Chapter 7

The Impacts of Policy on Energy Justice in Developing Countries

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Abstract Access to modern energy is vital to societal wellbeing and to economic development. Still, the majority of rural households in developing countries do not have access to improved energy systems for basic household energy services. Many energy policies have been devised and several energy projects have been implemented to improve the access. However, many of these policies and energy projects were not successful due to the socioeconomic, cultural, resource and technical conditions present in particular contexts. Major barriers were attributed to the weak understanding of local contexts and societal needs. Nevertheless, some projects considering local social needs through innovative approaches were successful. Hence, improving access to improved energy technology needs to understand local contexts, linking to income generation activities and poverty alleviation and inclusion of women to benefit from the system. A bottom-up approach is sustainable to increase energy access while contributing to poverty alleviation and livelihood improvement.

7.1 Introduction: Energy Access Situation in Developing Countries

Access to modern energy services is vital for societal wellbeing and countries' economic development. A modern energy system in tropical developing countries typically includes having reliable and affordable access to an improved cooking facility and having a connection to electricity (UNDP; Legros et al. 2009; IEA 2011). However, by the year 2009, about 2.6 billion people worldwide relied on biomass energy for cooking and 1.3 billion did not have a connection to electricity (IEA 2011). By the year 2030, the number of people without access to improved cooking technology will increase to about 2.7 billion, and about 1 billion people will remain without electricity. The additional number of people without access to improved

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cooking technology will be due to the increasing population in developing countries. Approximately 45% of the people deprived of access to a clean cooking facility live in Sub-Saharan Africa. Moreover, by the year 2030 about 70% and 50% of the people in this region will remain dependent on traditional biomass energy and without electricity supply. About 50% of the people without access to a clean cooking facility and electricity in Sub-Saharan Africa live in Nigeria, Ethiopia, Democratic Republic of Congo, Tanzania and Kenya. In Ethiopia, more than 95% of the households depend on biomass energy for cooking and over 70% do not have access to reliable electrical energy at least for basic purposes (lighting and appliances). Overall, this represents an enormous electrification challenge, and one that carries real energy policy and energy justice implications.

This chapter will explore the level of accessibility of improved energy in developing countries and discuss the associated socioeconomic and health problems. It also identifies the availability of renewable energy sources which could be used to solve the energy problems. These missed opportunities and continuing challenges as a result of low local community involvement and top-down government and donor policies will be given due emphasis and discussed. Finally, an alternative policy options will be discussed and recommended through which local interests are addressed and access to improved energy technologies are increased.

7.2 Variation in Energy Demand

Typically, household energy demand originates from cooking, lighting, heating and appliances. The variation between household's energy demands exists at the intensity of the energy used and preferences for the technologies providing the services. The variation in the amount of energy for lighting reflects the number of lighting facilities, their efficiency and length of time of use, for example. Hence, households using similar light arrays for the same period consume equal amounts of energy irrespective of their location.

Generally speaking, the energy demand for electronic appliances in rural areas of developing countries is very small due to lack of high energy demanding appliances. Nevertheless, high income urban households tend to use proportionally higher energy for appliances. The energy need for heating depends on the geographic condition. However, most households without access to improved energy services are living in tropical climates where energy for heating is not a big issue. Thus, important demand diversity exists between western and developing countries, as well as between urban and rural households in terms of the energy used for cooking.

In western and temperate climates, the main share of the household energy demand is for heating and appliances (IEA 2008). Energy demand from cooking constitutes the smallest share of the demand presumably due to consumption of processed food. Moreover, the energy system is well organized with efficient stoves using high-quality energy from electricity and gas. In contrast, the demand variation

between rural and urban areas in developing countries is complex. In rural areas, the energy demand for cooking is relatively high as people generally consume unprocessed food that require long cooking hours. Cooking unprocessed food also requires suitable cooking stoves matching local cooking habits. In addition, people do not typically have a facility to store cooked food, thus they cook more frequently. Long cooking hours together with frequent cooking leads to a high cooking energy share in terms of demand, which can account for up to 90% of a household's energy share (Tucho and Nonhebel 2017).

