of respondents were aged between 25-34 (36.6%) years and above 64 years were 7.2%.

4.2.3. Household Characteristics by Age

Table 4.3 Household Characteristics by Age

Age	Frequency	Percent
15-24	60	15.4
25-34	143	36.8
35-44	67	17.2
45-54	62	15.9
55-64	29	7.5
>64	28	7.2
Total	**389**	**100.0**

Source: Homa Bay County (2017)

4.2.4 Household Characteristics by Education Status

Table 4.4 shows that majority of the respondents had primary education (38/6%) followed by secondary education (31.1%). Only 14.4% had college and university education.

Table 4.4 Household Characteristics by Education Status

Education status	Frequency	Percentage
Never studied	36	9.3
Can read and write	26	6.7
Primary school	150	38.6
Secondary school	121	31.1
College	46	11.8
University	10	2.6
Total	**389**	**100.0**

Source: Homa Bay County (2017)

4.2.5 Household Characteristics by Income Level

Table shows that most of the respondents were self-employed (45.0%). The number of those who engaged in farming (28.5%) was also high.

Table 4.5 Household Characteristics by Income Level

Income level	Frequency	Percentage
Farming	111	28.5
Employment/Salaried	51	13.1
Self-employed/Business	175	45.0
Wage Labourer	15	3.9
Students	8	2.1
Others	28	7.2
None	1	0.3
Total	**389**	**100.0**

Source: Homa Bay County (2017)

4.2.6 Household Characteristics by Total Household Member

The size of most households ranged between 1-5 (69.9%) followed by 6-10 (28.8%) while very few households had more than 10 (1.3%) members.

Table 4.6 Household Characteristics by Total Household Member

Total household members	Frequency	Percent
1-5	272	69.9
6-10	112	28.8
11-15	5	1.3
Total	**389**	**100.0**

Source: Homa Bay County (2017)

4.3 The Types of Stoves and Fuels in Use for Household Cooking and lighting in Homabay County

Household fuels serve the essential energy needs for people's life, particularly cooking and water heating. The quality of supply of household fuels is characterized by different factors including the type of fuel (firewood, charcoal, LPG, kerosene, biogas, briquettes), the appliance used (traditional stove, improved stove, gas stove and ethanol stove), and delivery system (gathering, purchasing and self-production). These elements have several health and socio-economic effects on people. To analyse the extent to which energy initiatives have been implemented it was necessary to generate information on the type of cookstoves, lighting equipment and fuels which are in use in Homabay County.

4.3.1 Cooktoves for Household Cooking

Various cookstoves are owned and used by households as illustrated in figures 4.1. However, only KCJ (264), kerosene wick stove (82) and LPG (58) have been fairly adopted. Use of three stone fire is still high (254).

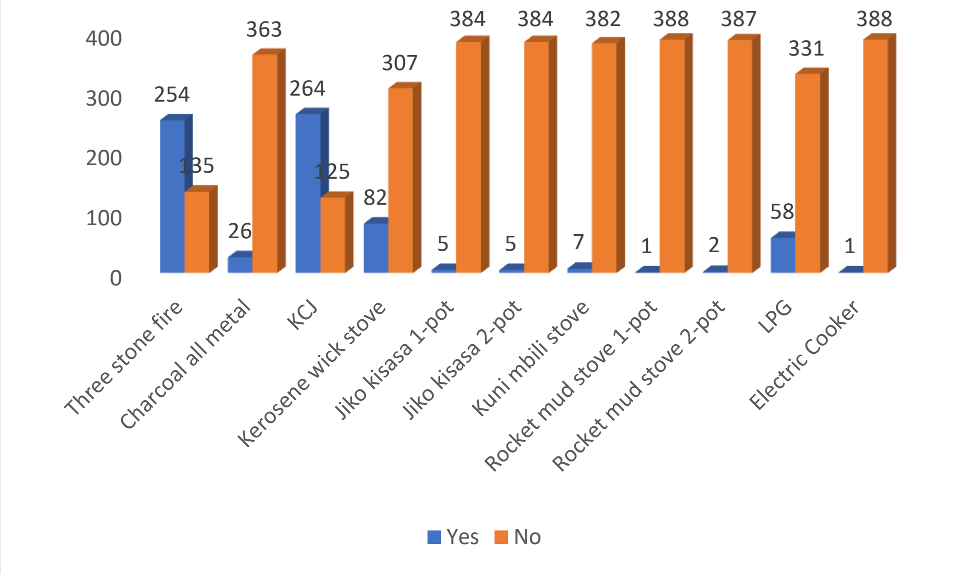


Figure 4.1: Cookstoves for Household Cooking

Source: Homa Bay County (2017)

National Institute of Population Research and Training (2009) also found that across rural Bangladesh, 98% of the population continues to cook with biomass in traditional cookstoves despite years of efforts to promote nontraditional cookstove technologies. According to ESMAP (2010) traditional cookstoves are inefficient, harnessing only 5–15% of biomass energy. The evidence of substantial use of traditional cookstoves therefore raises important questions about health and environmental risks associated with burning biomass in traditional cookstoves.

The number of households having ICS such as firewood jiko kisasa-one pot and two pot, rocket mud stove-one pot and two pot, sawdust stove, kerosene pressure stove and electric stove is low in the county. This is in line with the statement of WHO (2002) and Health Effect Institute that despite the negative effects of traditional cookstoves, half of the world's population and 75% of South Asians continue to burn solid fuels in inefficient traditional cookstoves for cooking and heating. Smith and Heigler (2008) also allude that many governments and development organizations have attempted to combat indoor air pollution by disseminating cleaner-burning cookstoves, but the adoption and use of these non-traditional cookstoves in the developing world has, with few exceptions, remained disappointingly low. This has been confirmed in the study area.

The study findings do not support what happened in Ecuador. In 2010, 800 rural families settled in the highland region of the Ecuadorian Andes received ICS(Zevallos et al., 2013). After six months of ICS usage the documented impacts included: an average reduction of wood consumption of 40% with a maximum value of 70% therefore reducing energy poverty; improvements on cooking conditions, such as a better position to cook leading to less time for cooking, less risk for fire accidents, physical modifications of kitchens after ICS installation (painting, shelves, household landfills, eco-refrigerators) and initiation of household health practices (consumption of boiled water, animals out of the kitchen, washing hands before eating, cleaning the kitchen and house) which improved food preparation, health conditions, and a reduction of indoor gas emissions, all of them influencing ultimately food security; women and children felt less pain in the eyes, headaches and throat pains; and due to warm temperature and kitchen cleanliness it became a frequent place to gather family members and neighbors hence enhancing social cohesion and improving the quality of life (Zevallos et al. 2013).

The study revealed that biogas digesters had not been constructed in the study area. This contradicts what has happened in Chunfeng village in China where at one time people depended heavily on firewood and coal for cooking. The Ministry of Agriculture (MOA) in an attempt to improve the rural living standards and to reduce the pollution from rural energy use, started the ‘prosperous eco-farmyards’ plan in

2000 (CPPCC, 2004). As the core instrument of this plan, the household-based biogas digester construction project was promoted in Chunfeng village from 2003 (MOA, 2002). By 2013, 136 biogas digesters had been built in Chunfeng village giving a penetration rate of 72% (Qin and Quan, 2014). The household biogas digester project emphasized a three-in-one ecological agricultural mode of pig raising (livestock feeding)-biogas digester-orchard cultivation (planting industry). The system consists of a toilet/livestock house (pigsty) biogas digester and orchard field. The human and livestock wastes are used as feedstock to produce biogas slurry and residues can be used as fertilizer in orchard or field around farmer’s house, while the anaerobic digestion effluent mixed with fodder can be used to feed pigs. The people of Chunfeng village use pig dung as the main feed stock for the biogas digester.

With respect to effect of biogas use on improved livelihoods, the household biogas digester project not only mitigates the contamination of drinking water by human and animal faecal matters (Chen et al., 2010), but also reduces the pollution of local surface and ground water caused by using chemical fertilizers and pesticides (He et al., 2013). Moreover, the use of biogas instead of firewood protects forests and thus can avoid the damage to watershed caused by deforestation and excessive exploitation of forest resources (Zhang et al., 2012). The project reduces the food production cost by decreasing household’s expenditure on chemical fertilizer.

The high-quality sludge-like organic fertilizers (i.e. anaerobic digestion residues and effluents, which could be regarded as by-product of biogas conversion process) are applied to backyard orchards or nearby fields to produce food without the pollution caused by the chemical elements (Zhang et al., 2012). The crop yields are raised by the improvement in the fertility of the soil through increasing the amount of organic and micronutrient elements in it. Besides, the use of biogas reduces the need for the traditional biomass energy such as crops straw and firewood, therefore reduce the time spent on collecting and processing them, and thus free the household labor from workload of biomass collection to food production (Gosens et al., 2013).

Other ICS found included three Ecozoom and one Jiko koa. These stoves were wrapped well and kept in their carton boxes. The three women who had Ecozoom explained that they were member of KWFT, ECLOF and Homabay Women Sacco respectively. Those who belonged to Homabay Women Sacco were given Ecozoom jiko at a deposit of Ksh 100 then they pay Ksh 700 per month. The total cost was Ksh 4500. A failure to use other energy sources to supply cooking energy might be either due to lack of awareness or to high costs It raises concern about diffusion and dissemination strategies for ICS and particularly for high-efficiency biomass stoves and also points to the evidence of limited demand.

4.3.2 Fuels for Household Cooking

Household cooking fuels came from four main sources. These included biomass, charcoal, kerosene and LPG.

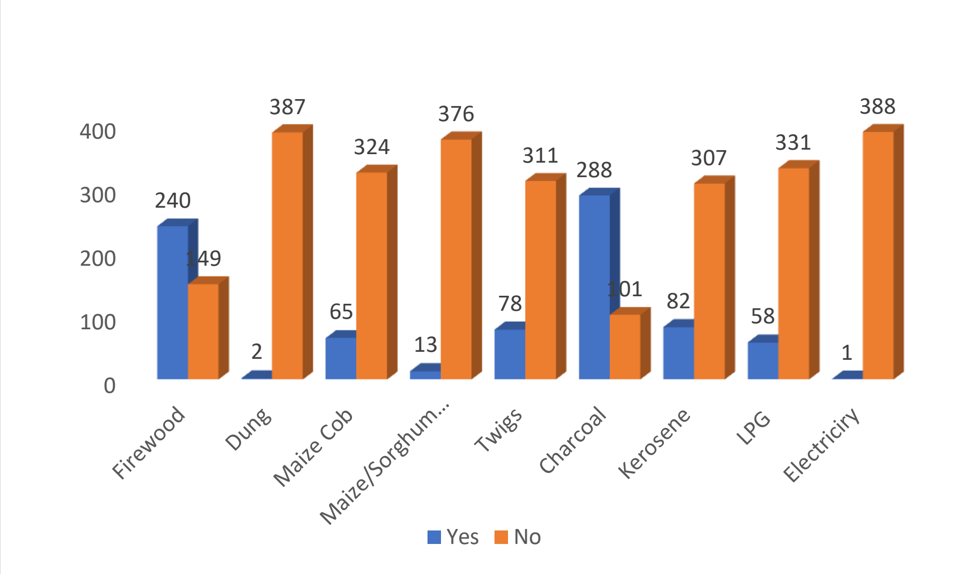


Figure 4.2: Fuels for Household Cooking

Source: Homa Bay County (2017)

The result agrees with the findings of the National Sample Survey 68th round, that the dominant fuel mix in rural India still consists of firewood and chips, with around two thirds of the households still dependent on them. Fuel wood, crop residue and animal dung are the three important types of biomass used in Ghaziabad (Government of India, 2015).Though kerosene is often advocated as a cleaner alternative to solid fuels, biomass and coal, for cooking some kerosene-using devices emit substantial amounts of fine particulates, carbon monoxide (CO), nitric oxides (NO_x), and sulfur dioxide (SO_2) (Cooper et al., 2012). Studies of kerosene used for cooking or lighting provide some evidence that emissions may impair lung function and increase infectious illness (including tuberculosis), asthma, and cancer risks. There is a strong and consistent body of evidence indicating that exposure to fine particulate matter (PM) increases the risk of respiratory and cardiovascular disease, cancer, and mortality (Krewski et al., 2005; Samet and Krewski, 2007; Yang, 2008; Tsai et al., 2012). One female cook gave the following explanation:

"We had to switch to charcoal and kerosene because of scarcity and high cost of firewood."

The study also revealed that electricity and biogas had not been widely adopted as cooking fuels.

The environmental and health benefits of a fuel are primarily dependent on its processing and usage techniques (GACC, 2011). Since households in Homabay still use traditional stoves, burning biomass fuel could continue to have a highly negative impact on health due to high emissions. Laan et al., (2010) explains that households using firewood in an open fire experience particulate matter (PM) concentration of over 3000µg/m^3 in the air compared to households using charcoal stoves, which are only exposed to PM concentration of around 500µg/m^3. According to the Global burden of Disease study (Kojima, 2011), 3.5 million premature deaths per year are directly attributable to IAP from the use of biomass fuels. Households in Homabay County are therefore at risk of suffering from impaired lung function and increased infectious illness.

4.3.3 Equipment for Household Lighting

Household lighting is a fundamental need, required in the home to extend work and study hours, and allow household tasks and social gatherings. People without any form of electricity supply resort to technologies such as kerosene lamps and candles that give off polluting fumes, pose a fire hazard, and are more expensive and of lower brightness than an electric light equivalent (*PPEO*, 2010). Respondents were asked to state the type of lamps used for lighting. Figure 4.3 shows that the households using kerosene use two types of lamps: kerosene tin lamp known as "*nyangile*" and kerosene Chinese lamp. Respondents from Suba North explained that:

"ICIPE rolled out a solar-Delight project whereby households were trained on the benefits of solar energy and then given a solar lamp free of charge. However, the solar lamps are controlled from a central point. They are switched on between 6pm and 6am. They also don't have provision for powering radio, TV and for charging mobile phones.

"

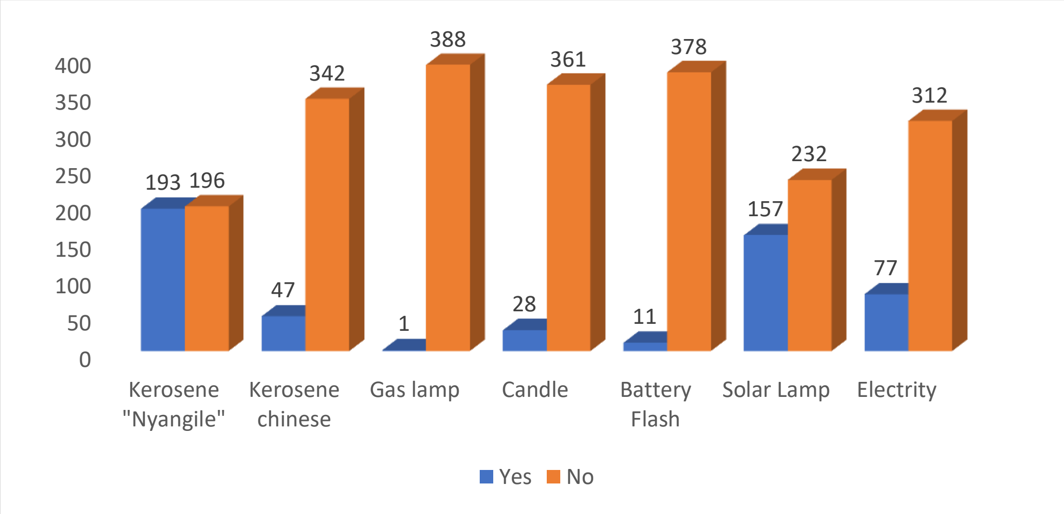


Figure 4.3: Equipment for Household Lighting

Source: HomaBay County

4.3.4 Main Source of Lighting

Respondents were asked to state the equipment used as the main source of light in the family. The study revealed high use of kerosene in traditional tin lamps (145). Use of solar (126) and electricity (76) as main fuels is fairly high.

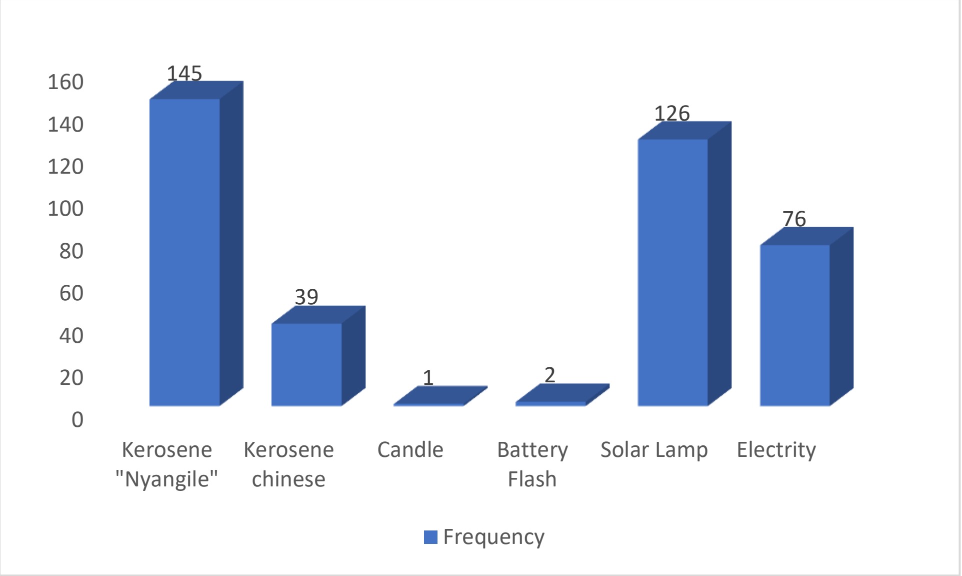


Figure 4.4 Main Source of Lighting in The Household

Source: Homa Bay County (2017)

The results support the findings of a study in Ghana that Households' lighting sources come from six main sources. These include grid electricity, small generators, rechargeable lamps, solar lamps and candles and traditional lamps/paraffin (Adusei, 2012).To meet the Total Energy Access minimum standard for lighting, a household must have atleast 300 lumens (a measure of light energy radiated by a light source) of light fora minimum of four hours per day (Practical Action, 2012).

Respondents were asked whether the lighting could be used for four hours. Figure 4.5 shows that very few households meet the lighting minimum standards prompting the question; is there energy poverty in Homabay County?