In contrast, urban households' cooking energy demand depends on the socio-economic condition of the households. Urban households are generally connected to the grid, which enables them to use electricity for cooking (though charcoal still remains one of the main energy sources for regular cooking in certain areas). Poor urban households who are unable to afford electricity charges mostly rely on biomass energy for all cooking practices. Though positively, it is also reported in literature that urban households are more likely willing to shift to a modern energy supply following their increasing income (Heltberg 2003). It is noted that urban households are more accessible to semi-processed food compared to rural households who rely on their own food produce. This variation in food type allows the urban household, this to cook with modern stoves.

Various studies illustrate the effect of local energy use, cooking behaviour and customs on adoption and sustained use of improved energy technologies (Wüstenhagen et al. 2007; Kowsari and Zerriffi 2011). Energy technologies failing to fit local cooking habits and foods are frequently not accepted by users. Thus, satisfying the rural developing country's cooking energy demand with western technologies not matching local cooking habit and conditions may not to be possible. Hence, energy technologies fitting local food and cooking habits need to be identified and provided, taking into account their modification with the available local materials, for instance biogas cooking stoves can be modified with local materials to the prevailing cooking contexts.

7.3 Impacts of Poor Accessibility to Improved Energy Supply

A lack of access to improved energy technologies carries many socioeconomic and environmental impacts. In developing settings, the most important environmental impacts are decline of common forests, exposure to indoor air pollution and increase in greenhouse gases emissions (Ruiz-Mercado et al. 2011; Kaygusuz 2012). The socioeconomic impact of lack of access to improved energy access is high particularly on women and young girls traditionally in charge of household activities. Women spend most of their productive time on extraction of firewood rather than using for income generating activities, going to school and other social activities (Wodon and Blackden 2006).

Most households in developing countries frequently cook food with wood obtained from common forests. Common forests are public resources with unrestricted access where everybody can have the right to use without any limitations. Common forests also serve as an additional means of income for poor urban and rural households selling firewood and charcoal. For instance, a large proportion of people in urban areas and those in small business such as local coffee sellers, use charcoal despite having access to grid connections. This heavy reliance of both rural and urban population on biomass for energy and income aggravates the intensity of firewood scarcity and deforestation (Allen and Barnes 1985; Arnold et al. 2006). In particular, the rate of deforestation is high in countries where large groups in the population depend on biomass energy for cooking. Ethiopia, Nigeria and Uganda are among the countries of the world with the highest wood fuel biomass pressure and high rate of deforestation (Putti et al. 2015). Nevertheless, with a good policy and integrated management these public resources can be one of the sustainable alternative energy sources.

The vast majority of households in rural areas of developing countries continue to depend on biomass energy used in open fire stoves for cooking. Open fire stoves convert only about 10% of the energy content of the biomass (Bhattacharya and Abdul Salam 2002; MacCarty et al. 2010). This means that 90% of the energy contents of the biomass dissipates into the open air without providing any gain. Satisfying the cooking energy demand of people using open fire stove requires a large quantity of wood from public forests. Continuous abstraction of large quantity of forest wood will have significant impact on the availability of wood supply. When firewood is critically scarce, households are often forced to shift to crop residues and dung to supply their firewood demand. For instance, in highland areas of Ethiopia where firewood is scarce, dung substitutes about 30% of the firewood demand (Bewket 2005; Duguma et al. 2014). In most cases, crop residues are burned on agricultural land to supply nutrient to soil for the next farming season. Removing and using of crop residues directly for the energy purpose affects the availability of nutrients to the soil (Lal 2009; Duguma et al. 2014). Thus, heavy dependence on both common forest and agricultural bio-wastes for use in traditional stoves significantly affects the local environment.

A lack of availability of biomass and its use in inefficient stoves may also carry a range of socio-economic and health consequences. When fuel woods are scarce, people will be forced to walk long distance to where sufficient firewood is available. This imposes huge burden on women and young girls who are traditionally in charge of household chores and firewood collection in addition to other activities. Due to the additional burden, women daily spend much more time on domestic activities than their male counterparts. Women may spend about 2–4 h per day to collect fire wood, heightening the risk of becoming deprived of education and other more productive activities (Blackden and Wodon 2006). A comparative overview of daily working hours of men and women in Sub-Saharan Africa is shown in Table 7.1. As shown in the Table and related literature, women in the region are forced to work more than 12 h per day due to increasing time for firewood collection. As a result, more than 50% of them are time-strapped for other activities (Wodon and Blackden

Table 7.1 Time spent on different activities by men and women (mean hours per day) in Sub-Saharan Africa

	Daily activities	Men	Women
1	Care work	0.10	1.0
2	Domestic work	1.5	5.5
3	Firewood and water collection	0.04	1.5
4	Work inside the household (1 & 2 & 3)	1.5	8.0
5	Work outside the house	5.0	4.0
	Total work time (4 & 5)	6.5	12.0

Source: adapted from Wodon and Blackden (2006)

2006). Spending such an amount of time on household chores will have huge impacts on the productive time these people have in order to contribute to the economy of the family. As a consequence, they are deprived of the time needed for education, to take care of children, generate income, farm and interact socially. In particular, a lack of sufficient time for children will have significant effects on the development of the children and on their health condition.

It was shown that one-third of the world's population burn wood, dung or charcoal for cooking, heating and lighting (Birol 2011). The use of biomass in inefficient stoves produces incomplete combustion by-products (ICB), which are hazardous to human health. Burning biomass involves smoke containing a large number of pollutants of known health hazards including particulate matter, carbon monoxide, nitrogen dioxide, formaldehyde and polycyclic organic matter, including carcinogen agents. Exposure to indoor air pollution from the use of solid biomass fuels has been reported as a causal agent of several diseases in developing countries. Exposure to these indoor air pollutants is associated with an increase in the incidence of respiratory infections, including pneumonia, tuberculosis and chronic obstructive pulmonary disease, low birthweight, cataracts, cardiovascular events and all-cause mortality both in adults and children, for example (Ezzati and Kammen 2002; Fullerton et al. 2008). A recent report by World Health Organization (WHO) shows that more than four million people die prematurely annually due to illnesses attributed to the indoor air pollution caused by inefficient use of solid fuel for cooking (WHO 2016). In addition, a lack of access to improved energy services also includes energy for lighting. Most rural households use kerosene wick lamps, which produce several hazardous by-products such as black carbon, with serious implications for human health (Lam et al. 2012). Kerosene is also very expensive, meaning it carries detrimental economic, environmental and health effects (Pokhrel, Bates et al. 2010; Lam et al. 2012).

The vast majority of Africans lack of access to modern energy services, which constitutes a major obstacle for achieving wellbeing and economic development. Improved access to energy for the poor and marginalized communities would make a significant difference in the fight against poverty. More than in any other region in the world, access to affordable and suitable energy services in Sub-Saharan Africa particularly needs to grow in order to improve the standard of living of the region's growing population.

Although the foregoing discussion has focused largely on the domestic sector, access to modern energy is not limited to the household services for cooking, lighting and powering of small appliances; it also extends to the energy use for agriculture. The paradox is that the agricultural sector—the major sector in the region—accounts to a very small modern energy use, despite employing the largest number of working population and contributing to the major share of the national domestic products (GDP) in most African countries. Like cooking methodologies and fuels, agricultural production remains largely traditional, being implemented by human and animal power. Modern, reliable and clean energy would enable living conditions to be transformed and in turn, would increase industrial, agricultural, urban and rural development.¹ However, in many countries the electrical energy loss surpasses 30% and not reliable. The unreliable and costly supplies of electricity and modern fuels hampers production, growth and development. Hence, increasingly high oil import bills and financial losses experienced by many Sub-Saharan African constitute huge economic growth lag in the region.