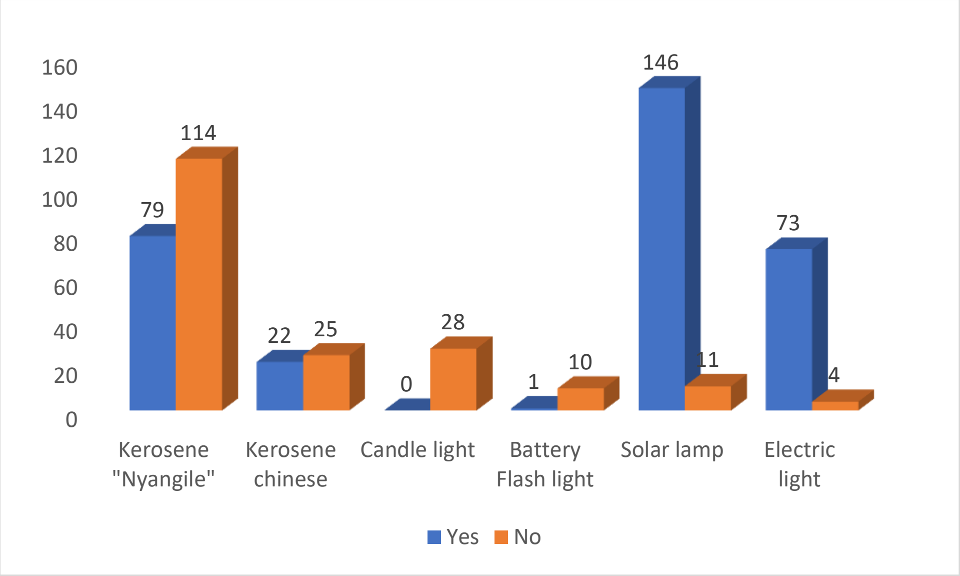


Figure 4.5 Using the Main Source of Light for More than Four Hours

Source Homa Bay County (2017)

The findings agree with that of Legros et al., (2009) who found that nearly 1.5 billion people, around 22% of the global population, do not have access to electricity. This is significant because it means that those without electricity for lighting have to resort to lamps that are polluting, dangerous and provide low-quality light. These options are more expensive than modern electric light. The very poor use flaming brands, candles and kerosene wick lamps in contrast with the high-efficiency light bulbs accessible to those with electricity. However, recent studies (PoppenDieck, 2010) reveal that pollutants from the cheapest kerosene wick stoves have the smallest particle size, and are thus the most dangerous since they are taken more deeply into the lungs. Beside candles and wick lamps, if unguarded, are intrinsically unsafe and lead to injury and death, particularly among women and children.

People without access to electricity use fuels for lighting that provide fewer luminescence or brightness (measured in lumens) for each watt of power consumed than electricity (Practical Action, 2012). A lumen (lm) is a measure of light energy radiated by a source. A kerosene wick lamp or a candle just provides 11 lm (PPEO, 2010) compared with 1300 lm from a 100w incandescent light bulb. This implies that those without access to electricity must endure light levels that are inefficient for safe work, study, or recreation.

Modern, efficient fuels produce a large amount of useful energy and little pollutants. However, they are generally more expensive. Photovoltaic solar lamps (PSL) and ICS can benefit the welfare and health of households that cannot afford high-quality fuels. ICS are technologically designed to burn biomass fuel efficiently and under the right conditions so as to minimize the production of harmful byproducts in the combustion process. The new generation ICS bring down emissions up to 50% (World Bank, 2012). PSL eliminate the need for kerosene fuels, since they rely on solar energy. This means PSL do not produce any damaging emissions.

4.4 Effect Energy Initiatives on People's Social-Economic Livelihoods

4.4.1 Benefits of Adoption of ICS

Finding a design that meets the needs of users plays a critical role, as consumers are at times hesitant to adopt a new and foreign technology. An analysis of perception of benefits from energy services showed that the respondents confirmed that the use of ICS saves fuel, saves time, reduces smoke, saves money, leaves a clean kitchen, less burns and accidents reduce respiratory diseases, less eye irritation and more comfort.

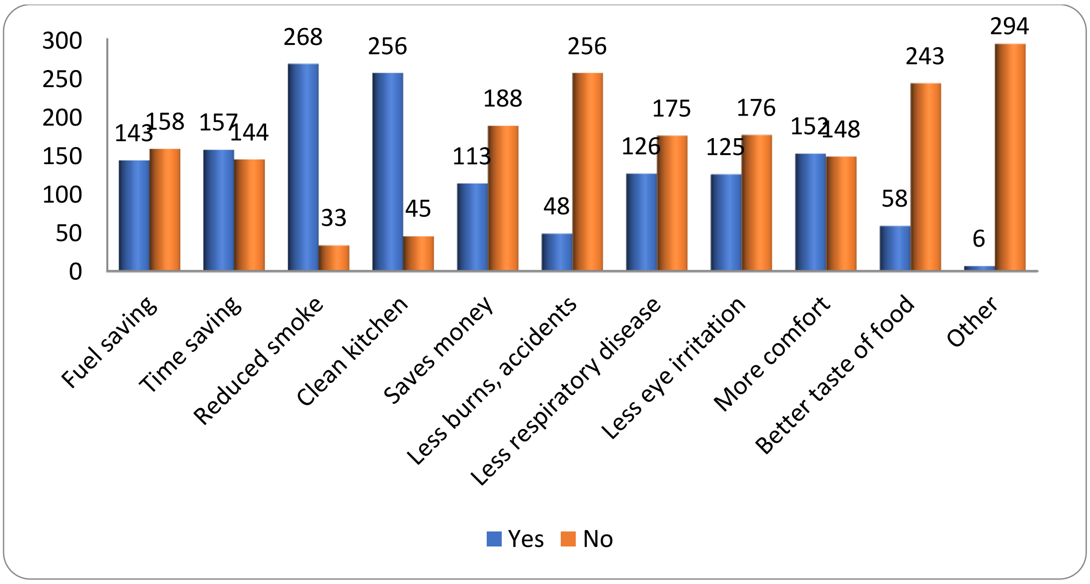


Figure 4.6 Perception of Benefits from Energy Services

Source: Homa Bay County (2017)

The finding agrees with the findings of a study carried out in Ghana by Adusei, (2012)in which Majority of households that use both charcoal and gas preferred gas over charcoal. Such category of household argued that the use of charcoal frustrated them and gave them a lot of stress. They argued that the ash produced during the use of charcoal caused dirt in the house which gave them additional work to do after cooking.

They also cited several benefits of using solar for lighting as shown in Figure 4.7.

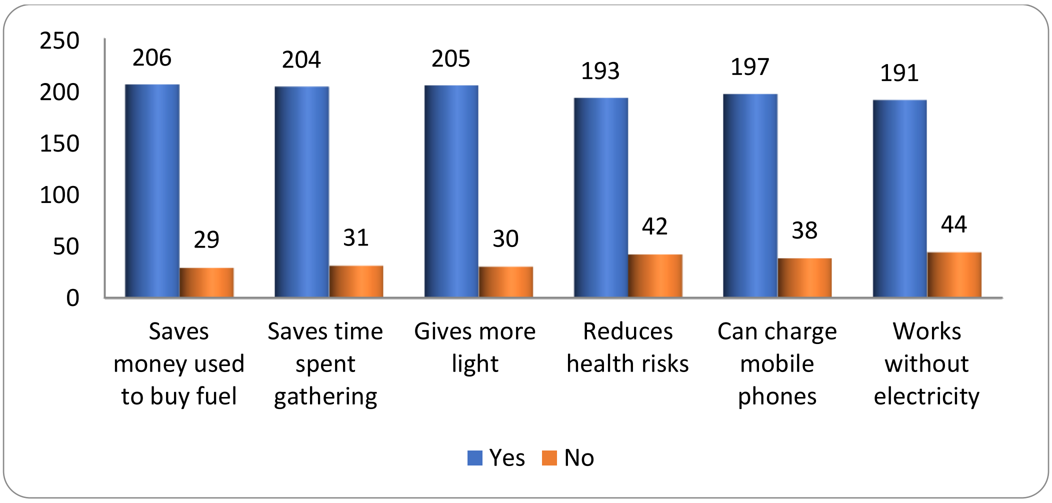


Figure 4.7 Knowledge about Benefits of Solar Lamps

Source: Homa Bay County (2017)

4.4.2 Time Saving by Households

Figure 4.8 shows that those who had ICS saved some time during cooking.

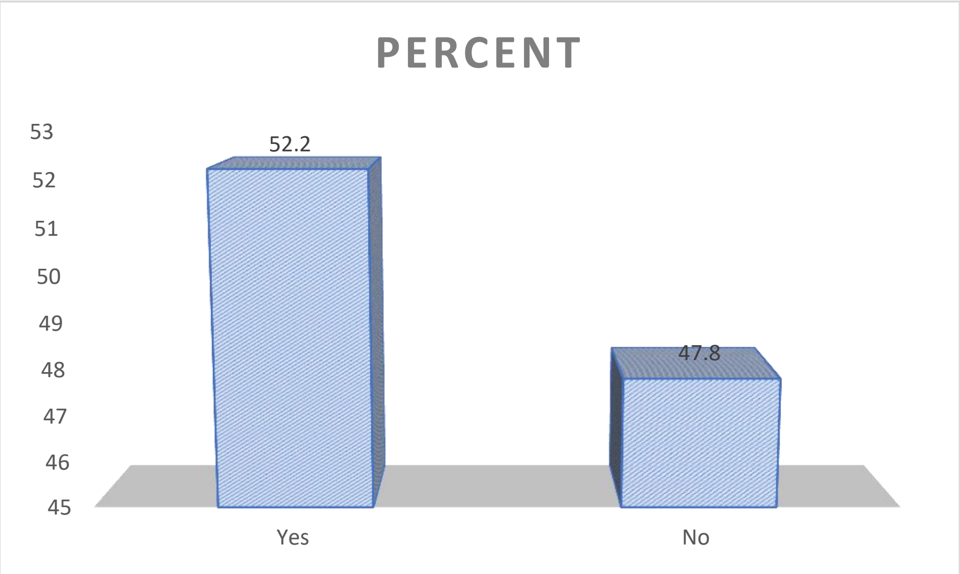


Figure 4.8 Time Saving by Households

Source: Homa Bay County (2017)

Majority of the households used the time saved to give attention to the children (35.7%) and attend community meetings (34.4%).

Table 4.7 Use of Time Saved

	Yes	**No**	**Total**
Gives more time to the children	56 (35.7%)	101 (64.3%)	157 (100.0%)
Started income generating activity	46 (29.3%)	111 (70.7%)	157 (100.0%)
Able to attend community meetings	54 (34.4%)	103 (65.6%)	157 (100.0%)
Meet friends and relatives	20 (12.7%)	137 (87.3%)	157 (100.0%)
Other uses of time saved	25 (15.9%%)	132 (84.1%)	157 (100.0%)

Source: Homa Bay County (2017)

A similar study done in Sri Lanka by Masse and Samaranayake, (2002) to explore how women used the time saving electricity had brought to their lives found that, 29% used it for extra housework while less than 5% reported using the time for productive activities. If improvement in wellbeing is an acceptable objective of development, then there should be no objection to "increase in free time" being used for rest; something women seem to be very short of. Yet rest was not reported by any respondent.

4.4.3 Electrical Appliances Adopted by Households

Adoption of electricity and solar made it possible for households to enjoy the benefits of other electrical appliances as shown in figure 4.10 below.

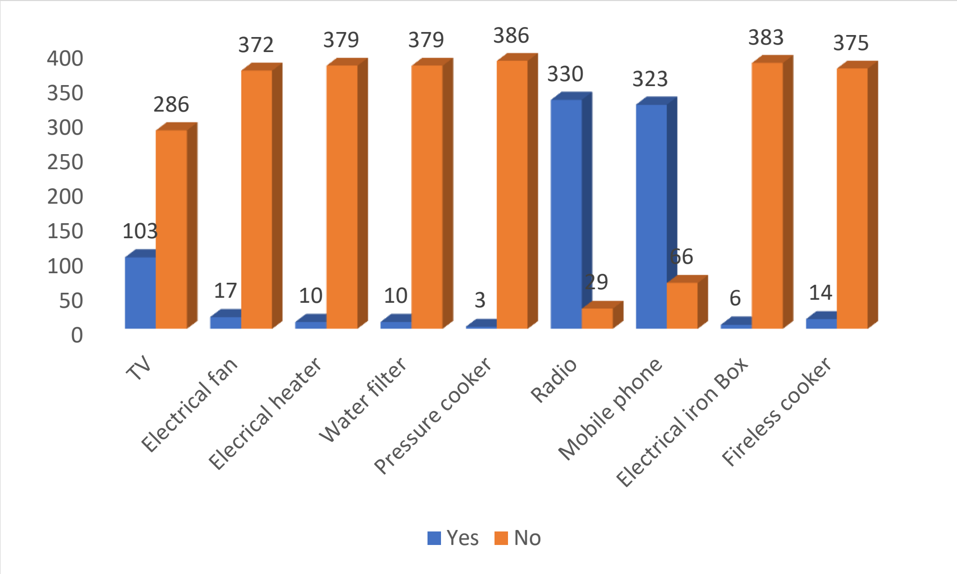


Figure 4.9 Electrical Appliances Owned by Households

Source: Homa Bay County (2017)

4.4.4 Effect of Energy Initiative on Education

The study examined whether light from solar and electricity was used to study and do school assignments at night. Table 4.8 shows that children used solar lamp (72.4%)and electricity (73.8%) for studies and doing school assignments. Use of kerosene for studies and doing assignments was majorly found to be high as shown in Table 4.8.

Table 4.8 Cross Tabulation of Main Source of Lighting and Source of Light used for Homework and Assignment

Main source of light	Child currently studying		Total
	Yes	No	
Kerosene Nyangile	86 (59.3%)	59 (40.7%)	145 (100.0%)
Kerosene Chinese	31 (79.5%)	8 (20.5%)	39 (100.0%)
Candles	0 (0.0%)	1 (100.0%)	1 (100.0%)
Battery flash light	2 (100.0%)	0 (0.0%)	2 (100.0%)
Electricity	55 (72.4%)	21 (27.6%)	76 (100.0%)
Solar lamp	93 (73.8%)	33 (26.2%)	126 (100.0%)
Total	267 (68.6%)	122 (31.4%)	389 (100.0%)

Source: Homa Bay County (2017)

Barnes, (2010a) carried out a national rural lighting survey of 6000 people in rural Peru. The study found that candles and kerosene lamps provided barely enough light to walk around the house. Higher income households without grid electricity used car batteries to power electric lights. In addition, studies have shown that electric lamps are much more efficient than kerosene in converting energy into light (PPEO, 2010). A 100w incandescent light bulb provides 12.8 kilolumens of light per kilowatt-hour compared with 0.1klm/kWh for a kerosene lamp. Moreover, fluorescent lights are four times more efficient than incandescent bulbs.

A simple small wick bottle lamp burns 10ml of fuel hourly and gives out light equivalent to that from a small electric flashlight (torch) bulb. The light is too dim for reading. Since the light is of poor quality, one tends to move close to the lantern, which increases the threat of inhaling more of the kerosene fumes. These fumes contain harmful components, such as CO, NOx, SOx and VOCs (Pope, 2010). There is evidence inhalation of these fumes can lead to respiratory deceases, throat and lung cancer, eye complications and infections and low birth weights (Torres-Duque et al., 2008). Also, those who cannot access kerosene may even use burning brands. The German Development Agency (GTZ) recommends 300ml (Bazilian et al., 2010) as a minimum ‘energy level’ of illumination required per household. The light is needed for a minimum of 4 hours, preferably 6 hours. This can neither be achieved by candle nor kerosene wick lamps, suggesting they are not adequate sources of household lighting. UNDP, (2005) explains that the availability of modern energy provides an opportunity to extend the daily time for course learning at night. It is not the case in the study area since most households used kerosene.

The study examined whether the energy generated from solar and electricity was used to power radios, TVs and mobile phones from which they would be able to access vital information. Table 4.9 shows that respondents were able to listen to educative programs on the radios, mobile phones and watch them on TVs as some of these programs are tailor-made for rural people and address specific issues pertaining to rural people’s welfare. However, the number of households who had mobile phones and radios in households where tin lamp was the main source of light was high. The implication is that they pay to have their mobile phones charged and also rely on dry cells to power their radios. The result is an additional cost on the already strained income. The results also suggest that electricity and solar influence getting information from TV, mobile phone and Radio.

Table 4.9 Getting Update Information from TV, Radio and Mobile Phones

Main source of light	Getting Update information					
	Mobile Phone		Radio		Television	
	Yes	No	Yes	No	Yes	No
Kerosene Nyangile	152	41	156	37	16	77
Kerosene Chinese	31	16	31	16	4	43
Candles	26	2	26	2	18	10
Battery flash light	11	0	9	2	7	4
Electricity	70	7	72	5	62	15
Solar lamp	144	13	146	11	59	98
Gas lamp	1	0	1	0	1	0

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between source of lighting and adoption of TV. The relationship between these variables was significant for electricity and TV, X^2(1, N=389) =140.58, p=.000; solar lamp and TV X^2(1, N=389) = 15.72, p=.000; kerosene "nyangile" lamp and TV X^2(1, N=389) =63.23, p=.000; kerosene Chinese lamp and TV X^2(1, N=389) = 7.85, p=.005; candle and TV X^2(1, N=389) =20.11, p=.000; battery flash light and TV X^2(1, N=389) =6.165, p=.013. The type of fuel has a significant influence on adoption of TV.

A chi square test of independence was performed to examine the relation between source of lighting and adoption of Radio. The relationship between these variables was significant for electricity and radio, X^2(1, N=389) = 4.80, p=.018; solar lamp and radio X^2(1, N=389) = 12.58, p=.000; kerosene "nyangile" lamp and radio X^2(1, N=389) =4.18, p=.029; kerosene Chinese lamp and radio X^2(1, N=389) = 13.18, p=.000; candle and radio X^2(1, N=389) =0.219, p=.000; battery flash light and radio X^2(1, N=389) =0.000, p=.1.000. the type of fuel has a significant influence on adoption of TV.

These findings imply that respondents benefited from advertisements aired on radio and TV which helped them get updates on trade, health and generally what is happening in their country. It also meant that they could inform each other of emergencies, meetings, opportunities and events in their villages through mobile phone calls. In addition, it strengthens social bonds between members of a family or community and fosters understanding and cohesion. It would also provide the much-needed entertainment to relax after a day's work. However, households with no solar or electricity complained about the high cost of charging the mobile phones and as a result they could neither leave them on during the day and/or night nor use them to listen to radio. It means that money which could be used to meet essential requirements in the home was diverted to charging of mobile phones.

The results concur with studies carried out by Matly (2003) in Sri Lankaand Asian Development Bank in Bhutan (ADB, 2010) which showed that access to television resulted in greater awareness of gender issues and rights. A study on the impact of cable television in rural India also found lower son preference, more self-determination, and less acceptance of domestic violence (Jensen and Oster, 2009). The study of households in Bangladesh (Barkat et al, 2002) found that women from electrified households were less likely to display son preference, less likely to arrange marriages for their children, less likely to suffer wage discrimination and had higher levels of empowerment (consisting of three indicators: women's freedom in mobility, participation in family decision-making process, and knowledge about gender equality issues), and this held true even when comparing electrified poor households to non-electrified rich ones.

4.3.5 Effect of Energy Initiatives on Income Generation

The participants were asked if they used ICS for any income generating activity. Figure 4.10 shows that only 15 participants used ICS for income generating activity. The number of households who did not use it for productive/income generating activity was very high.

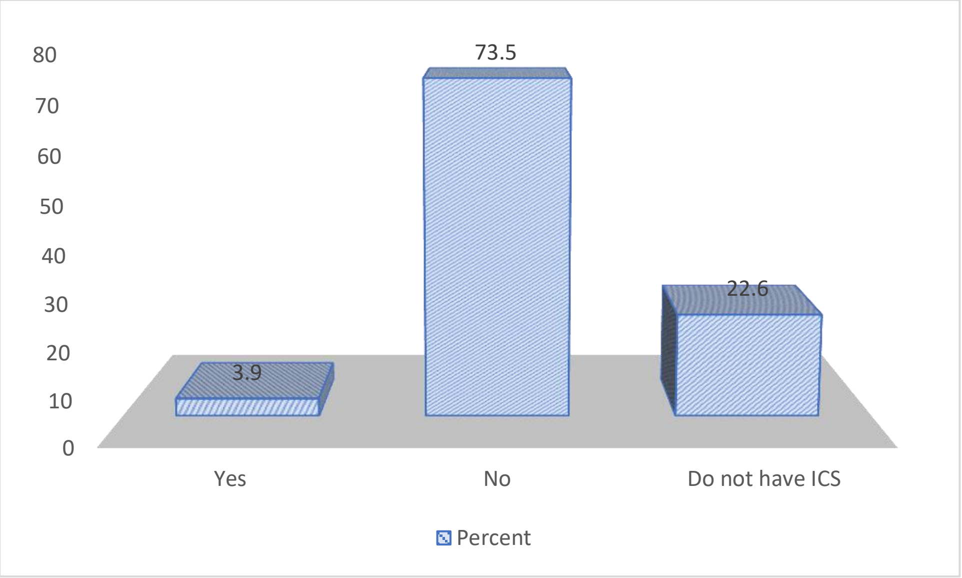


Figure 4.10 Use of ICS Stove for Income Generating Activities

Source: Homa Bay County (2017)

Women's micro-enterprises, an important contributor to household income, are often heat-intensive (food processing), labour intensive; and or light intensive (home based cottage industries with work in evenings). As a result, lack of adequate energy supplies for these activities affects women's ability to operate these microenterprises profitably and safely (Dutta, 2003).

Participants were asked to state the type of fuel used for cooking food/drink for sale. Table4.10 shows that 379 households said that they did not sell cooked food. There was no difference in the number of households per division. The study revealed that a number of households used firewood (1.3%), twigs (0.3%) and charcoal (1.0%) to prepare food for sale.

Table 4.10 Type of Energy/Fuel Used for Cooking Food/Drink for Sale

		Frequency	Percent
Valid	Firewood	5	1.3
	Don't sell cooked food	379	97.4
	Twigs	1	.3
	Charcoal	4	1.0
	Total	**389**	**100.0**

These finding contradicts the recent UNDP (2012) study, which concluded that the greatest potential for poverty alleviation comes from combining energy service delivery with efforts to support income generation through information services, training in business development skills and access to capital and markets, including support for the active engagement of women in the energy sector through new enterprises, entrepreneurial activities and sustainable resource management.

A study in Tanzania, Bolivia and Vietnam found that locating the enterprise in the household allows women in particular to combine income-generating tasks with household duties. Men report that the level of power available at the home is often not sufficient to operate the type of equipment they would use in enterprises, such as welding gear and motors. Encouraging women to sell energy products and lead energy enterprises can contribute to their economic and social empowerment. A growing number of energy enterprises have begun to engage women as sales representatives in order to reach consumers at the base of the pyramid with electricity and cooking solutions. Examples include sale of solar lights and mobile phone chargers (Solar Sister in Africa and SEWA in India), sale of clean energy products in largely women-run Tech Kiosks and Tech Agents (by Kopernik Solutions in Indonesia) and women building biogas digesters and managing biogas construction companies (Centre for Rural Technology in Nepal) (Biogas Sector Partnership Nepal, 2009). Women help ensure that energy products reflect the priorities of women users, thereby increasing the likelihood of adoption and use. Through their informal networks, they can reach remote and poor customers.

The study examined whether respondents were able to work at home way into the night if they had good illumination from solar and electricity. Women respondents did not mention working at night. In one house a female respondent who belongs to a women group who used *nyangile* to seal small polythene bags containing yeast, citric acid, bicarbonate soda, coffee and groundnuts for sale had this to say:

> *"We usually met at night to seal the polythene bag. We use heat from several nyangile lamps in one room. The lamps produce a lot of smoke and soot and most of us suffer from coughs and colds."*

When asked if there was any other alternative lamp that could serve the same purpose, she said that:

> *"A candle could be used but it has low heat, uncomfortable and expensive to use."*

The finding does not support Evaluations from South Africa and Guatemala which show that electrification has resulted in a 9% increase in female employment, with no comparable increase in male employment, and in Nicaragua electricity has increased the propensity of rural women to work outside the home by about 23% while having no effects on male labour force participation (Grogan & Sadanand, 2009; Grogan

&Sadanand, 2011). A study in Bangladesh (Barkat, 2002) showed that women in electrified households were more likely to do handicrafts and sewing during the evening; 11.2% of women in households with electricity were involved in such activities compared to 5.6% of women in un electrified households. The same is not supported by the study findings. Matly (2003) studied two communities who gained access to electricity, one in Indonesia and the other in Sri Lanka, the study showed that some women used their time gain for home-based income generating activities such as processing nuts and wrapping cigarettes. However, this extended day may sometimes be a mixed blessing. Lumampao et al (2005) found that a micro-hydro project in the Philippines actually had the net effect of increasing the time women spent working, and hence drudgery and time pressure, because having light available to do household chores at night meant that they could spend longer hours doing agricultural work during daylight hours.

4.5 Challenges Encountered in the Adoption and Use of the Energy Initiatives

This section presents an overview of the main challenges encountered in adopting and using energy initiatives in Homa Bay County. It describes the constraints identified in the adoption and use of energy initiatives in the County.

4.5.1 Intra-Household Dynamics

4.5.1.1 Household Income and Stove Adoption

Table 4.11 shows that the use of three stone fire (44.5%)and Kenya ceramic jiko (54.5%) was high among self-employed/business followed by farmers. The difference in the adoption of Kenya ceramic jiko between the two groups was high suggesting that income level has an influence on stove adoption. The self-employed/Business households also had high uptake of Charcoal all metal stove (65.4%), which is classified as a traditional stove, kerosene wick stove (79.3%) and LPG meko (44.8%). The adoption of electric cookstove was found to be negligible in the sub counties.

Non-adoption of jiko kisasa and kuni mbili stove was high across all income levels. The non-adoption of ICS such as rocket mud stove and sawdust stove remained high across all income levels. No household was found to have adopted kerosene pressure stove and LPG big cylinder in both sub-counties. These findings suggest that income is not the only factor influencing the choice of fuel at household level.

Table 4.11 Cross Tabulation of Income and Stove Adoption

	Occupation of household members						
	Farming	Employed/ salaried	Self-employed/ business	Wage labourers	Students	Others	Total
Three stone fire	98 (38.6%)	20 (7.8%)	113 (44.5%)	11 (4.3%)	0 (0.0%)	12 (4.7%)	254 (100.0%)
Charcoal all metal	2 (7.7%)	7 (26.9%)	17 (65.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	26 (100.0%
KCJ	45 (17.0%)	33 (12.5%)	144 (54.5%)	12 (4.5%)	8 (3.0%)	22 (8.4%)	264 (100.0%)
Kerosene wick	2 (2.4%)	5 (6.1%)	65 (79.3%)	0 (0.0%)	2 (2.4%)	8 (3.0%)	82 (100.0%)
Jiko kisasa-1pot	2 (40.0%)	1 (20.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)	5 (100.0%)
Jiko kisasa-2pot	1 (20.0%)	0 (0.0%)	4 (80.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
Kuni mbili	2 (28.6%)	1 (14.3%)	4 (57.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (100.0%)
Rocket mud stove-1pot	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Rocket mud stove -2pot	0 (0.0%)	0 (0.0%)	2 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
LPG	6 (10.3%)	21 (36.2%)	26 (44.8%)	0 (0.0%)	1 (1.7%)	4 (6.9%)	58 (100.0%)
Electric stove	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between income level and stove adoption. The relationship between these variables was significant for income level and adoption of three stone fire, $X^2(6, N=389) = 64.83$, $p<.05$; income level and adoption of Kenya ceramic jiko $X^2(6, N=389) = 60.85$, $p<.05$; income level and kerosene wick stove $X^2(6, N=389) = 60.35$, $p<.05$; income level and adoption of LPG $X^2(6, N=389) = 38.49$, $p<.05$.

4.5.1.2 Household Income and Fuel Adoption

Biomass has been widely adopted among farmers, employed/salaried and self-employed/business. Use of firewood was highly reported by self-employed/salaried (45.8%) and farmers (37.9%). Use of cow dung was found among farmers (100.0%) only. Maize cob (80.0%) and maize/sorghum stalk (76.9%)and twigs (67.9%) was high among farmers. harcoal has been highly adopted among the self-employed/business (55.2%), farmers (17.0%), and employed/salaried (12.5%). Clean fuels such as Kerosene, LPG and electricity have been adopted among the self-employed/business people. Adoption of Bio gas is negligible in all the income levels. These findings suggest that household income determine the transition from biomass to clean fuels.

Table 4.12 Cross Tabulation of Income and Fuel Adoption

Type of fuel	**Occupation of household members**						
	Farming	**Employed/ Salaried**	**Self-employed/ Business**	**Wage labourers**	**student**	**Other**	**Total**
Firewood	91 (37.9%)	19 (7.9%)	110 (45.8%)	9 (3.8%)	0 (0.0%)	11 (4.6%)	240 (100.0%)
Dung	2 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
Maize cob	52 (80.0%)	2 (3.1%)	4 (6.2%)	1 (1.6%)	0 (0.0%)	6 (9.2%)	65 (100.0%)
Maize/ sorghum stalk	10 (76.9%)	0 (0.0%)	1 (7.7%)	1 (7.7%)	0 (0.0%)	1 (7.7%)	12 (100.0%)
Twigs	53 (67.9%)	7 (9.0%)	8 (10.3%)	7 (9.0%)	0 (0.0%)	3 (3.8%)	78 (100.0%)
Charcoal	49 (17.0%)	36 (12.5%)	159 (55.0 %)	12 (4.2%)	8 (2.8%)	24 (8.3%)	288 (100.0%)
Kerosene	2 (2.4%)	5 (6.1%)	64 (78.0%)	0 (0.0%)	2 (2.4%)	9 (11.0%)	82 (100.0%)
LPG	6 (9.8%)	23 (37.7%)	27 (44.3%)	0 (0.0%)	1 (1.6%)	1 (1.6)	58 (100.0%)
Electricity	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between income level and fuel adoption. The relationship between these variables was significant for income level and use of firewood, X^2(6, N=389) = 52.79, p<.05; income level and use of maize cob X^2(6, N=389) = 107.93, p<.05; income level and maize/sorghum stalk X^2(6, N=389) =17.79, p<.05; income level and use of twigs X^2(6, N=389) = 90.95, p<.05; income level and charcoal X^2(6, N=389) = 82.06, p<.05;income level and adoption of kerosene X^2(6, N=389) = 60.35, p<.05income level and adoption of LPG X^2(6, N=389) = 42.84, p<.05. Income level has a significant influence on the type of fuel adopted.

> *"I use twigs and maize cob for cooking because I'm not strong enough to go far to look for firewood. These fuels fill the house with smoke which irritate the eye and cause running nose."*
>
> *"I used to use twigs to start the fire and then add large pieces of wood. This gave us time for other chores. The large pieces are not available so we spend more time cooking since we have to keep feeding the fire with twigs."*
>
> *"These days there are no forests to gather firewood from so we gather twigs from our firms. These are sometimes wet and we have to leave them to dry first. There are times we use wet twigs and get exposed to a lot smoke."*

These results support the findings of studies by Barnes et al. (2011) and Lee (2013) who found that as per capita income increase, households tend to switch to cleaner, more efficient fuels for cooking. The study revealed that use of firewood was high among the self-employed and salaried respondents. The finding contradicts that of Arthur et al., (2010) which showed that household wealth determined the transition from biomass to electricity in Mozambique. However, finding agrees with that of Sehjpal et al., (2014) who in his study in rural India found that household income is less significant compared to other social and cultural factors in choosing cleaner fuels.

4.5.1.3 Household Size and Stove Adoption

Adoption of ICS such as KCJ (69.7%), kerosene wick stove (74.4%), jiko kisasa (100.0%), kuni mbili (57.1%), LPG (77.0%) and electricity (100.0%) is high among households with 1-5 members.

Table 4.13 Cross Tabulation of Household Size and Stove Adoption

Type of stove	Total number of household members			
	1-5	**6-10**	**11-15**	**Total**
Three stone fire	158 (62.2%)	91 (35.8%)	5 (2.0%)	254 (100.0%)
Charcoal all metal	12 (46.2%)	14 (53.8%)	0 (0.0%)	26 (100.0%)
KCJ	184 (69.7%)	78 (28.8%)	4 (1.5%)	264 (100.0%)
Kerosene wick	61 (74.4%)	20 (24.4%)	1 (1.2%)	82 (100.0%)
Firewood jiko kisasa-1 pot	5 (100.0%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
Firewood jiko kisasa-2 pots	5(100%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
Kuni mbili	4 (57.1%)	3 (42.9%)	0 (0.0%)	7 (100.0%)
Rocket mud stove- 1 pot	0 (0.0%)	1 (100.0%)	0 (0.0%)	1 (100.0%)
Rocket mud stove-2 pots	1 (50.0%)	0 (0.0%)	1(50.0%)	2 (100.0%)
LPG	45 (77.0%)	13 (22.4%)	0 (0.0%)	58 (100.0%)
Electric cooker	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Biogas	1 (100.0%)	0 (0.0%)	0 (0.0%)	1(100.0%)

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between total household size and stove adoption. The relationship between these variables was significant for total household size and three stone fire, $X^2(2, N=389) = 21.47, p<.05$.

however, it was not significant for total household size and adoption of Kenya ceramic jiko X^2(2, N=389) = 0.344, p=.842; total household size and kerosene wick stove X^2(2, N=389) = 0.999, p=.607; total household size and LPG X^2(2, N=389) = 3.289, p=.193; total household size and electric cooker X^2(2, N=389) = 0.431, p=.806

4.5.1.4 Household Size and Fuel Adoption

Adoption of charcoal (68.8%), kerosene (75.6%), LPG (77.6%) and electricity (100.0%) was high among households with 1-5 members. Studies have found that large household size could influence stove adoption negatively, since in large households fuelwood collection and cooking can be shared between household members, consequently reducing the significance of the time and labor required to accomplish such tasks (Jürisoo and Lambe, 2016; Schlag and Zuzarte , 2008;Ray et al., 2014).

Table 4.14 Cross Tabulation of Type of Family and Fuel Adoption

Type of fuel	**Total number of household members**			
	1-5	**6-10**	**11-15**	**Total**
Firewood	14 (60.8%)	89 (37.1%)	5 (2.1%)	240 (100.0%)
Dung	0 (0.0%)	2 (100.0%)	0 (0.0%)	2 (100.0%)
Maize cob	44 (67.7%)	20 (30.8%)	1 (1.5%)	65 (100.0%)
Maize/Sorghum stalk	8 (61.5%)	4 (30.8%)	1 (7.7)	13 (100.0%)
Twigs	52 (66.7%)	25 (32.1%)	1 (1.3%)	78 (100.0%)
Charcoal	198 (68.8%)	85 (29.5%)	5 (1.7%)	288 (100.0%)
Kerosene	62 (75.6%)	19 (23.2%)	1 (1.2%)	82 (100.0%)
LPG	45 (77.6%)	13 (22.4%)	0 (0.0%)	58 (100.0%)
Electric cooker	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Biogas	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)

Source: Homa Bay County (2017)

4.5.1.5 Level of Education and Stove Adoption

The study revealed that the number of participants using three stone fire and Kenya ceramic jiko was high for respondents who had primary (43.3%) education followed by secondary (28.7%) education. The number of participants with tertiary education who had adopted Kenya ceramic jiko was fairly high. The level of education did not seem to have an influence on the adoption of firewood jiko kisasa and kuni mbili jiko and Rocket mud stove since the number of participants having them was very low and widely distributed despite their level of education. Adoption of kerosene wick stove was evenly distributed among participants with primary (40.2%) and secondary (39.0%) education. Table 4.15 shows the results.

Table 4.15 Cross Tabulation of Level of Education and Stove Adoption

Type of stove	Level of Education						
	Never studied	Can read and write	Primary school	Secondary school	College	University	total
Three stone fire	33 (13.0%)	21 (8.3%)	110 (43.3%)	73 (28.7%)	16 (6.3%)	1 (0.4%)	254 (100.0%)
Charcoal all metal	2 (7.7%)	1 (3.8%)	4 (15.4%)	17 (65.4%)	2 (7.7%)	0 (0.0%)	26 (100.0%)
KCJ	8 (3.0%)	13 (4.9%)	110 (41.7%)	90 (34.1%)	37 (14.0%)	6 (2.3%)	264 (100.0%)
Kerosene wick	3 (3.7%)	1 (1.2%)	32 (39.0%)	33 (40.2%)	12 (14.6%)	1 (1.2%)	82 (100.0%)
Jiko kisasa-1pot	0 (0.0%)	1 (20.0%)	1 (20.0%)	2 (40.0%)	1 (20.0%)	0 (0.0%)	5 (100.0%)
Jiko kisasa-2pot	0 (0.0%)	1 (20.0%)	2 (20.0%)	2 (20.0%)	0 (0.0%)	0 (0.0%)	5 (100.0%)
Kuni mbili	0 (0.0%)	1 (14.3%)	1 (14.3%)	4 (57.1%)	1 (14.3%)	0 (0.0%)	7 (100.0%)
Rocket mud stove-1pot	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Rocket mud stove - 2pot	0 (0.0%)	0 (0.0%)	1 (50.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
LPG	1 (1.7%)	2 (3.4%)	9 (15.5%)	24 (41.4%)	16 (27.6%)	6 (10.3%)	58 (100.0%)
Electric stove	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	1 (100.0%)

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between level of education and stove adoption. The relationship between these variables was significant for education status and three stone fire, $X^2(5, N=389) = 51.78$, $p<.05$; education status and Kenya Ceramic Jiko $X^2(5, N=389) = 46.22$, $p=.000$ education status and kerosene wick stove $X^2(5, N=389) = 12.38$, $p=.030$; education status LPG meko $X^2 51, N=389) = 47.29$, $p<.05$. Education status has a significant influence on the type of stove adopted.

Adoption of LPG meko was high among participant with secondary (41.4%) and college (27.6%) education. One participant with college education had adopted the use of electric stove. These findings suggest that adoption was not influenced by the knowledge of the options available or consequences of the use of the available energy technology rather people bought stoves based on affordability and the most available type of fuel. Those consumers who know their options may often be ignorant of the effects of their consumption choices. Because they do not understand the consequences of the use of traditional stove/fuel, specifically, the health and environmental effects, they could continue to use it in spite of the benefits of a transition to clean alternatives.

4.5.1.6 Level of Education and Fuel Adoption

Table 4.16 shows that biomass is widely used by those who have attained secondary education and below. Use of firewood was highest among those who had primary school (44.6%) and secondary school(27.9%) education. Maize cob was majorly used by those who had primary education (40.0%). Use of maize/sorghum stalk was 30.8% among those who had primary education and below. Use of twigs was 29.5% among those who never studied and those who had primary education. Use of charcoal was found to be high among those who had primary (39.2%) and secondary (37.2%) education. Those who had primary education also reported high adoption of kerosene (40.2%) while those in secondary school reported high adoption of LPG (41.4%) and electric cooker (100.0%). These results suggest that education level has some influence on the fuel used.