7.4 Evolving Energy Policies in Developing Countries

For much of the last 200 years, the steady growth in modern energy consumption has been closely linked to rising levels of prosperity and economic opportunities across the globe (Sokona et al. 2012). However, high inequalities persist in the worldwide distribution of access to modern energy services. In particular, people in Sub-Saharan Africa experience the lowest per capita access to modern energy compared to others in the developing world. In this context, the most immediate energy priority is to expand access to meet the population's social and economic development agendas. Yet despite recognition of the need to expand energy access, the definition of energy access is ambiguous and not universal.

Access to electricity is often defined as the proportion of households supplied by the electricity system compared to the total number of households overall, or as a lack of access to clean cooking facilities. Yet it neglects the energy for productive services. In principle, access to energy for the poor needs to include the energy required to drive economic growth and to generate income. Access to modern energy also needs to consider the provision of and ability to afford and use modern and clean fuels for basic human needs, productive uses and modern societal needs like entertainment. Thus, a more comprehensive definition addresses the need for modern energy services to improve the livelihoods of the poor while at the same time, using modern energy to drive local economic development on a sustainable basis.

¹Although it must be acknowledged that other burdens and trade-offs will occur from this modernization.

Many energy policies and programs have been attempted to provide improved energy facilities to households living in rural areas of developing countries. Major progress began during the 1970s and 80s, when the relationship between wood-based fuel and deforestation became known (Allen and Barnes 1985; Arnold et al. 2006). The mitigation efforts made ever since and still ongoing vary across the regions and countries due to differential priorities and capacities yet in principle, it is a well acknowledged fact that providing improved energy facilities requires a lot of investments (Brew-Hammond 2010; IEA 2011). The principal energy sector transition of the 1990s made through privatization and reform of energy supply utilities, has helped the utilities improve their accessibility and guarantee a provision of electricity to those able to pay but did not include the poor (to a certain extent) (Sokona et al. 2012). This success implies the need for further policy, social and institutional support in order to harness the great potential natural energy resources of the region and promote sustainable development. Particular emphasis needs to go towards the evaluation of existing practices and processes, national development policies and institutional set-up, and to the problem context and conditions across the region. Further, a new approach is required to achieve regulatory reforms targeting poverty reduction agendas and the needs of the local populations within microeconomic contexts. In this way, the energy access agenda needs to solve these fundamental problems and be broadened to an inclusive vision of the economy rather than narrowly focusing on the household energy sector.

Largely speaking, most of the improved energy implementation programs were organized centrally as a top-down approach. Such programs usually neglect local practices and user interests, and yet failing to take public interests into account in these programs strongly affects the implementation and sustainability of the system (Ni and Nyns 1996). Recent literature on the global improved biomass cook stove programs shows lack of success in most of the top-down approach programs due to their failure to address local interests and culture, for instance (Urmee and Gyamfi 2014). Similar constraining factors are observed with the biogas implementation programs (Mwirigi et al. 2014; Getachew et al. 2016). India and China are the leading countries in developing cost-effective biogas digesters and dissemination (Bond and Templeton 2011). Many of the Sub-Saharan African and other Asian countries who also followed their footsteps and developed their biogas programs, now remain at a standstill, with only a few success stories to be found (Parawira 2009; Mengistu et al. 2015). To mention some, Ethiopia, Uganda, Tanzania and Rwanda are some of the Sub-Saharan African countries that adopted the biogas technology and implemented this through their national biogas program (NBP). The problem is worse in rural Sub-Saharan Africa where about 95% of the population still rely on the traditional use of biomass energy. Failure to articulate local interests and conditions affects the progress of modern energy technology adoption, installation and use (Ni and Nyns 1996; Urmee and Gyamfi 2014). Hence, these factors should be understood from the grassroots level before starting any improved rural energy programs.