Table 4.16 Cross tabulation of Level of Education and Fuel Adoption

Type of fuel	Level of Education						
	Never studied	Can read and write	Primary school	Secondary school	College	University	total
Firewood	30 (12.5%)	21 (8.8%)	107 (44.6%)	67 (27.9%)	14 (5.8%)	1 (0.4%)	240 (100.0%)
Dung	0 (0.0%)	0 (0.0%)	2 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (100.0%)
Maize cob	13 (20.0%	10 (15.4%)	26 (40.0%)	12 (18.5%)	4 (6.2%)	0 (0.0%)	65 (100.0%)
Maize/sorghum stalk	4 (30.8%)	4 (30.8%)	4 (30.8%)	1 (7.7%)	0 (0.0%)	0 (0.0%)	13 (100.0%)
Twigs	23 (29.5%)	10 (12.8%)	23 (29.5%)	14 (17.9%)	8 (10.3%)	0 ((0.0%))	78 (100.0%)
Charcoal	10 (3.5%)	15 (5.2%)	113 (39.2%)	107 (37.2%)	38 (13.2%)	5 (1.7%)	288 (100.0%)
Kerosene	3 (3.7%)	1 (1.2%)	33 (40.2%)	32 (39.0%)	12 (14.6%)	1 (1.2%)	82 (100.0%)
LPG	1 (1.7%)	2 (3.4%)	9 (15.5%)	24 (41.4%)	16 (27.6%)	6 (10.3%)	58 (100.0%)
Electricity	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)

Source: Homa Bay County (2017)

A chi square test of independence was performed to examine the relation between education status and fuel adoption. The relationship between these variables was significant for education status and use of firewood, $X^2(5, N=389) = 49.41, p<.05$; education status and use of maize cob $X^2(5, N=389) = 26.76, p<.05$; education status and maize/sorghum stalk $X^2(5, N=389) = 22.92, p<.05$; education status and use of twigs $X^2(5, N=389) = 58.88, p<.05$; education status and charcoal $X^2(5, N=389) = 61.62, p<.05$; education status and adoption of kerosene $X^2(5, N=389) = 11.76, p=.038$. education status and adoption of LPG $X^2(5, N=389) = 59.02, p<.05$. Education status has a significant influence on the type of fuel adopted.

4.5.1.7 Gender Dynamics

4.5.1.7.1 Decision Making and Stove Adoption

When asked about who made specific decisions on purchasing fuel, assets and land and taking loans and saving with banks and Mfis women came in with a higher ranking as seen in decision on purchasing fuel. As seen in figure 4.11 men mainly had more say than women when it came to purchasing assets and land, taking loans and access to banks and Mfis. This shows that although men are considered head of the household women still have some decision-making power. The roles played by different family members in various household decisions gives an overview of the relative bargaining power within the family and how power is shared and concentrated within any family or household setting. Women may want to give stoves and fuels priority on their list of items to purchase but if financial decision are male dominated then they may be disadvantaged. Lack of finances means less transition to ICS and clean fuels

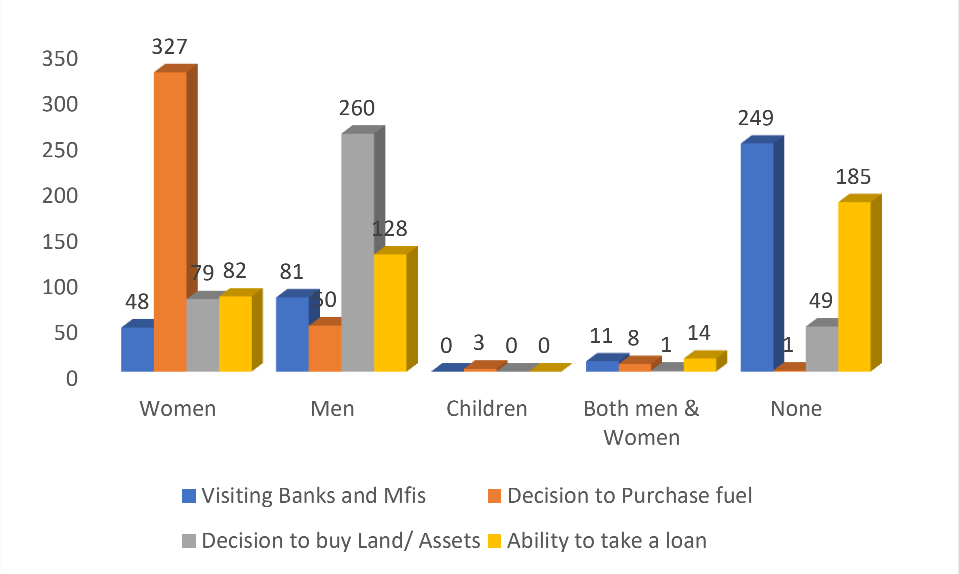


Figure 4.11 Decision Making in the Family

Source: Homa Bay County (2017)

Nearly all sub-Saharan African societies are characterized by patriarchy: generally, men are in control of the meaningful economic decisions in each household Mbuthi et al. (2007). Because it is women who are most often responsible for duties associated with household cooking, there could arise a minor conflict of interest, as household cooking is not a priority among men. In this study household decision making was examined.

The role of decision making to purchase fuel was also analyzed based on responsibility for taking loans. Table 4.17 show that decision to purchase fuel was dominated by women while ability to take loan was dominated by men. A chi square test of independence showed that there was a significant association between who makes decision to purchase fuel and the person who makes decision to take a loan, $X^2(15, N=389)=101.30$, $p<.05$. The significant relationship suggests that transition to

ICS and clean fuels would the upscaled if women could be exposed to more sources of finance.

Table 4.17 Relationship Between Decision to Purchase Fuel and Decision to take a Loan

Responsibility for purchasing fuel	Responsibility for taking loans				Total
	Women	Men	Both	None	
Women	62 (18.8%)	101 (30.7%)	8 (2.4%)	158 (48.1%)	329 (100.0%)
Men	0 (0.0%)	24 (48.0%)	1 (2.0%)	25 (50.0%)	50 (100.0%)
Both	0 (0.0%)	2 (25.0%)	5 (62.5%)	1 (12.5%)	8 (100.0%)
None	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)
Total	62 (15.9%)	128 (32.9%)	14 (3.6%)	185 (47.6%)	389 (100.0%)

Source: Homa Bay County (2017)

4.5.2 Behavioural Factors

4.5.2.1 Knowledge about ICS

Those who had traditional stove only were asked if they had heard of ICS. The response in figure 4.12 shows that all the 65.9% of the households had heard about ICS. This points to the need to examine why those who have heard about ICS still use three stone fire.

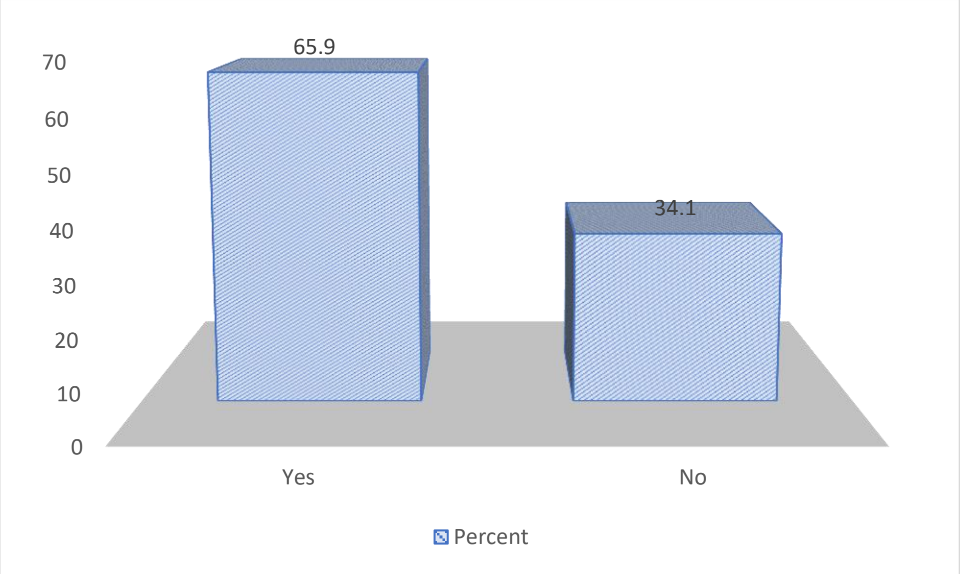


Figure 4.12 Knowledge of ICS among Those Who Did Not Have ICS

Source: Homa Bay County (2017)

Those who had heard about ICS were asked to give reasons why they were not using ICS. Table 4.18 shows that 28.6% households did not know where to find it pointing to the need to create awareness. The number of households who could not afford an ICS was 46.4% which is fairly high. There is need to come up with ways of generating money for example, revolving funds or schemes that give the cookstove at an affordable down payment followed by monthly installments.

Table 4.18 Reasons why Some Households were Using Traditional Stoves Only

	Frequency	**Percentage**
Don't know where to find it	16	28.6
No knowledge of dangers of indoor smoke	3	5.3
Not easily accessible	5	8.9
Can't afford	26	46.4
Traditional stove better fits our use	5	8.9
ICS does not use firewood	1	1.7
Total	56	100.0

Source: Homa Bay County (2017)

Some respondents said that:

> *"I have to use three stone fire because I have no other option since I lack money to purchase ICS."*
>
> *"Our financial condition is not good so we can't afford ICS."*
>
> *"I have always used the three stone fire. My parents used it and are still using it. We also have reliable source of firewood, agricultural waste and cow dung which can easily be used as fuel, so we are using them."*

Those who use traditional stove were asked to state how frequent they used three stone fire. Table 4.19 shows that the number of households who use the stove daily (74.4%) was very high

Table 4.19 Frequency of Using Three Stone Fire

	Frequency	**Percentages**
Every day	186	74.4
Often	8	3.2
Sometimes	38	15.2
For special occasion	18	7.2
Total	**250**	**100.0**

Source: Homa Bay County (2017)

Households who were using traditional stove only were also asked to state if they were happy with the existing stove. Table 4.20 shows that 69.4% households were happy with the existing stove.

Table 4.20 Household who are Happy with the Traditional Stove

	Frequency	**Percentage**
Happy with the existing stove	59	69.4
Want to switch to another type of stove	26	30.6
Total	**85**	**100.0**

> *"I have not experienced any disadvantage with my traditional stove. Members of our community have used it since time immemorial. However, the new generation women seem to have a problem with three stone fire."*
>
> *"We are not happy with the current stove. More smoke is generated in rainy seasons and the heat generated from it during hot dry seasons is not comfortable."*
>
> *"We are not happy with the current stove because a lot of smoke is generated during rainy seasons and in hot seasons we suffer from high heat while cooking."*
>
> *"We are not happy because the traditional stove makes my wife eye to burn from the smoke generated. Smoke also blackens the pots, burns clothes and hands but we have to continue using the traditional stove since we have no option."*

Those who heard no solar lamps were asked to state whether they had heard of solar lamp. Table 4.21 shows that 210 households had heard about solar lamps.

Table 4.21 Information about Solar Lamps

	Frequency	**Percent**
Have solar lamps	157	40.4
Yes	210	54
No	22	5.6
Total	389	100.0

They were also asked to state why they had not purchased one. 39.3% said that they could not afford. Others did not know where to find it confirming lack of information about energy initiatives available in the county.

Table 4.22 Reasons for not Purchasing Solar Lamps

	Frequency	Percent
Have solar lamps	157	40.4
Can't afford	153	39.3
I don't know where to find it	13	3.3
No source of income	5	1.3
Waiting for my husband to buy	2	.5
Has electricity	39	10.0
Declined to answer	20	5.1
Total	389	100.0

4.5.2.2 Socio-Cultural Issues

Respondents with ICS were asked to state whether they used the stove daily. Table 4.23 shows that 57.5% respondents reported using the ICS daily while 42.5% did not use it daily. A number of minor social and cultural issues could reinforce the dependence on traditional fuels. Cultural tradition could also play a role in the rejection of clean cooking stoves and fuel. The traditional methods of cooking with firewood could be so deeply ingrained in many local cultures making modernization to have little appeal, even when the potential savings are recognized. The incompatibility of household cookware with improved stoves could also illustrate how tradition can hinder the process of stove and fuel switching.

Table 4.23 Number of Respondents who Used ICS Daily

	Frequency	Percentages
Yes	173	57.5
No	128	42.5
Total	**389**	**100.0**

Source: Homa Bay County (2017)

Respondents who said that they did not use ICS daily were asked to state why they did not use it daily. 46 respondents said that they preferred to use traditional stove. Other respondents reported that ICS were not comfortable to use.

Table 4.24 Reasons for not using the Stove Daily

	Frequency	Percent
Prefer to use traditional stove	46	35.9
Not comfortable to use	63	49.2
Not seen any benefit	1	0.8
Other reasons	15	11.7
Declined to answer	2	1.6
Total	**128**	**100.0%**

Source: Homa Bay County (2017)

During FGD discussion respondents reported that;

"*I am not using LPG because I fear it might explode",*

"Jiko takes too long to light compared to three stone fire,"

> *"The metal used to make charcoal all metal stove gets damaged very fast then ash pours on the floor and it's also very hot leading to burns as you cook. Also, the pot rest for jikos and the door easily fall off."*
>
> *"When the ceramic for Kenya ceramic jikos break, we have nowhere to repair it. Consequently, I abandon the new casing and buy another one."*

Behavioral and cultural characteristics affecting household fuel choice are important to consider. A number of studies have looked into cultural factors such as food preparation and traditional customs, either to explain the prevalence of biomass as preferred fuel of choice or to account for the low adoption rates of cleaner fuels (Masera et al., 2000; Israel, 2002; Gupta & Kolhin, 2006; Ouedraogo, 2006; Joon, et al., 2009; Victor, 2011). The distinct flavor attained by foods cooked with either charcoal or firewood is by many considered to be better than the taste of food cooked with gas or electricity (ESMAP, 2015).

The study explored the reason why respondents either preferred traditional stoves or were not comfortable with ICS. Households who use ICS were asked to state any disadvantages they had encountered while using ICS. Majority admitted that there were disadvantages. Table 4.25 shows the results.

Table 4.25 Those who Experienced Disadvantages while using ICS

	Frequency	**Percent**
Yes	227	75.4
No	74	24.6
Total	**301**	**100.0**

Households who reported disadvantages were further asked to state the disadvantages they had experienced while using ICS. Figure 4.13 shows that respondents complained ofnot being able to sit around the fire, roast maize/meat and that ICS took more time to cook. Others reported that they were not able to cook on big pots, ICS need maintenance and that it was not possible to cook certain meals (mainly boiling potatoes, beans and *nyoyo*, a mixture of dry maize and beans, which require long time to cook). The category of others complained of the high cost of purchasing the appliances, buying charcoal, refilling LPG and fear of operating LPG cylinders.

> *"Kerosene wick stoves produce irritating smoke and black carbon which make it necessary to wash it every now and again."*

> *"Even though I prefer three stone fire, my house is small and so I am forced to use kerosene wick stove. The stove produces soot which gets clogged on the curtains which separate the bed area from the cooking area. The soot makes us suffer from blocked nose at night."*

The findings show that besides income and education, some deeply rooted cultural traditions, specific to each household or even to each person, play a crucial role as drivers of energy transitions.

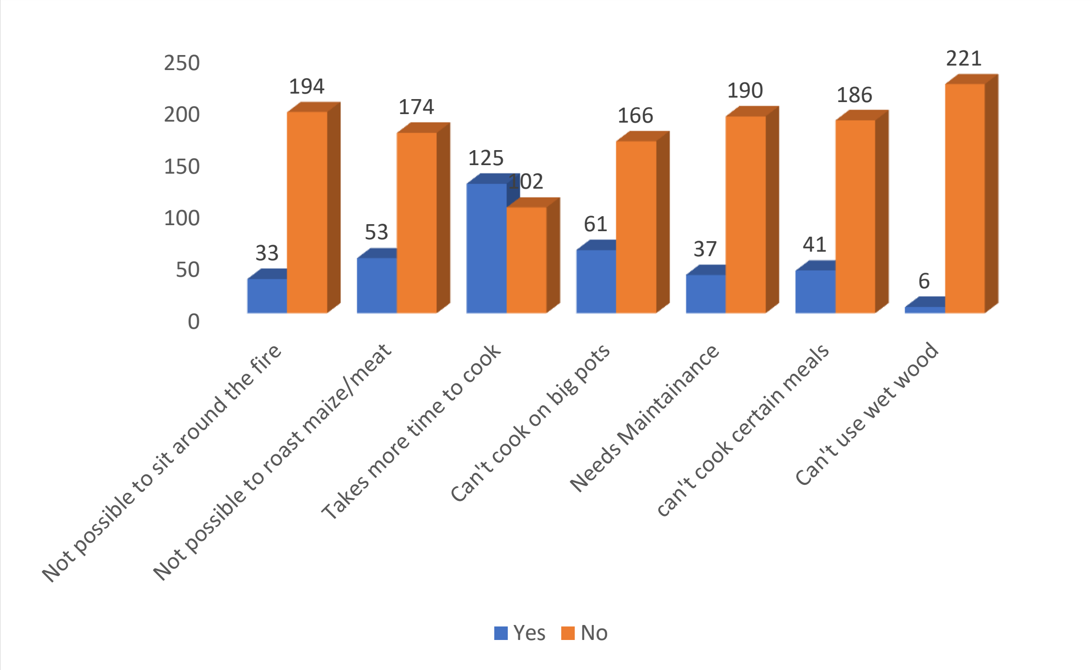


Figure 4.13 Disadvantages of ICS

Source: Homa Bay County (2017)

The results support the findings of similar studies in India and Mexico that when cooking traditional foods such as bread (Chapati) in India (Joon et al., 2009) and tortillas in Mexico (Masera et al., 2000), interviewees preferred the taste these foods acquired when cooked with biomass rather than LPG.

4.5.3 Market factors

4.5.3.1 Cost Perception of Fuels

One of the major barriers to the use of clean cooking fuel is its cost to the individual, which in many regions can be significantly higher than the cost of traditional fuel. Respondents were asked to state the amount of money spent on fuel per day, per week or per month. This was then converted to annual cost of fuel with the aim of finding out whether cost of fuel was responsible for low adoption and use of the energy initiatives and hence improvement on livelihoods. The results shows that majority of the households spent over ksh 10,000 annually on firewood. For clean cooking fuels to attain widespread use, they must be offered to the public at a price that competes with traditional fuels. Yet where direct and significant economic incentives to encourage demand for clean cooking fuel have not been implemented, there could emerge a clear pattern in which traditional options are much cheaper and are more widely used than clean cooking fuel.

The number of households who spent above ksh 10,000 on charcoal was high. Also high was the number of households who spent between ksh 9001-10,000, 7001-8000 and 5001-6000. The results suggest lack of firewood in the county.

> *"Use of charcoal has imposed serious financial burden on my family and I can only afford to buy it in small quantities each time I want to cook a meal."*

> *"My family relies on firewood but sometimes we prefer to buy kerosene to support cooking of simple foods like porridge, tea or baby food. This helps us save on firewood to be used for cooking other meals."*

Some of the households interviewed had so little cash flow that they bought charcoal twice rather than in large quantities. This in turn has financial implications since smaller bags cost more per unit weight than larger bags meaning the poorest people pay more for fuel. The number of households who spent between ksh 7001-8000 and between ksh 5001-6000 on kerosene was high.

Table 4.26 Cross-Tabulation of Type of Fuel and Annual Cost of Fuel

Annual cost (Ksh)	Firewood	Charcoal	Kerosene
1001-2000	2 (2.4%)	5(1.4%)	25 (9.8%)
2001-3000	19 (22.9%)	11 (4.0%)	34 (13.3%)
3001-4000	0 (0.0%)	6 (2.2%)	19 (7.4%)
4001-5000	0 (0.0%)	10 (3.6%)	15(5.9%)
5001-6000	8 (9.6%)	30 (10.5%)	55 (21.4%)
6001-7000	0 (0.0%)	0 (0.0%)	3(1.2%)
7001-8000	10 (12.0%)	31 (10.8%)	56 (21.9%)
8001-9000	0 (0.0%)	6 (2.2%)	9 (3.5%)
9001-10000	5 (6.0%)	40 (14.1%)	4 (1.5%)
>10000	39 (47.0%)	144 (51.3%)	36 (14.1%)
Total	83 (100%)	277 (100%)	256 (100%)

Source: Homa Bay County (2017)

The results support a report by Rysankova et al. (2014)that total annual spending on biomass cooking fuels (wood and charcoal) in sub-Saharan Africa was estimated to be US$12 billion in 2010 (or 0.9% of the region's GDP that year); this figure was set to increase to US$29 billion by 2020, assuming that current fuel price and consumption patterns continue. Other studies supported by these findings include that of Jain (2010) who found that Indian households continued to depend on traditional and inefficient fuels mainly due to high cost of clean and modern fuels.

Table 4.27 shows that majority of the households spent above Ksh 10,000 on LPG.

Table 4.27 Annual cost of LPG (Ksh)

Amount (Ksh)	Number of households	Percentage
1200	2	3.5
14400	22	37.9
15600	21	36.2
16800	2	3.5
18000	11	18.9
Total	**58**	**100**

Source: Homa Bay County (2017)

A similar study in India showed 7-10% of a household's income was spent on fuel and light, with almost 50% of this expense going for solid fuel in rural areas versus 6% in urban areas. Furthermore, 67% of all families used solid fuels as a primary fuel source, broken down into 87% in rural areas and 26% in urban areas (GACC 2013). In addition, in rural households in Bangladesh, approximately 8% of household expenditures went to energy use (Miah *et al.* 2010). All of the above-mentioned studies have a common argument: rural areas spend less on energy as a percentage of their income, but they rely more on solid fuel for energy. As a result of declining supplies of solid fuel, and without a viable alternative, households in rural areas are susceptible to rapidly rising fuel prices, thereby increasing their average fuel expenditure.

4.5.3.2 Financing Clean Cooking

The study explored whether respondents were involved in social groups and if their involvement in the groups had an effect on stove and fuel adoption. Out of the 389 households surveyed only 98 belong to formal groups. FGD revealed that the groups were not energy related. Most of them either were for table banking or small welfare groups within the community formed with the aim of raising money to take care of the welfare needs that arose within the community.

Table 4.28 Membership in formal/informal/traditional group related to energy by division

	Frequency	Percent
Yes	98	25.2
No	281	74.8
Total	**389**	**100.0**

Source: Homa Bay County (2017)

In light of the size of the initial investment, how to disseminate stoves more widely is a major question. However, while high capital cost is a deterrent, programmes that have offered subsidized stoves to households for free or at a minimal cost have been received with little enthusiasm. In such programmes, the direct subsidies created an undervaluation of the stoves and the users did not make the effort to operate it properly or maintain it to ensure its durability. This resulted in low usage rate; end users did not value that which was freely given (GACC, 2015). Many dissemination efforts have succeeded by pricing the stove at a self-sustaining level in a market where the socio-economic benefits of its use are recognized. The user is thus encouraged to purchase, and more importantly use, this stove for its financial value and also for its social benefits (e.g. in terms of health and opportunity cost).

Over the decades, energy interventions in Kenya have evolved to address various needs in energy. Netherlands Development Organization (SNV) partnered with the Visionary Empowerment Programme (VEP) in addressing some of the energy barriers facing women. VEP enables rural population to save money, provide a cushion against economic fluctuations and encourage a cooperative and community feeling.

VEP lending follows the Grameen Principles where groups save a standard amount of money every month, which they then lend out to themselves at an agreed interest rate. This approach targets the poorest women who live in households that own little or no assets. More than 7000 solar products were sold (75% through credit) between January and October 2012, reaching more than 10,000 people with clean lighting. VEP, being a women initiative, has enabled it to reach to the real people using the social capital approach. As an implementing partner of the Kenya National Domestic Biogas Programme, VEP had by end of November 2012 facilitated the construction of 812 bio-digesters half of which were financed through credit provided to women. Some of the products require large upfront investments and the credit provided by VEP at low interest rates of 1% per month on reducing balance has served as an incentive for low-income households to acquire the new technologies. No similar initiative was reported in the study area.

The Millenuim Villages Project (MVP) began in 2004 (Sanchez, 2010). In Kenya, the MVP in Dertu (North Eastern) and Sauri (Nyanza) in partnership with the government, private partners and local communities aimed at extending the electrical grid, increasing access to off-grid electricity and improving energy for cooking. The benefits of these innovations have not been realized in the study area.

EcoZoom is a social enterprise with the mission of transforming lives by supplying healthy, efficient charcoal and wood burning cookstoves and solar lights and offering the services needed to support the long-term uptake of these products. Operations in EcoZoom Kenya began in October of 2013; since then, the company has sold more than 17,000 stoves. The charcoal stove costs US$47 and saves households on average US$14 per month, with a payback time of 3.3 months. The wood-burning stove costs US$39 and will save the average household US$5 per month, amounting to an average payback period of 8.3 months.

EcoZoom does not provide end-user subsidies. Instead, it works to make products affordable to all customers by providing credit terms to distributors who then pass them on to end-users; by working with microfinance institutions to provide loans for product purchases; and by partnering with corporations that use “check-off” programmes with their staff. The company is also piloting a direct financial inclusion programme where loans are provided to end-users and are repaid over a three- or six-month period via mobile money. Only one participant reported owning EcoZoom cookstove. Only three participants reported credit facility or subsidy.

Kenya also has a good reputation for developing and promoting the use of more efficient stoves in rural areas (Zulu and Desanker (2001); Muchiri (2008)). In 1995, the Intermediate Technology Development Group (ITDG) initiated Upesi Cook Stoves Project whose objective was to improve the living conditions of rural women in western Kenya by giving them access to fuel-saving wood stoves (Khamati 2001). Existing women’s groups learned how to produce and market the cookstoves and how to draw up business plans, organize and manage production activities and access credit facilities.

Over 16,000 stoves had been installed, providing significant improved health, poverty alleviation and a relief from pressures caused by woodfuel shortage as well as time savings for users of the energy efficient stoves, (Khamati 2001). Women were trained in stove production, distribution, marketing skills, and stove installation in order to ensure project sustainability. The groups also had good leadership through, which they could channel resources, support from key government, non-governmental funding. The women's groups also engaged in tree planting, and helped to raise awareness of the need for conservation among the rural and urban populations. Existence of similar well organized energy related groups was not reported in the study area.

In SEI, project report 2014-01interviewees reported that majority of the energy related businesses were using microfinance institutions or village lending schemes to help customers access finance to buy the stoves. In addition, village level lending schemes, including "merry-go-round" schemes, which are very common in Kenya, and several Kenyan-based private actors, particularly the larger ones, had established strong links with such organizations to finance and distribute their products. The report adds that all of the large and medium-sized actors, particularly in Kenya, noted the importance of having an established rural distribution network to tap into village-level savings and loans facilities (Lambe et al., 2014). This was not the case in the study area. Anin-depth review of Project Design Documents in India showed that a majority of projects are relying on established networks to distribute their products. A number of actors were linking up with microfinance institutions to offer a full "package" in terms of product, finance and after-sales support, with the MFI typically handling marketing of the stove.

The MFI played a crucial role in awareness raising and stove marketing, often by demonstrating the stoves when customers come to its offices to access loans for other purposes (Lambe et al., 2014).

4.5.3.3 Sources of Information about ICS

Respondents who had ICS were asked to state how they came to know about the ICS for the first time. The study findings show that neighbours (175), radio (88) and marketing groups (79) played a key role in creating awareness. So far, the role of the private sector (cookstove producers, installers, NGOs) seems to be very low. In addition, the role of public meetings/field days and brochures/leaflets/calendars was also very low (figure 4.14). These results show that household have little access to information about their options. Many households may not be aware of the available alternatives and therefore not have a clear understanding of what their purchasing options are.

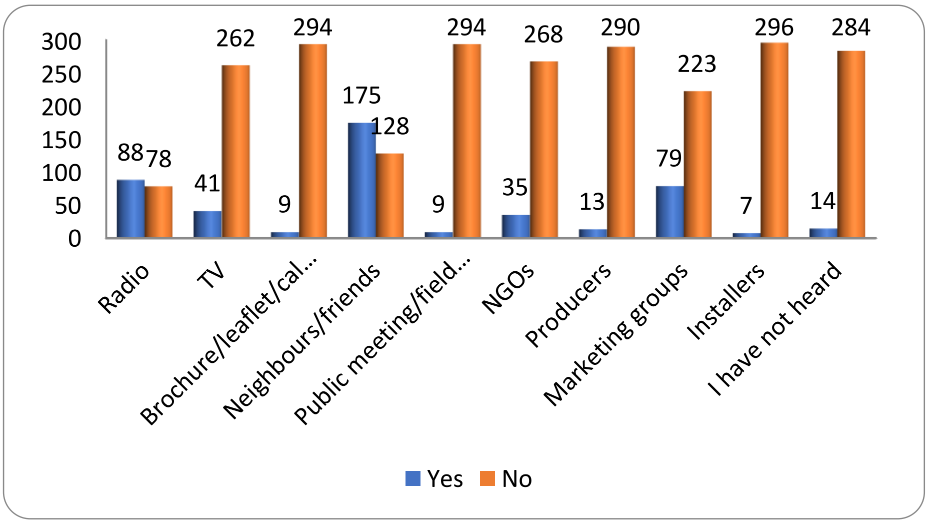


Figure 4.14 Sources of Information about ICS

Source: Homa Bay County (2017)

4.5.3.4 User Training

The study examined if they received any training on kitchen and fuel management. Table 4.29 shows that only 79 had received training. The number of respondents who had not received any training on kitchen and fuel management was high.

Table 4.29 Training on Kitchen and Energy Management

	Frequency	**Percentage**
Yes	79	20.3
No	310	79.7
Total	**389**	**100.0**

Source: Homa Bay County (2017)

Since many people have received little education that would help inform their choice of fuel, encouraging a shift to clean alternatives is a difficult task. However, it is likely that better awareness would increase consumers' willingness to make the change. Thus, public education would play an important role in encouraging a transition to clean cooking fuels.

4.5.3.5 Lack of Infrastructure

Respondents were asked to state the type of shop where they purchased the lighting/stove products from. Majority of the respondents (224) reported that they purchase from open air markets. One of the major impediments to the distribution of clean cooking fuels is underdeveloped infrastructure which is mainly a problem in rural areas, where lack of an extensive distribution network complicates efforts to offer modern alternatives to traditional fuel.

Table 4.30 Type of Shop where Lighting and Stove Product are Bought from

	Frequency	**Percentage**
Open air	224	57.6
Recognized dealer	163	41.9
Declined	2	0.5
Total	**386**	**100.0**

Source: Homa Bay County (2017)

Respondents were asked to comment on the distance between their homes and the market from where they purchased lighting/stove products. Majority said that it was far (49.1%) and a substantial number said that it was very far (8.7%).

Table 4.31 The Distance between Homes and the Market Place

	Frequency	**Percent**
Not far	162	41.6
Far	191	49.1
Very far	34	8.7
Decline to respond	2	0.5
Total	**389**	**100**

Source: Homa Bay County (2017)

The finding agrees with those of a study carried out by Adusei (2012)at Sekondi Takoradi, Ghana to explore household's experience with energy. The study found that not only is infrastructure to deliver energy weak, but in cases where infrastructures are available, physical access to energy is hampered by frequent shortages of LPG, irregular supply of grid electricity, frequent power cut, high cost of energy appliances (gas burners, cylinders, improved cookstoves, prepaid meters) and affordability problems among others. These greatly affect the socio-economic activities of members of the households particularly women who have a duty to secure fuel for activities such as cooking.

> *"Electricity is very unreliable. The blackout can last for two weeks making it impossible to watch news or charge phone."*
>
> *"Frequent power failures making it difficult for children to complete their homework in time. I'm also not able to extend chores into the night."*
>
> *"I prefer purchasing stoves and lighting equipment from open air market because they are cheaper there"*
>
> *"Open air market is preferable to me since I do not have enough capital to invest in durable ICS and lighting equipment." (*Open air stove dealer*)*

Apart from improving regional infrastructure, one solution could be the development of small-scale local energy resources. Here, biogas digesters, briquettes and micro-distilleries for ethanol might prove successful. If biogas were widely adopted, the need to establish extensive distribution systems would be bypassed.

4.5.3.6 Distribution Challenges

The study explored the challenges related to time spent purchasing fuel with the aim of finding out whether the energy initiatives had freed up household's time. Figure 4.15 shows that substantial amount of time was spent in going to purchase fuel.

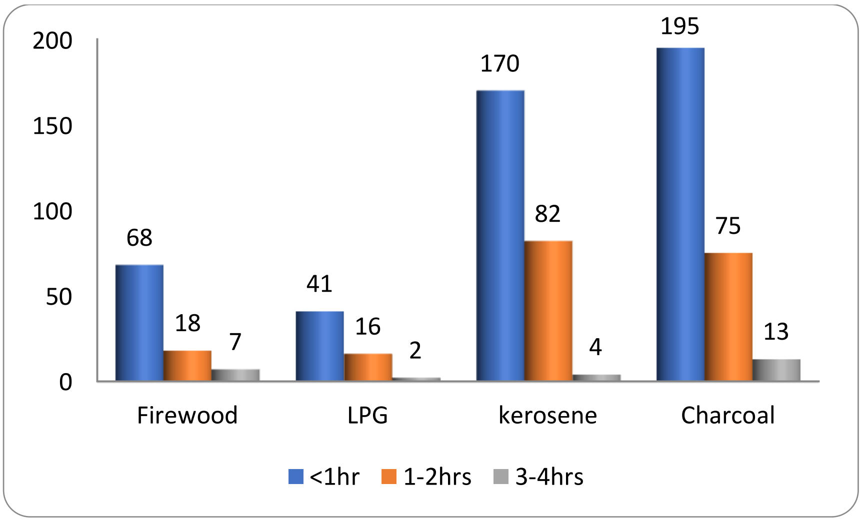


Figure 4.15 Average Time Spent to Purchase Fuel per Visit

Source: Homa Bay County (2017)

Collection time could have a significant opportunity cost, limiting the opportunity for women and children to improve their education and engage in income-generating activities(Clancy and Skutsch 2003). The results therefore suggest that respondents are deprive of time and may have to forfeit their economic opportunities. Many children, especially girls, may be withdrawn from school to attend to domestic chores related to biomass use, reducing their literacy and restricting their economic opportunities (Dutta, 2003).

The results shows that most households walked to and fro to the fueling points. This implies that firewood is carried on the head in most households. Use of bicycle, motorbike and cars suggest that they had to cover a wide distance in order to access the fuel. Majority of the households who purchased charcoal also walked.

Table 4.32 Mode of Transporting Fuel

	Walking	Bicycle	Motorbike	Hawkers	Car	Total
Firewood	79 (84.9%)	2 (2.2%)	7 (7.5%)	5 (5.4%)	0 (0.0%)	**93 (100.0%)**
LPG	6 (10.3%)	2 (3.4%)	38 (65.5%)	0 (0.0%)	12 (20.6%)	**58 (100.0%)**
Kerosene	242 (94.5%)	3 (1.2%)	11 (4.3%)	0 (0.0%)	0 (0.0%)	**256 (100.0%)**
Charcoal	238 (84.1%)	10 (3.5%)	30 (10.6%)	3 (1.1%)	2 (0.7%)	**283 (100.0%)**

Source: Homa Bay County (2017)

4.5.4 Technological Issues and Stove Performance

4.5.4.1 Stove Design

Majority of the users think that ICS are much better than traditional stoves. Together these constitute nearly 287 of ICS using households who prefer ICS to traditional stoves. A few users still have negative impression of ICS as the stoves are not performing as per their expectations. The number of respondents who thought that there was no difference was eight while those who thought that they were worse were three. However, it is important to note that since respondents were using different tiers of ICS, they had different perceived benefits of ICS and these negative impressions may be due to the use of an ICS which is not actually performing well, highlighting the need for more comprehensive testing of ICS.

Table 4.33 Comparison of ICS and Traditional Stove

	Frequency	**Percent**
Much better	169	43.4
A bit better	118	30.3
No difference	8	2.1
Worse	3	0.8
No response	91	23.4
Total	**389**	**100**

Source: Homa Bay County (2017)

4.5.4.2 Energy Initiative and Indoor Air Pollution

The presence of black carbon was confirmed by observation of the wall as shown in table 4.34

Table 4.34 Evidence of Soot Covered Walls

	Frequency	Percent
No soot	34	8.7
Yes	328	84.3
No	27	6.9
Total	389	100.0

Source: Homa Bay County (2017)

The presence of smoke and soot was confirmed by the results obtained from the observation of the kitchens and areas from where cooking was done. Table 4.35 show that smoke/soot level ranged from no soot to high soot level. This could be explained by the type of appliance and fuel used to cook supper.

Table 4.35 Smoke/Soot Level in the Kitchen

Smoke/soot level in kitchen	Frequency	Percent
No response	120	30.8
High	126	32.4
Medium	52	13.4
Low	91	23.4
Total	389	100.0

Source: Homa Bay County (2017)

4.5.4.3 Health Problems Reported in the Study Area

Respondents reported a number of health problems including chesty cough, eye irritation and high heat as shown in figure 4.16 below.

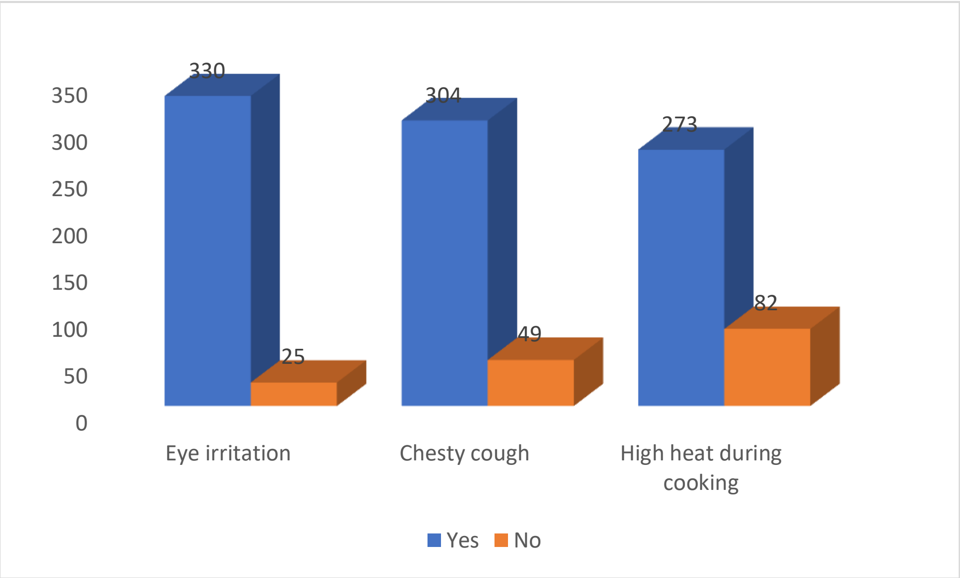


Figure 4.16 Health Problems Reported in the Study Area

Source: Homa Bay County (2017)

Studies have shown that use of inefficient cookstoves or cooking over open fires causes a range of serious health impacts, including death from IAP and increased incidence of respiratory illnesses (e.g., asthma) among women and children (Smith, 2012).