The practice of providing access to modern energy services to the poor in Africa is complex, mainly due to the dual nature of the energy system across Sub-Saharan

Africa where in some instances, traditional and modern energy systems and practices co-exist. As noted above, rural household energy is often dominated by traditional modes of production and use. On one side, there is overlapping of modern and traditional energy use in urban areas where access to electrical energy and traditional technologies exist. In many urban areas across Africa, the simultaneous use of biomass fuels, kerosene or electricity is also common including among economically better-off households. Thus, when other socio-cultural dimensions are taken into account, the distribution of modern energy access across Sub-Saharan Africa and increasing access for a growing population becomes even more challenging. Provision of modern energy requires availability of sufficient renewable energy resources which can achieve sustainable service provisions.

7.5 Renewable Energy Resources

The provision of improved energy services for developing countries requires the availability of a sufficient amount of energy resources, which can be obtained from a variety of sources. In western and oil-rich countries, the demand for household energy is still largely met by fossil fuel sources. Yet due to growing environmental concerns and rising oil price, fossil fuel sources cannot be a long-term realistic option. Instead, and positively, most of the countries deprived of access to improved energy services have tropical climates, presumably with abundant renewable energy resources.

Of course, renewable energy resources are not evenly distributed across the world, regions and countries and within the country itself, but they (solar, wind and hydro) are suitable to provide electrical energy for large and small scales, where the small-scale application of hydro and wind depends on their local availability.² The effects of these conditions can be small on local solar energy because of the uniformly arriving solar radiation on certain locations. However, their local potential sufficiency for the demand is very necessary.

Until sixteenth century, humanity depends on biomass energy for all household services. The first transition started in England with the introduction of chimneys and suitable grates when consumers in urban areas started switching from wood fuels to coal (Fouquet 2010). Since then, mankind has gone through several energy transitions in the past five centuries, although the most significant progress is made around the late 1950s (Fouquet and Pearson 2012).

Given the known negatives of biomass energies, initiatives to formulate biomass as alternative energy policies based on recognition, formalization and modernization of the sector are not appreciated by decision-makers in government, whose vision of economic growth and poverty reduction is usually based on fossil fuels and electricity (Owen et al. 2013). The same applies to the use of charcoal. The production, use and trade of charcoal for domestic cooking and heating is also char-

²Which itself is determined by the local geographic and climatic conditions.

acterized by contradictions, stereotyping, and misconceptions of its negative consequences (Mwampamba et al. 2013). Nevertheless, biomass can be a better alternative to meet the demand if income generation activities are integrated and promoted through an enabling framework involving sustainable biomass supplies and value chain considering better technologies.

Biomass can be obtained from different plant sources in different forms and can be divided into “common” and “produced” resources. Common resources are those owned collectively for free access. These are public forest resources open for everybody to use without limitations. Produced biomass, on the other hand, comes from the private land resources and its availability relies on the presence (ownership) of land resources and its yield (Berndes et al. 2003). The availability and productivity of land varies from place to place and from scale to scale, usually being unevenly distributed. Thus, the availability of biomass at household level depends to some extent on a specific households’ resource ownership. Households holding a large area of land can produce an excess of biomass, while those holding a small parcel of land can hardly produce enough. In addition, households can freely decide whether to use their bio-wastes for energy supply or for soil mulching and for animal fodder and food.

The potential at individual household level is vital for the implementation of biomass energy technology that could deliver continuous functionality and sustainability. Hence, the potential at household scales needs to be understood, taking into account household ownership and competing purposes. It is also important to note the land-use system of the households to identify free and non-agricultural lands. Households may have degraded, marginal or extra lands for tree planting and use for energy, as well as for income generation. Planting tree for both energy and income helps households to have sustainable energy supply while providing an economic incentives (Gebreegziabher and van Kooten 2013; Meilby et al. 2014).