The results agree with the findings of Diaz etal. (2007) and Dherani et al. (2008) that women and children are afflicted with physical discomfort from smoke inhalation and cooking that includes eye irritation, headache, and lower back pain. Tielsch et al. (2009) adds that because of the cultural role of women in many regions of the world, both women and children experience a highest level of daily exposure. Therefore, both women and children are at the highest risk of health-related complications from IAP.

Dherani et al. (2008) carried out a meta-analysis of studies on pneumonia rise in children under 5 years. The findings of the study indicated that children exposed to solid fuels were more than 1.8 times more likely to contract pneumonia, compared to children without exposure. A study by Smith, Bruce, and Mehta, (2010) reviewed classified and summarized studies conducted over the past 15 years on the relationship between households' air pollution and health showed that household air pollution is related to a variety of illnesses. The study found increased health risk for acute lower respiratory infection (ALRI), chronic obstructive pulmonary disease (COPD) cataracts, lung cancer and cardiovascular disease. The increased probability of contracting such illnesses ranged from 78% for ALRI in children under 5 to more than 150% for COPD in women over 15 (Smith, Bruce, and Mehta, 2010).

The study also looked at how the problems reported were correlated with the type of fuel used. The results show that the problem of chesty cough was reported for all types of fuels used by households.

Table 4.36 Relationship between Chesty Cough and Type of Fuel Used

Type of Fuel		**Chesty Cough**		
		Yes	**No**	**Total**
Charcoal	33(11.5%)	221(76.7%)	34(11.8%)	**288(100.0%)**
Kerosene	11(15.8%)	53(74.6%)	7(9.9%)	**71(100.0%)**
LPG	19(31.1%)	32(52.3%)	10(16.4%)	**61(100.0%)**
Firewood	0(0.0%)	214(89.2%)	26(10.8%)	**240(100.0%)**
Maize cob	0(0.0%)	58(98.2%)	7(10.8%)	**65(100.0%)**
Twigs	0(0.0%)	61(78.2%)	17(21.8%)	**78(100.0%)**

Source: Homa Bay County (2017)

The people who reported chesty cough were comparatively few for Charcoal (76.7%) and kerosene (74.6%) compared to firewood (89.2%) and maize cob (98.2%) showing that adoption of clean fuels can improve health.

The chi-square values for the association between the problem of chesty cough and firewood, twigs and LPG was obtained as shown in the table below with 2 degrees of freedom and a significance probability less than 0.000 is a very highly significant result. The data also shows that the contribution of maize cob ($X^2(2, N=389) = 8.655$, $p<0.05$), firewood (X^2 $(2, N=389) = 57.876$, $p<0.05$), LPG (X^2 $(2, N=389) = 44.406$, $p<0.05$ and twigs (X^2 $(2, N=389) = 15.582$, $p<0.05$) were statistically significant. LPG is a clean fuel and therefore its positive contribution to the problem of chesty cough can be explained by fuel stacking whereby LPG is used by most households as a second fuel. The association is less statistically significant for charcoal (X^2 (2, N=389) = 6.656, $p<0.05$).

Cooking with kerosene did not show any significant contribution to chesty cough. Basing on the chi-square and p-value for charcoal and kerosene it can be concluded that adoption of these fuels has impacted positively on the health of the households.

Table 4.37 shows that number of people who suffered from eye irritation was high for all types of fuels.

Table 4.37: Relationship between Eye Irritation and Type of Fuel Used

Type of fuel	**Eye Irritation**			
		Yes	**No**	**Total**
Charcoal	31(10.8%)	235(81.6%)	22(7.6%)	**288(100.0%)**
Kerosene	11(15.5%)	54(76.1%)	6(8.5%)	**71(100.0%)**
Firewood	0(0.0%)	236(98.3%)	4(1.7%)	**240(100.0%)**
Maize Cob	0(0.0%)	64(98.5%)	1(1.5%)	**65(100.0%)**
Twigs	0(0.0%)	76(97.4%)	2(2.6%)	**78(100.0%)**

Source: Homa Bay County (2017)

The number of households who reported eye irritation was less for charcoal (81.6%) and kerosene (76.1%) compared to firewood (98.3%), maize cob (98.5%) and twigs (97.4%).

Based on the Chi-square and p-values at 2 degrees of freedom shown in table 4.4 association between eye irritation and the type of fuel used, the variables firewood X^2(2, N=389) = 90.318, $p<0.05$), LPG X^2(2, N=389) = 57.419, $p<0.05$), maize cob X^2(2, N=389) = 11.431, $p<0.05$)) and twigs X^2(2, N =389) = 12.619, $p<0.05$)) were statistically significant factors contributing to the problem of eye irritation. Charcoal $X^2(2, N=389) = 9.101, p<0.05$), kerosene $X^2(2, N=389) = 5.873, p<0.05$), reduced the problem of eye irritation.

A study on the use of biogas in Nepal showed that its use resulted in a 24% reduction in respiratory diseases, a 39.7% decrease in eye infections, 40.9% reduction in headaches, and 26% reduction in cough among women who had reported that they were suffering (Katuwal., et al., 2009). There were also reductions among men and children. Particularly vulnerable are the children because they spend a lot of time indoors close to the women who are doing the cooking.

Furthermore, research over the last few years has clearly shown that improved cookstoves can reduce particulate matter (PM) and carbon monoxide (CO) from burning firewood by 24 % – 70 %. As a result, firewood can nowadays be considered a relatively clean-burning fuel given the appropriate equipment. Charcoal emits fewer pollutants, has higher energy content and is easier to transport than firewood. A complete transition to charcoal would reduce the incidence of acute respiratory infections by 65 % (World Bank, 2009). LPG stoves emit 50 times less pollutants than biomass burning stoves (Schlag and Zuzarte, 2008). Indoor air pollution (IAP) resulting from biomass fuel combustion is ranked 4^{th} in the WHO top-10 list of global health risks responsible for 1.5 million premature deaths per year (IEA, 2006). The severity of the damages to health caused by IAP depends on three indicators. The first, source of pollution, deals with fuel and stove type, which in this case is biomass and Traditional cookstove. The second indicator, pollutant dispersion, deals with the type of house and how well ventilated it is. And the third, time spent indoors, looks at the time different household members spend indoors cooking or in direct contact with smoke(IEA, 2006).

Observation revealed that majority of the houses had iron roof. This easily supports construction of chimneys and other types of openings that can improve ventilation in a house as stated in the second indicator above.

Table 4.38 Type of Roof in the Kitchen

Type of roof in the kitchen	Frequency	Percent
No separate kitchen	130	33.4
Iron sheet	206	53.0
Wooden tiles	5	1.3
Grass thatch	40	10.3
Tiles	8	2.1
Total	389	100.0

Source: Homa Bay County (2017)

However, observation revealed that 117 houses had no ventilation, 79 had small holes or gaps while 63 houses had large holes and gaps.

Table 4.39 Permanent Ventilation in Roof of Kitchen

Permanent ventilation in roof of kitchen	Frequency	Percent
No separate kitchen	130	33.4
None	117	30.1
Small holes or gaps	79	20.3
Large holes and gaps	63	16.2
Total	389	100.0

Source: Homa Bay County (2017)

The finding shows that the second indicator has not been met. Bruceet al. (2004) found that in addition to stove and fuel type, kitchen volume and eaves have some effect on kitchen Carbon monoxide. Similarly, in Honduras Clark et al. (2010) found that stove quality alone as a proxy for exposure was not sufficient. Household characteristics influencing ventilation provided a better evaluation. In Ghana and Ethiopia, Pennise (2009) found that ICS brought significant improvements, yet more changes in stove and/or fuel type or in household stacking patterns was found necessary to bring PM levels to safe levels.

In addition, observation of the type of ventilation in the kitchen showed that it was bad for a notable number of houses and worse for others. The number of houses where there was no separate kitchen was also high. Most of these were single rooms where cooking was done from inside in an area close to the bed.

Table 4.40 Ventilation of the Kitchen (Window/Door Size, Eave Space etc)

		Frequency	Percent
Kitchen ventilation	Very good	50	12.9
	Good	88	22.6
	Okay	61	15.7
	Bad	56	14.4
	Worse	4	1.0
	No kitchen	130	33.4
	Total	389	100.0

Source: Homa Bay County (2017)

Smithet al. (2010) explains that cooking indoors and in poorly ventilated, enclosed areas can greatly increase the risk of respiratory disease. Eventually it is the women and children who are primarily affected by IAP as they are in constant contact with biomass combustion smoke from being involved with cooking or, in the case of children, being around the fire while it is burning. He adds that a simple chimney stove can substantially reduce chronic exposures to harmful indoor air pollutants among women and infants. Additionally, placement of an improved vented stove can reduce acute respiratory illness (Harriset al. 2011).

Observation of the size of the kitchen revealed that it was above average for most houses with a separate kitchen. However, the number of houses where cooking was done from a space that was part of the main house and where the kitchen was much smaller than average was high.

Table 4.41 Size of the Kitchen

Kitchen size	Frequency	Percent
No separate kitchen	130	33.4
Much larger than average size	36	9.3
About average	143	36.8
Much smaller than average	38	9.8
Part of the main house	42	10.8
Total	389	100.0

Source: Homa Bay County (2017)

Respondents were asked to state the number of hours spent near a stove the previous day. This was to find out if time spent indoors (indicator three) was long enough to increase the risk of IAP. The data shows that a substantial number of households spent three hours and above.

Table 4.42 Time Spent Near Stove Yesterday

		Frequency	Percent
Valid	<1 hours	6	1.5
	1-2 hours	36	9.3
	2-3 hours	105	27.0
	3-4 hours	178	45.8
	Above 4 hours	64	16.5
	Total	389	100.0

Source: Homa Bay County (2017)

Similar results were found by Balakrishnan et al. (2002) in Tamil Nadu, India, where women cooks spent over six hours per day in the kitchen area, whereas those not involved in cooking spent less than an hour. Although a common theme in rural settings is that women spend significantly more time in the kitchen area than do men, thereby increasing their exposure to indoor pollution (Jiang and Bell 2008), ICS has benefits at household level. Cooking time is reduced with ICS as they are better at retaining heat, therefore cooking becomes faster, this allows women more time to perform other household tasks.

4.6 The Interventional Strategies for Enhancing Adoption and Efficient Use of the Energy Initiatives

4.6.1 Proper Ventilation and Use of Chimneys

To achieve clean and convenient cooking, and reap the full range of socioeconomic benefits from improved cooking practices, requires consideration of both the stove and the fuel, and how they combine in practice. People should be educated on how to minimize IAP. Figure 4.17 shows that respondents are conversant with possible strategies used to minimize IAP. However, there is need for more education and awareness creation on importance of good ventilation and inclusion of chimneys and smoke hoods during construction and why switching to ICS can help mitigate this problem.

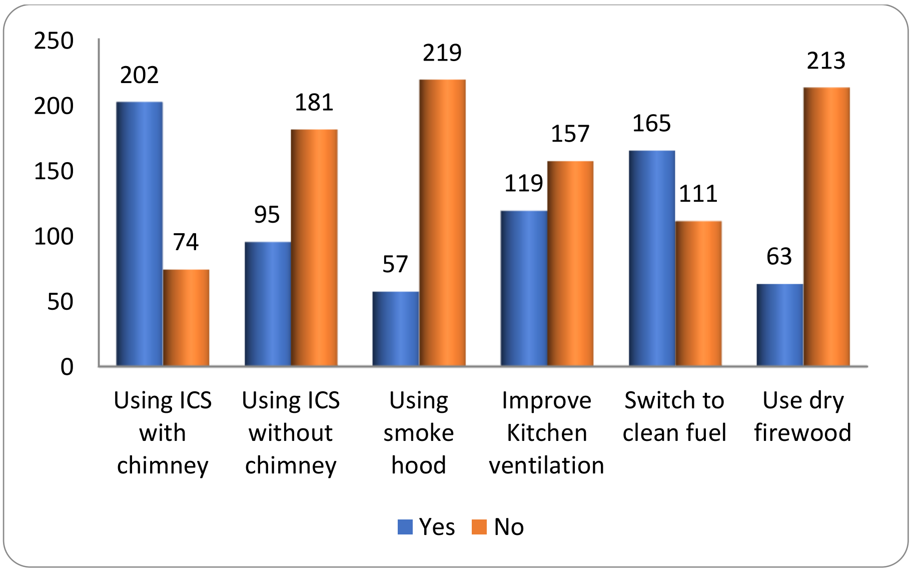


Figure 4.17 Possible Solutions to the Problem of Smoke

Source: Homa Bay County (2017)

4.6.2 Purchasing Fuel in Small Quantities

The study revealed that 92 households purchased firewood. Majority of these households bought firewood daily while some bought firewood per week. Most respondents purchased kerosene per week. The number of households who purchased kerosene per day was also high. The number of households who purchased charcoal per day and per month were equal. 56 of the respondents bought charcoal per week.

Table 4.43: Frequency of Purchasing Fuel

	Per day	Per week	Per month
Firewood	58	33	1
Kerosene	51	190	15
Charcoal	113	56	113

Source: Homa Bay (2017)

Respondents were asked to state how much money they spent on firewood. Majority of the households spent between sh50 and sh100 per day. The number of households who spent between sh 20 and sh 30 per day was significantly high.

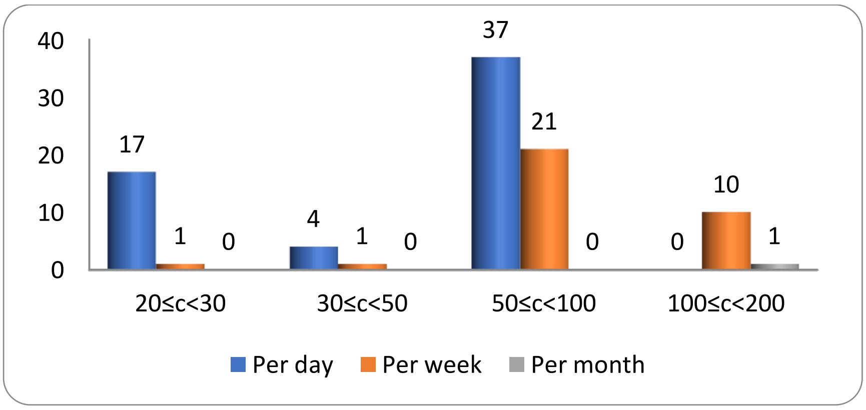


Figure 4.18 Cost of Firewood per Unit

Source: Homa Bay (2017)

The number of households who spent between sh 50-200 per week was quite high. Those who spent between sh20-30 and sh 50-100 per day was also high. Households in rural villages tend to use kerosene for lighting and purchase it in small quantities that are under one-litre (Tracy and Jacobson 2012).

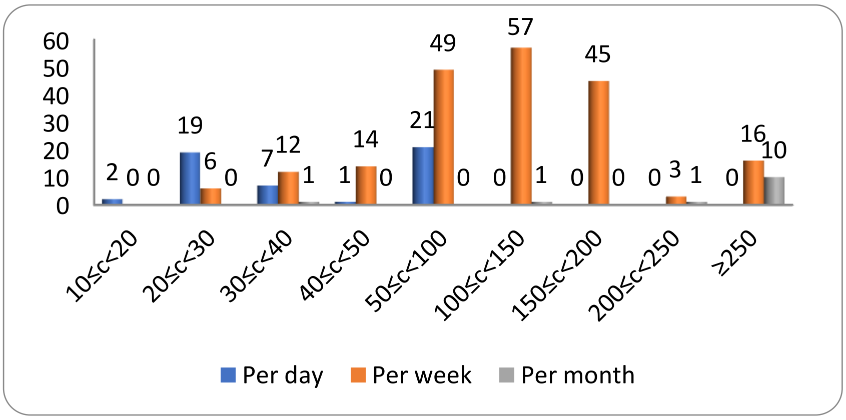


Figure 4.19 Cost of Kerosene per Unit

Source: Homa Bay (2017)

Respondents were asked to state how much money they spent on charcoal. The study revealed that a significant number of households spent between sh 10-50 per day.

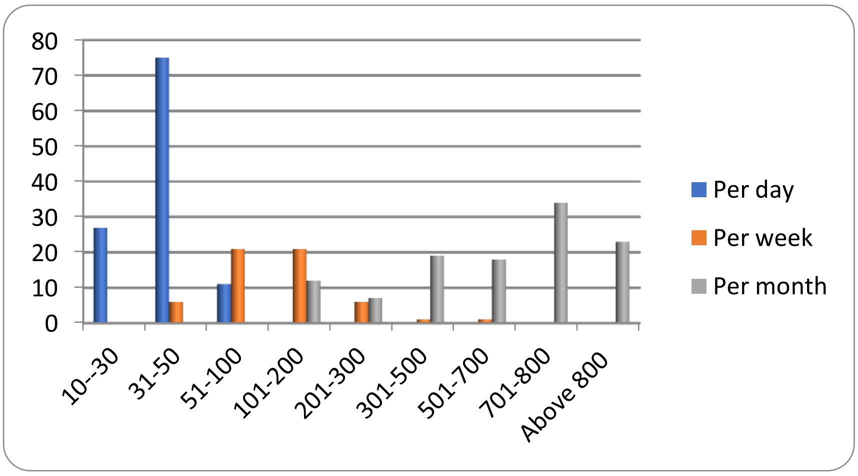


Figure 4.20 Cost of Charcoal per Unit

Source: Homa Bay (2017)

This agrees with a study in Ghana which revealed that in some households, buying bits of charcoal was used as strategy to address the huge amount of money required to refill gas. In some households improved cook-stoves (Gyapa) that used charcoal were used as alternative to gas cylinders and burners. Some households had also acquired two cylinders which were always filled to ensure that LPG would always be available for cooking whenever shortages occurred. For electricity the strategies used include buying generators, rechargeable lamps, solar lamps that can be recharged and using candles and paraffin. Some have bought prepaid meters to reduce their bills and also to make it convenient for them to consume electricity (Chevalier, 2009 and Ottinger, et al., 2000). The finding also agrees with the finding that Poor households find it more affordable to purchase woodfuel on a day-to-day basis (Kebede and Dube 2004). Poor households tend to prefer fuel that can be purchased in small, discrete quantities (e.g. charcoal, firewood) to that which requires the purchase of a larger unit of fuel (e.g. a tank of LPG) (Alfstad et al. 2003). This purchasing pattern complicates the discussion of economic issues: in the long term, poor households might spend more money by purchasing traditional fuels each day instead of purchasing larger quantities of clean cooking fuels.

4.6.3 Stove/Fuel Stacking

Respondents were asked to state whether they used another stove at the same time. The study findings revealed that 226 households used another type of stove. 77 households reported that they used it all the time, 22 used it most of the time, 29 used it occasionally while 75 stated that they did not use another stove at the same time.

Table 4.44 Use of Supplementary Stoves by Households

Use of another stove at the same time	**Frequency**	**Percentage**
Do not own ICS	88	22.6
All the time	77	19.8
Most of the time	22	5.7
Sometime	98	25.2
Occasionally	25	6.4
Not at all	75	19.3
Total	389	100.0

Source: Homa Bay (2017)

Masera et al.'s (2000) multiple fuel model states that there are various interacting social, economic and cultural factors that explain household energy use patterns. Consequently, a linear transition to cleaner fuels is hardly achieved but rather, households become involved in 'fuel stacking'. Fuel stacking is the term used to describe multiple fuel use patterns (Masera et al., 2000) and it means that various cooking fuels are used at the same time possibly for different purposes. As a result, rather than fuels being abandoned and substituted for cleaner ones a combination of fuels is used. Observation revealed very high use of multiple stoves.

More than 60% of households use more than one cookstove, with two stoves being the most common. The number of households who use three stoves was also high. They preferred to use three stone fire whenever they needed to cook fast, while for regular cooking they preferred to use Kenya ceramic jiko due to scarcity of firewood. Likewise, the LPG user households also use biomass stoves, as they are not always sure of raising money to refill the gas and therefore need to minimize their expenditure on LPG fuel.

Households tended to have multiple stoves for convenience and for the various foods they preferred cooking using firewood. One respondent had this to say:

> *We rarely us the three stone cookstoves because of scarcity of firewood except on special occasions such as when cooking beans or 'nyoyo', a mixture of maize and beans, which require strong heating and when having large gatherings and church functions*

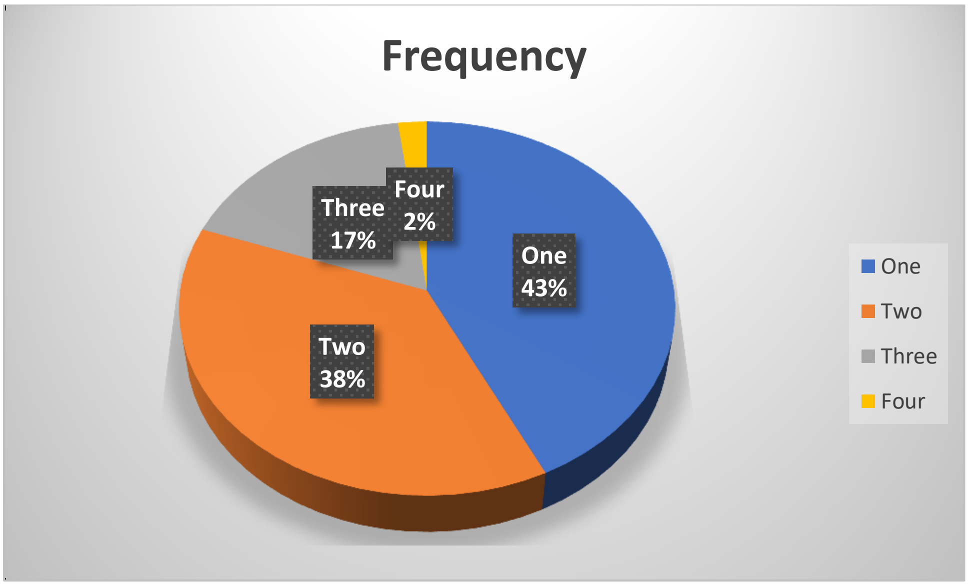


Figure 4.21 Number of Stoves in the Households

Source: Homa Bay (2017)

The result agrees with the finding of Masera et al. (2000) that improved cookstoves, such as the Lorena stove and LPG, were unfit for cooking traditional dishes such as tortillas, therefore, people revert back to their traditional cooking practices (use of open fires) for such specific dishes.

In Paraguay, cooking practices are dictated by certain customs. For example, during large gatherings and holidays, households bake corn bread products, which require ovens and lengthy cooking times. Cooking yucca, a staple of the Paraguayan diet consumed at nearly every meal, can take several hours in preparation and cooking time. Households living in the city and who do not own any land may eat bread instead of yucca, because they may not have the time for cooking or they may not be able to pay the electric or gas expense required to cook yucca for a long period of time (Grossman 2012). They therefore, change what they eat and how they cook to adjust to their specific circumstances. Paraguayan customs and practices can be compared to those found in Homa Bay County.

Respondents were asked to state whether they used any other type of fuel. Quite a number of households used biomass as supplementary fuel. Treiber et al. (2015) explain that households regularly use various energy carriers and technologies in order to ensure a continuous supply of cooking energy in the most convenient and appropriate form for the task at hand. Also, the same person may cook different meals with different appliances. Tomei et al. (2014) note that even within each carrier, users will frequently employ multiple appliances for different tasks. Interestingly, despite this, 42% of households indicated that they rely on just electricity for cooking, indicating that grid connections for this sector of society must be sufficiently reliable. Electricity is also paired with firewood, paraffin and LPG for around a third of the population (around 10% each). Households with a low standard of living tend to pair paraffin and firewood.

Sander et al., (2011) explains that fuel stacking provides a sense of energy security, since complete dependence on a single fuel or technology would leave households vulnerable to price variations and unreliable services, especially in the case of LPG. Conclusive evidence has been provided by the following country cases in which the price of LPG reached a certain threshold, causing users to return to using wood fuels. In Senegal, large numbers of consumers reverted to wood-based biomass for cooking after subsidies for LPG were removed (Sander et al.,2011). In Madagascar, the upper-middle class has become increasingly unable to afford LPG due to a price increase of more than 55 % between 2009 and 2013, therefore being forced to revert to charcoal (PGME-GIZ/ECO, 2013). The case of Dar es Salaam is also noteworthy as the number of households using charcoal for cooking increased from 47 % – 71 %, while the use of LPG declined from 43 % – 12 % (World Bank, 2009).Research has shown that to meet the WHO indoor air quality guidelines, near complete replacement of traditional stoves with low-emission stoves is necessary (Johnson and Chiang, 2015). This requires eliminating the common practice of stove stacking, i.e., the concurrent use of both traditional and improved stoves, which is common in rural populations worldwide (Ruiz-Mercado and Masera, 2015). Thus, reducing exposure to household air pollution not only requires technological advancement, but also significant changes to cooking behavior, norms, and preferences, including stove use, fuel use, and food preparation (Rosenthal and Borrazzo, 2015).

Table 4.45 Supplementary Fuel Used by Households

Second most used fuel		Sub County		Total
		Suba North	Rangwe	
Second most used fuel	Use one type of fuel	38	66	104
	Firewood	17	8	25
	Firewood and maize cob	0	1	1
	Firewood, maize cob and stalk	0	2	2
	Firewood, maize cob and twigs	0	2	2
	Firewood, maize cob and charcoal	0	1	1
	Firewood and twigs	0	4	4
	Firewood and charcoal	4	1	5
	Firewood and kerosene	2	0	2
	Firewood and maize cob	1	0	1
	Cow dung and maize cob	0	1	1
	Cow dung and twigs	0	1	1
	Maize cob	0	5	5
	Maize cob and maize stalk	0	2	2
	Maizecob/stalk,twigs and charcoal	0	1	1
	Maize cob/stalk and twigs	0	1	1
	Maize cob and twigs	0	17	17
	Maize cob, twigs and charcoal	0	5	5
	Maize cob, twigs, charcoal and gas	0	2	2
	Maize cob, twigs and gas	0	1	1
	Maize cob and charcoal	0	3	3
	Maize stalk, twigs and charcoal	0	1	1
	Twigs	2	22	24
	Twigs and charcoal	0	13	13
	Charcoal	103	31	134
	Charcoal and kerosene	3	0	3
	Charcoal and gas	1	1	2
	Kerosene	18	0	18
	LPG	6	2	8
Total		195	194	389

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter outlines a summary of the key findings from the data, conclusions drawn from the results and recommendation made to that. It focuses on the analysis of the energy initiatives in Homa Bay County, their benefit to households, challenges facing adoption and use and interventional strategies used by households in the study area.

5.2 Demographic Characteristics of the Households

Data was collected over two sub-counties; Suba North and Rangwe. More females were interviewed compared to the male. Most respondents were aged between 25-34 followed by 35-44. Majority of the respondents had primary education followed by secondary. Very few had college and university education. The dominant income generating activity was self-employment/business followed by farming. Most households had few members ranging between 1-5.

5.3 Summary of Findings

5.3.1 The Type of Stoves and Fuels in Use for Household Cooking and Lighting in Homabay County

The study revealed that household cooking technologies came from two main sources. These included traditional three stone fire and Kenya ceramic jiko. The number of households having ICS such as firewood jiko kisasa-one pot and two pots, rocket mud stove-one pot and two pot was low. The study revealed that biogas digesters had not been constructed in the study area. Household cooking fuels came from four main sources. These included biomass, charcoal, kerosene and LPG. The study also revealed that electricity had not been widely adopted as cooking and lighting fuels in the study area. The number of households using kerosene for lighting was high in in the study area. Two types of lamps were in use: "*nyangile*" and kerosene Chinese lamp. The use of gas lamps was reported by one household only. Households using kerosene tin lamp as the main source of light were very many. Most lighting equipment do not provide light continuously for four hours hence they do not meet the Total Energy Access minimum standards.

5.3.2 The Effect of the Energy Initiatives on People's Social-Economic Livelihoods in Homa bay County

5.3.2.1 Benefits of Adoption of ICS

The study revealed that households in Homa Bay County benefited from the energy initiatives. They reported that use of ICS saves fuel, time and money, reduces smoke, leaves a clean kitchen, minimizes burns and accidents, respiratory diseases and eye irritation and provides more comfort while cooking. They also reported that adoption of solar lamps resulted in saving money and time, solar lamps give more light compared to kerosene lamps, reduces health risks, solar can charge mobile phones and is able to work without electricity. Adoption of ICS enabled households to save time during cooking and the time saved is mostly used to give more attention to the children, pursue income generating activities and attend community meetings. In addition, households adopted other electrical appliances as TV, radio, Mobile phones, electrical fan, heater and iron box, water filter and pressure cooker.

5.3.2.2 Effect of Energy Initiatives on Education

The study findings show that children used solar lamp and electricity for studies and doing school assignments. Use of kerosene lamp for studies and doing assignments was high in the study area. Candle light, mobile phone and battery flash light were in use but as supplements to electricity and solar. Respondents were also able to listen to educative programs on the radios, mobile phones and to watch them on TV. A chi square test of independence confirmed a strong association between type of fuel and adoption of TV, mobile phone and radio.

5.3.2.3 Effect of Energy Initiatives on Income Generation

The data shows that only 15 participants used ICS for income generating activity**.** The number of households who did not use it for productive/income generating activity was very high (288). The study revealed that a number of households used firewood, twigs and charcoal to prepare food for sale.

5.3.3 Challenges Encountered in the Adoption and Use of the Energy Initiatives

5.3.3.1 Intra-Household Dynamics

The study findings revealed that the use of three stone fire and Kenya ceramic jiko is highest among self-employed/business followed by the farmers. The self-employed/business households also had high uptake of charcoal all metal stove, kerosene wick stove and LPG stove. The chi square test of independence was significant suggesting that income level has an influence on stove adoption. No household was found to have adopted kerosene pressure stove and LPG big cylinder. The adoption of ICS such as jiko kisasa, kuni mbili, rocket mud stove and sawdust stove are low across all income levels. Adoption of electric cookstove is also negligible in both. Biomass has been widely adopted among farmers, employed/salaried and self-employed/business. Adoption of charcoal is high among the self-employed/business, farmers, and employed/salaried. Clean fuels such as Kerosene, LPGand electricity have been adopted among the self-employed/business people. A chi square test of independence confirmed that income level has a significant influence on the type of fuel adopted.

ICS such as KCJ, kerosene wick stove, jiko kisasa, kuni mbili and electricity is highly adopted among households with 1-5 members. The association is significant for three stone fire but not significant for Kenya ceramic jiko, kerosene wick stove, LPG and electric cooker. Report on relationship between household size and adoption of fuel revealed that charcoal, kerosene, LPG and electricity are widely adopted among households with 1-5 members.

The study revealed that the number of respondents using three stone fire and Kenya Ceramic Jiko was high for respondents who had secondary education and below. The rate of adoption of charcoal all metal stove was high among respondents with secondary education. Adoption of kerosene wick stove was evenly distributed among respondents with primary and secondary education. Adoption of LPG meko was high among respondents with secondary and college education. The level of education did not seem to have an influence on the adoption of jiko kisasa and kuni mbili jiko since the number of respondents having them is very low. Kerosene pressure stove and LPG big cylinder have not been adopted in both sub-counties. Chi square test of independence confirmed a significant relationship between level of education and stove adoption.

Biomass has been widely adopted by those who have attained secondary education and below. Use of charcoal and kerosene was found to be high among those who had primary and secondary education while those in secondary school reported high adoption of LPG and electricity. The relationship between level of education and type of fuel used was statistically significant for all types of fuel.

5.3.3.2 Gender Dynamics

The results show that decision to purchase fuel was dominated by women. The decision to purchase assets and land, taking loans and accessing banks and Mfis is dominated by men and there is a significant relationship between ability to take a loan and decision to purchase fuel.

5.3.3.3 Behavioural Factors

Households who had traditional stoves only admitted that they had knowledge of ICS. They gave several reasons for not adopting them but the most prominent reason was lack of finances followed by not knowing where to find the ICS. Most households who had three stone fire used it daily majority reported that they were happy with the stove. Most respondents who had no solar lamps also reported that they had knowledge of solar lamps. Majority of those who had no solar lamp said that they could not afford it.

5.3.3.4 Socio-Cultural Issues

The data shows that most respondents reported using ICS daily. The number of respondents who said that they did not use it daily was fairly high. Respondents who did not use ICS daily said that they preferred to use traditional stove. Other respondents reported that ICS were not comfortable to use. Majority admitted that ICS had disadvantages. Respondents complained that it was not possible to sit around the fire, roast maize/meat, they were not able to cook on big pots, ICS need maintenance and that it was not possible to cook certain meals (mainly boiling potatoes, beans and *nyoyo*, a mixture of dry maize and beans, which require long time to cook). Others complained of the high cost of purchasing the appliances, buying charcoal and refilling LPG. They also complained of irritating smoke and black carbon from kerosene wick stoves which made it necessary to wash it every now and again and fear of operating LPG cylinders.

5.3.3.5 Market factors

Most participants noted that the high cost of fuels is a barrier to the adoption of stoves. According to the participants, majority spent over ksh 10,000 annually on firewood, charcoal and LPG. Refilling the LPG tank was seen as a substantial household expense costing roughly ksh 1300 every three months. Most participants preferred to save money by gathering their own fuel for use in the traditional or locally improved stoves, despite the additional time burden. Since all stoves require an upfront payment but only LPG stoves require continuous payment for fuel, initial stove costs were perceived as more acceptable than continuous payments for LPG fuel refills. The number of households who spent between 7001-8000 and between ksh 5001-6000 on kerosene was very high.

Out of the 389 households surveyed only 98 belong to formal groups. The respondents explained that the groups were not energy related. Most of them either were for table banking or small welfare groups within the community formed with the aim of raising money to take care of the welfare needs that arose within the community.

The study findings show that radio and neighbours have played a important role in creating awareness in about ICS. So far, the role of the private sector (cookstove producers, marketing groups, NGOs) is very low. In addition, the role of public meetings/field days and brochures/leaflets/calendars is very low. The number of respondents who had been trained on kitchen and fuel management was very low.

Majority of the respondents reported that they purchase their lighting/and stove equipment from open air markets. Majority said that the distance between their homes and the market from where they purchased lighting/stove products was far and others said that it was very far.

Respondents experienced problems with distribution. A lot of time was spent walking to and from the distribution point. This suggests that firewood is carried on the head in most households. Bicycle, motorbike and cars are used to transport fuel suggesting that they have to cover a wide distance in order to access the fuel.

5.3.3.6 Technological Issues and Stove Performance

An analysis of performance of stoves revealed that the respondents confirmed that the use of ICS saves fuel, time and money, reduces smoke, leaves a clean kitchen, less burns and accidents, reduces respiratory diseases, less eye irritation and more comfort. Majority of the users reported that ICS are much better than traditional stoves. Others rated them a bit better than traditional stoves. A few users still have negative perception of ICS as the stoves are not performing as per their expectations.

The walls and roofs of the areas where cooking was done was covered with soot. Smoke was also observed in houses where cooking was on going at the time of administering the questionnaire. Smoke and soot resulted in chesty cough and eye irritation in most households. The association between type of fuel used and chesty cough and type of fuel used and eye irritation was statistically important.

5.3.4 The Interventional Strategies for Enhancing Adoption and Efficient Use of the Energy Initiatives

5.3.4.1 Proper Ventilation and Use of Chimneys

Respondents are conversant with methods of minimizing IAP. Possible interventions include using ICS with chimneys, kitchens fitted with smoke hoods, improving kitchen ventilations, switching to clean fuels and use of dry firewood.

5.3.4.2 Purchasing Fuel in Small Quantities

Majority of the households purchased firewood per day. The number of households who spent less than Ksh 20 and between 20-30 shillings was significantly high. Most participants purchased kerosene per week but the number of households who purchased it per day was also fairly high. Most households spent either between 50-100 or 100-150 Kenya shillings. All the households who had LPG had the 6kg cylinder. Most households spent between1200-1300 Kenya shillings to refill the gas after every three months. The number of households who purchased charcoal per day was equal to the number who purchased it per month. However a significant number purchased it per day. Majority of the households spent between 10-50 Kenya shillings per day.

5.3.4.3 Stove/Fuel Stacking

Another intervention strategy was the use of multiple stoves. More than 60% of households use more than one cookstove, with two stoves being the most common.

5.4 CONCLUSION

The study revealed two main sources of cooking technologies used by households in Homa Bay County; three stone fire and Kenya ceramic jiko. Household cooking fuels in the study area included biomass, charcoal, kerosene and LPG. Even though solar lamp and electricity have been adopted as sources of light the number of households using kerosene in tin lamps is very high. Households have realized a number of benefits from use of the initiatives. They are able to save furl, money and time. Uptake of the initiatives has also reduced IAP and hence health complications. Other benefits include ability to study and do homework from home and access information through mobile phones, radio and TV.

The findings indicate that uptake of ICS and clean fuels is influenced by variables such as intra-household factors, gender dynamics, behavioural, socio-cultural, market and technological factors. Income and education have a significant influence on adoption and use of the initiatives. Lack of information about availability of the initiatives and inability to raise capital for initial investment and sustained use featured prominently as a barrier to uptake and use of the initiatives. Households also reported presence of smoke and black carbon in the houses and this resulted in chesty cough and eye irritation. It was reported that some of the stoves are not performing well, creating a negative impression of ICS. Several interventional strategies are in use in Homa Bay County. Households reported use of chimneys, installation of hoods in the kitchen, adoption of ICS, use of dry firewood, purchasing fuel in small quantities and stove and fuel stacking.

5.5 RECOMMENDATIONS

The study makes the following recommendations based on the findings and conclusion of the study. The study found that biomass currently serves as the major source of cooking energy for the majority of households. Very little partial switching to cleaner and alternative cooking energy has occurred. Therefore:

a) There is a need to strengthen efforts to promote use of ICS, which use biomass in a more efficient ways.

b) The limited use of improved cook stoves suggests a need to explore reasons for the low adoption rate, and a need to solve some technical problems experienced by adopters.

c) Those promoting ICS, and technicians, should work with communities to address the socio-cultural and technical problems that lead to stove and fuel stacking, in order to increase the likelihood of adoption of ICS and clean fuels.

d) Massive awareness activities on clean cooking should be carried out, targeting both men and women. Short, women-focused trainings on kitchen and fuel management should be carried out in the County.