7.6 Drivers of Energy Transition in Developing Countries

It has been indicated that mankind has gone through several energy transitions in the past five centuries, with major progress in the twentieth century (Fouquet and Pearson 2012). The twentieth century transitions were driven by the invention and the development of more fuel types, technological changes and service restructurings. These historical transitions are relevant in understanding the perspective of the current energy transition in developing countries which may follow similar trends. Energy transition is a slow process taking over 100 years (Fouquet 2010), a complete transition may not be expected in short period of time. However, a good progress can be achieved due to increasing penetration of electronic appliances operated on electricity.

Currently, people have different choices of energy sources and technologies. In particular, the present advanced communication technologies are vital to make

people aware of the advantage of modern energy services. The increasing demand for micro-electronic appliances is a good example. A recent estimate shows that more than one in three Africans had at least one mobile subscription and about 76% of the population has Global System for Mobile communication (GSM) coverage although the electrification rate in their countries is still about 30% (Smertnik et al. 2014; IEA 2015). According to this estimate, more than 358 million people in Sub-Saharan Africa are covered by mobile networks despite not having access to an electricity grid. All these technologies require electrical energy for their operation which may foster expansion of electricity and its access. Mobile phone provides a lot of economic and social benefits to rural households. This attracts an innovative mobile phone charging business in some Sub-Saharan African countries. The mobile phone charging micro-business in Tanzania and Uganda could be a good example (Collings 2011). Experiences from Uganda and Kenya shows an expansion of solar technologies to rural areas for phone charging which also significantly contributed to reduction in kerosene use (Stojanovski et al. 2017).

In addition, improvement in education can be a stimulus to aim for a better life and improved energy access. In many developing countries, education is considered as a basic human right where every child should go to school at least for basic education. It has been shown that adoption of improved energy technology increases with the level of education and technology penetration (Lewis and Pattanayak 2012). To date, it is not uncommon to find a television set in remote rural areas among households able to afford diesel generators or solar PV. Thus, an increase in demand of micro-electronic appliances and awareness can be big drivers for improved energy technology adoption and use. What is more, these conditions can shorten the duration of the transition to low carbon energy and efficient technologies. These technologies require electrical energy, which can be managed by stand-alone solar energy technologies.

7.7 Energy Transition and Donor Policy in Developing Countries

Innumerate energy transition policies have been proposed at a global scale to transform the traditional energy system towards more efficient energy technologies. For a long time, the transition of household energy system was explained with the prominent energy ladder model (Fig. 7.1), which considers the household socioeconomic situation as the driver of the transition (Leach 1992). This model has been criticized for its linear transition mode since an increase in household economy does not necessarily achieve a complete transition from traditional to modern energy system (Masera et al. 2000; van der Kroon et al. 2013). It is obvious that an increasing income helps households to afford the costs of the technology. However, the decision to adopt and use the technology depends on the local conditions. A survey report from different villages in Mexico affirms that stove types, cooking practices,

Fig. 7.1 A classic energy ladder model (Kowsari and Zerriffi 2011)

fuel economy, accessibility conditions and cultural preferences came to be the main household decision tools, for instance (Masera et al. 2000). This decision also varies between urban and rural households. Urban households with better incomes more likely adopt and use improved energy technology than rural households (Heltberg 2003). It is evident that, socio-cultural factors related to the demand and the availability of local resources can be more important than increasing income to achieve the transition in rural areas (Kowsari and Zerriffi 2011). This indicates the complex behaviour of rural energy transition which money alone cannot solve.