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APPENDIX I

INTRODUCTORY LETTER

DONATA A. ODAGO,
MOI UNIVERSITY,
P.O. BOX 3900-30100,
ELDORET.

Dear Sir/Madam,

RE: EFFECT OF ENERGY INITIATIVES ON PEOPLE'S SOCIO ECONOMIC LIVELIHOODS

I am student at the Moi University pursuing a Doctor of Philosophy degree in Development Studies. The purpose of this research is to assess the effect of energy initiatives on people's socioeconomic livelihoods. Your genuine responses to the items in this paper will make the study a success and help all concerned to provide better services in future.

Please indicate your answer to the statements carefully by ticking (√) the appropriate responses according to you. Please respond to the statement as honestly as you can. Your responses will be treated with utmost confidentiality.

Thanks you in advance

Odago D. A.

APPENDIX II: HOUSEHOLD QUESTIONNAIRE

The following has to be filled out before the interview:

Serial No ______________________________ Date ______________________________

County ______________________________ Sub-county _________________________

SECTION A: Personal Information

Household characteristics

	1. Sex	2. Age	3. Time spent near stove yesterday	4. Education status	5. Occupation
	Male=1 Female=2			1=Never studied 2=Can read and write 3=Primary school 4=Secondary school 5=College 6=University 7=Other (specify)	1=Farming 2=Employed/salaried 3=Selfemployed/business 4=Wage labourer 5=Student 6=Other (specify) 7= None

6. How many people regularly live and eat in the household? Specify numbers.

1) Older people (>64 years) ………………………………………..

2) Adults (>16 years) ……………………………………………....

3) Children (<15 years) ……………………………………………

4) Total number of household members …………………………..

7) Only ask this Question for Children 6–14 Yrs	
Is child currently studying 1=Yes 2=No	If not studying, give reasons
	1=Never studied 2=Must work at home 3=Cannot afford 4=Still young

8) If you have school-age children, what type of lamp/fuel do they use for studies?

i) Lamp ……………………………………………………………………

ii) Fuel ……………………………………………………………………

SECTION B: Type of stove and their Use

Answers to questions 9 to 10 to be filled in the table below.

Type of stove (show pictures)	9. Number of stoves present	10. Stove used daily for cooking and boiling water (Used for cooking meals (write 'C'), preparing tea and snacks (T), for room heating (H), for making/preparing animal feed (F), cooking for sale/business purpose (B), smoking/drying fish (D), other purpose (O)	
Three stone fire			
Firewood Jiko Kisasa – one pot			
Firewood Jiko Kisasa – two pots			
Firewood Kuni Mbili			
Rocket Mud Stove– one pot			
Rocket Mud Stove– two pots			
Kenya Ceramic jiko			
Charcoal all metal stove			
Sawdust stove			
Kerosene wick (chinese)			
Kerosene pressure			
LPG 6 kg (meko)			
LPG 2-			
Electric stove			
Other (specify)			

11. Do you use a fireless cooker? 1) Yes [ ] 2) No [ ]

Households where there is no improved cookstove

12. *For all households where there is a* **3 stone fireplace**, *ask the following question*:

a) Do you use this stove:

1. Every day [ ]

2. Often [ ]
3. Sometimes [ ]
4. For special occasion [ ]
5. Never [ ]

b) i.Have you heard about ICS? 1) Yes [ ] 2) No [ ]

ii) If yes, which type of stoves do you know?

13) Why don't you use one?

1. Don't know where to find [ ]
2. Don't know about negative impact of indoor smoke [ ]
3. Improved stove/clean fuel not easily accessible [ ]
4. Can't afford [ ]
5. Don't want to change traditional practice [ ]
6. It is not priority of other family members [ ]
7. Traditional stoves better fits to our need [ ]
8. ICS does not use firewood [ ]
9. Other (specify) ………………

14) i. Are you happy with the existing stove, or do you want to switch to another type of stove?

1 Happy with the existing stove [ ]
2 Want to switch to another type of stove [ ]

For households with ICS or clean fuel users only

15. How did you know about the improved stoves for the first time? (*several answers possible*)

1) Radio [ ]
2) TV [ ]
3) Brochure, leaflet, calendars [ ]
4) Neighbours, family, friends [ ]
5) Public meeting, field days [ ]
6) NGOs [ ]
7) Producers [ ]
8) Marketing groups [ ]
9) Installers [ ]
10) Others (specify) ………………………

16. i. Do you use the stove daily? 1) Yes [ ] 2) No [ ]

ii. If no give a reason:

1. prefer to use traditional stove [ ]
2. not comfortable to use [ ]
3. not seen any benefits [ ]
4. other (specify) [ ]

17. When using the ICS did you use another type of stove at the same time?

1. All the time [ ]
2. Most of the time [ ]
3. Sometime [ ]
4. Occasionally [ ]
5. Not at all [ ]

18. Why did you use another stove at the same time?

1. It is our culture/habit [ ]
2. Because it is quicker [ ]
3. For space heating [ ]
4. Because I wanted to cook two different foods at the same time [ ]

5. Other (specify) ……………………………………………………………………
……………………………………………………………………………………………

19. How is the ICS compared to the traditional stove?
1. Much better [ ]
2. A bit better [ ]
3. No difference [ ]
4. Worse [ ]
5. Much worse [ ]

20. What do you see as an advantage of the ICS? (*several answers possible*)

1) Fuel saving	[ ]	6) Less burns, accidents	[ ]
2) Time saving	[ ]	7) Less respiratory diseases	[ ]
3) Reduced smoke	[ ]	8) Less eye diseases	[ ]
4) Saves money	[ ]	9) More comfort	[ ]
		10) Better taste of food	[ ]
5) Clean kitchen	[ ]	11) Other (specify): ………………………	

……………………………………………………………………………………………

21. If time is being saved how is it used?
1. Give more time to the children's care [ ]
2. Started to do income generating activities [ ]
3. Able to attend community meetings [ ]
4. Meet friends and relatives [ ]
5. Others (specify)

22. Does the ICS have any disadvantages for you? (*several answers possible*)

a) Yes [ ] No [ ]

b) If yes, which ones?

1) Not possible to sit around the fire	[ ]	5) Needs maintenance	[ ]
		6) Can't cook certain meals	[ ]
2) Not possible to roast maize / meat	[ ]	7) Can't use wet wood	[ ]
3) Takes more time to cook	[ ]	8) Other (specify) …………………	
4) Can't cook on big pots	[ ]		

23. What is the biggest disadvantage for you?
……………………………………………………………………………………………
……………

24. Are you using the stove for any productive use/earning an income in any way?

1) Yes 2) No

If yes, explain
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………

SECTION C: Information on cooking

25. Do you cook your meals on one stove (*one pan after the other*) or on two stoves at the same time? 1) One stove [ ] 2) Or two stoves [ ]
Other (specify) :
……………………………………………………………………………………..

26) Is there smoke in the kitchen?
1) Yes: [ ] 2) No: [ ]

SECTION D: Types and uses of household fuel (Tick (√) the ones which applies to you)

27.What types of fuel/energy source do you use for cooking? (*several answers possible*)		
1- Firewood 2- Dung 3- Maize cob 4- Maize/Sorghum stalk 5-Twigs 6-Sawdust	7- Charcoal 8- Kerosene (paraffin) 9- Bottled gas (LPG) 10- Solar cooker 11- Solar electric (solar PV)	12- Grid electricity (electric heater) 13- Batteries 14- Wax candle 15- Bio gas
Other (specify)		

28. Using the fuel list above, what types of fuel/energy source do you use for the following purposes? (List in order of importance using numbers shown above)

(select fuel from the table above; use codes)	Most used fuel	Second most used fuel
Cooking (including boiling water for drinking		
Making tea/coffee		
Lighting		
Room heating		
Heating water for other purposes		
Spirits brewing for sale		
Cooking food/drink for selling		
Cooking animal feed		
Other task (specify)		

29. If fuel is used, is it: a) Gathered 1) Yes [ ] 2) No [ ]
b) Bought: 1)Yes [ ] 2) No [ ]

30. If the fuel is bought, fill the table below

Serial No.	Type of fuel	Average time spent to purchase per visit	Annual visits (times)	Who goes to purchase normally 1=women 2=men 3=girls 4=boys	Mode of transporting the fuel	Purchase		
						Unit	Cost per unit (sh)	Annual purchase (sh)
1	Fuel wood							
2	LPG							
3	Kerosene							
4	Electricity							
5	Briquette							
6	Saw dust							
7	Maize cob							
8	Maize/sorghum stalk							
9	Other (specify)							

31. *For households, where the main stove is not a 3 stone fire, how was it in the past:*
a) How many times did you go for firewood collection per week, when you were cooking on the 3 stones? ……………………………..times per week
b) How much money did you spend for fuel, when you were cooking on the 3 stones? Per day: ……………… or per week: …………… or per month: ………………………

HEALTH RELATED PROBLEMS

32. What problems do you face in cooking with firewood/ animal waste/agricultural waste? (Limit the question to long-term respiratory illness—chronic cough, chronic obstructive pulmonary disease, asthma, lung cancer, tuberculosis, pneumonia, and other lower respiratory tract illnesses; long-term discomfort in eyes including cataracts; burns from stove fire; chronic back related issues linked to carrying fuelwood; chronic headaches, etc.)

Problems in cooking with firewood	Yes	No
More smoke		
Dirty pans		
Dirty house		
Hard to blow		
Eye irritation		
Long time to cook		
High heat during hot weather		
Chesty cough		

33. Do you think smoke from cooking is a problem that should be solved? 1) Yes 2) No

If yes, suggest possible solutions (more than one can be selected)?

1. Using improved stove with chimney [ ]
2. Using improved stove without chimney [ ]
3. Using smoke hoods [ ]
4. Improving kitchen ventilation system [ ]
5. Switch to clean fuel (using LPG, electricity, etc.) [ ]
6. Using dry firewood only [ ]
7. Other (specify)

…………………………………………………………………………………………

34. Has the cook received any training on kitchen and energy management?

1)Yes [ ] 2) No [ ]

Part F: Information about lighting

35. What is the main source of lighting in your house?

1. Kerosene *nyangile* [ ]
2. Kerosene Chinese lamp [ ]
3. Gas lamp [ ]
4. Candles [ ]
5. Battery flash light [ ]
6. Electricity [ ]
7. Solar lamp [ ]
8. No lighting [ ]

Other (specify) ……………………………………………………………….

36. Do you use this light for more than four hours a day?

9. Kerosene *nyangile* Yes [ ] No [ ]
10. Kerosene chinese lamp Yes [ ]No []
11. Gas lamp Yes [ ] No [ ]
12. Candles Yes [ ] No [ ]

13. Battery flash light Yes [ ]
No [ ]

15. Solar lamp Yes [ ]
No [ ]

14. Electricity Yes [ ]
No [ ]

Other (specify)
………………………………………………………………………………………

37. Where do you purchase lighting/stove products from?

1. What kind of shop?

   a) Open air ……………….. b) Recognized dealer ………………………

2. Name of nearest town/market where you purchase lighting/stove products from
   …………………………………………………………………………………….

3. Comment on the distance of the town …………………………………………

4. On average, how much does your household spend on lighting fuel per week?

   Ksh. ………….

Questions to those who do not have solar lanterns:

38. Have you heard of solar lanterns? Yes [ ] No [ ]

1. If yes, why have you not purchased one? ....

………………………………………………………………………………………………

2. Do you know of anyone who owns a solar lantern? Yes [ ] No [ ]

39. Are you aware of the following benefits of solar lantern? Tick (√) where appropriate

Benefits of solar lantern	**Yes**	**No**
Will save money spent on buying fuel		
Will save time spent on acquiring fuel		
Gives more light than kerosene/oil lamp		
Reduce health impacts		
Can often be used to charge mobile phones		
Work where there is no electricity		

Household Assets

40.Tick (√) the items present in your house

1. TV [ ]
2. Electric fan [ ]
3. Electronic heater [ ]
4. Water filter [ ]

5. Pressure cooker [ ]
6. Radio [ ]
7. Mobile phone [ ]
8. LPG cylinder [ ]

9. None [ ]

41. Who does the following tasks mostly? (1=women, 2=men, 3=girls, 4=boys, 5=None)

Who carries out the following activities?	Always	Sometimes
Attending community/NGO/group meetings		
Getting updated information by watching television, listening to radio, or reading newspapers		
Visiting banks and MFIs		

42. Who makes the following decisions mostly? (1=women, 2=men)

	Always	Sometimes
Purchasing stoves and fuels		
Purchasing of kitchen utensils		
Purchasing of assets and land		
Taking out loans		

52. Do you or any of your household members belong to formal/informal/traditional groups related to energy use and access, and women's empowerment? If yes,

Name of group	His/her role in the group	Activities of the group

APPENDIX III: FOCUS GROUP DISCUSSIONS GUIDE

Sub-County…………………………………………………………………………..

Date…………………………………... ………………………………………….

1. What type of fuels and stove do you use most often for cooking, space heating, and baking?
   Cooking…………………………………………………
   Space heating …………………………………………..
   Baking/brewing ………………………………………..
   Fish processing ………………………………………...
2. Are you happy with the fuel/stoves you are using?
   ………………………………………..
   What are positive aspects? Please explain (with particular reference to health, economics, comfort, availability, etc.).
   i. Health
   ii. Economics
   iii. Comfort
   iv. Availability

   What are the disadvantages of using three stone fire?

   Do you wish to switch stove/fuel in near future?
   ……………………………………………………………………………………………
   Please explain, giving reasons, why you wish to switch.

3. Do you use the stove for income generating activity?
   ……………………………………………
   And what type of stove/fuel is used for that?

4. Has the distance to purchase equipment and fuel increased or decreased over the past 3 years)?
   ………
5. Do you face any problems while using ICS?
   ………

6. Is there time saving with the improved cookstove stove?
   ……………………………………………..
   If yes, how are you using the saved time?

7. Is indoor air pollution a big environmental health problem or not in your home? Please explain with reasons.

SOLAR ENERGY

8. Means of lighting before using solar energy:
   i. Describe the sources of lighting you used before you acquired solar home systems? *Put them in order of importance*
   ………………………………………………………………………………………
   ii. What problems did you face when using these sources?
   ………………………………………………………………………………………
   ………………………………………………………………………………………
9. Please describe the benefits that you have realized from the use of solar home systems in your households.
   ……………………………………………………………………………...
   ……………………………………………………………………………

Thank You Very Much

APPENDIX IV: OBSERVATION GUIDE

1. **How is the kitchen ventilation (window size, door, eave space, etc.)?**
   i. Very good [ ]
   ii. Good [ ]
   iii. Okay [ ]
   iv. Bad [ ]
   v. Worse [ ]

2. **Type of roof in the kitchen (just of kitchen, not whole house)**
   i. Iron sheet [ ]
   ii. Wooden tiles [ ]
   iii. Grass thatch [ ]
   iv. Tiles [ ]
   v. Other[ ]

3. **Permanent ventilation *in roof* of kitchen**
   i. None[ ]
   ii. Small holes or gaps (less than 10 cm in diameter) [ ]
   iii. Large holes and gaps (more than 10 cm in diameter) [ ]

4. **Kitchen Size**
   i. Much larger than average size [ ]
   ii. About average [ ]
   iii. Much smaller than average [ ]

5. Smoke/soot levels in kitchen (write based on observation)
   i. High [ ]
   ii. Medium [ ]
   iii. Low [ ]

6. *Own observation on cooking practices: if the researcher finds cooking going on, is there*
   1. Use dry firewood? 1) Yes [ ] 2) No [ ]
   2. Use few sticks? 1)Yes [ ] 2) No [ ]
   3. Use split firewood? 1) Yes: [ ] 2) No [ ]
   4. Use a lid on the pot? 1) Yes: [ ] 2) No[ ]

7. Condition of the mostly used stove and chimney
   i. Very good[ ]
   ii. Good [ ]
   iii. Okay [ ]
   iv. Bad [ ]
   v. Worse [ ]

Other observation (if anything important)

APPENDIX V: NACOSTI PERMIT

THIS IS TO CERTIFY THAT:
MS. DONATA ADHIAMBO ODAGO
of MOI UNIVERSITY, 0-902 KIKUYU, has been permitted to conduct research in *Homabay County*

on the topic: *EFFECT OF ENERGY INITIATIVES ON PEOPLE'S SOCIO-ECONOMIC LIVELIHOODS IN HOMABAY COUNTY, KENYA*

for the period ending:
29th July, 2017

Permit No : NACOSTI/P/16/48988/12472
Date Of Issue : 1st August, 2016
Fee Recieved : ksh 2000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

CONDITIONS

1. **You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.**
2. **Government Officers will not be interviewed without prior appointment.**
3. **No questionnaire will be used unless it has been approved.**
4. **Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.**
5. **You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.**
6. **The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice**

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 10380

CONDITIONS: see back page

APPENDIX VI: LETTER FROM THE MINISTRY

OFFICE OF THE PRESIDENT

Telegrams ....
Telephone: ....
When Replying please quote Ref
Ref ....

OFFICE OF THE ASSISTANT CHIEF
MBITA TOWNSHIP SUB-LOCATION
P. O. BOX 45 – 40305
MBITA.

DATE 25-07-2016

MINISTRY OF INTERIOR AND COORDINATION OF NATIONAL GOVERNMENT

TO:

WHOM IT MAY CONCERN.

RE: AUTHORIZATION TO CONDUCT THE RESEARCH ON THE EFFECT OF ENERGY INITIATIVES ON PEOPLE'S SOCIO ECONOMIC LIVELIHOODS.

This is to confirm that the bearer of this letter Donata A. Odago of Moi University is authorized to conduct the above research in Mbita township Sub-location, Gembe West location in Mbita sub-county. Mbita township Sub-location is Situated in Suba North Constituency which used to be called Mbita Constituency.

The research will help to identify the gaps in the effective use of energy saving methods in the community as a whole.

Kindly assist where necessary for a recommended result.

Towns
ASS / CHIEF
MBITA TOWNSHIP
DATE 25/07/2016.
Makon Wilson

REPUBLIC OF KENYA
THE PRESIDENCY
Ministry of Interior and coordination of National Government

Telegram……………………
When replying please quote
Tel: 0724459522
Our Ref No. GWL/ADM.4/3/VOL/102
Your Ref No……………………

OFFICE OF THE CHIEF
GEM WEST LOCATION
P.O. BOX 47-40303
RANGWE
DATE 29TH JULY, '16

TO WHOM IT MAY CONCERN.

PERMISSION TO CONDUCT SURVEY

DONATA ADHIAMBO ODAGO ID.NO.10287848

The above has been given full authority by this office to conduct her inventory survey in this location Gem-West (Kanyanjwa and Karonagawi) She is currently undergoing her Post graduate on Human Resource Development at Moi University.

You are there therefore asked to give her all the co-operation and assistance she may need or ask.

Any kind of assistance tendered in her favour is highly appreciated otherwise thanks in advance.

Yours at service.

CHIEF
GEM WEST LOCATION
P.O. BOX 47, RANGWE
DATE 29/7/016...

[signature]

JOEL OTIENO OGUTA
CHIEF GEM-WEST LOCATION.