The development and implementation of clean cooking energy technology for households in developing countries are relevant to at least five of the Sustainable Development Goals (SDGs), including Goal 3: Good health and well-being; Goal 5: Gender equality; Goal 7: Affordable and clean energy; Goal 13: Climate action and Goal 15: Life on land (Rosenthal et al. 2018). Yet addressing the SDGs related to energy and achieve the low-carbon energy transition requires an understanding of the trade-offs and synergies between the opportunities they present. In particular, an increasing access to renewable energy consumption has a positive impact on economic development and poverty reduction. Nevertheless, at the same time, most energy policies in developing countries focus on large-scale grid electrification directly and the majority of the big energy projects are often linked to foreign donations. Getting access to these foreign donations involves a lot of bilateral gaming and discussions and the negotiation process is mostly led by donors' interest and objectives. In the processes, the receiving countries may compromise the citizens' interest to comply with the donor interest. In addition, some researchers argue that the transition possibilities in countries with low access to modern energy are shaped by post-colonial legacies and political agendas, where non-western traditions of thought are overlooked (Broto et al. 2018). Thus, the effectiveness of aid can be further affected when political ideology differs between the donor and the recipient

(Dreher et al. 2015). In this regard, addressing poverty, climate change and energy security requires awareness on association between energy systems and social justice, typified by the situation in which all individuals have safe, affordable and sustainable energy access.

A sustainable energy transition in a developing country context requires an integrated policy approach involving local resources availability and viable technological options that match local demands and contribute to livelihood improvements. To achieve this, the following specific basic questions need to be taken into account. Are there sufficient renewable energy resources available for the demand? Are there efficient technologies available to convert renewable resources into suitable type of energy to meet the demand? Are the technologies affordable and do they match local socio-cultural conditions? Are they applicable with low labour requirements? Do the technologies and projects contribute to economic development and poverty alleviation?

The energy transitions processes is further geared towards questions of ethics and justice, which include the notion of fair distribution of energy infrastructure, allowing equal and equitable access to decision-making and services, and participation of marginalized groups. Failure to adequately engage with the questions of justice and energy transition process may aggravated poverty, entrenched gender bias and non-participation of the locals (Jenkins et al. 2018). As a particular strategy then, energy justice focuses on the evaluation and identification of the affected and the existing processes to provide solution and reduce injustice (Jenkins et al. 2018). It does so by focusing on distributional, recognition, and procedural justice issues, considering the equitable distribution of benefits and costs by stressing the need for inclusion and equal participation in decisions through recognition, in this case, the diversity of needs, values and interests of the locals (Williams and Doyon 2019).

7.8 Sustainable Policy Alternatives

The provision of affordable and sustainable energy supply is one of the key options of improving the livelihoods of millions of poor people in Africa. Small-scale biogas technology has huge potential to satisfy domestic energy needs and provide numerous economic and environmental benefits. Most Sub-Saharan African countries have adapted the Chinese and Indian biogas technologies and tried to disseminate through their national biogas programs, with the financial support of funding agencies. However, widespread adoption of the technology and its continuous functionality were not achieved due to various socioeconomic, cultural, technical and attitudinal factors (Mwirigi et al. 2014; Getachew et al. 2016). This implies the importance of local conditions and missing opportunities as a result of ignoring or giving them less considerations.

Sustainable supply should give greater emphasis to productive uses of energy and energy for income generation. This helps to contribute to generation of higher incomes through the mobilization of local resources, technologies and financial

resources (Brew-Hammond 2010; Rupf et al. 2015). There are some successful energy projects with special innovative approach integrating income generation based on local needs. One of these is a Solar Sister project in Uganda, Tanzania and Nigeria implemented through innovative women-to-women entrepreneurial networks providing a wide range of high-quality clean energy products. This projects provides access to clean energy alongside its value in terms of a long life-cycle, and the creation of a new value chains through micro-entrepreneurship and networking of multi-stakeholder partnerships (Heuër 2017). Solar Sister always consults with the community leader first and then seeks to include households in their initiatives. The Solar Sister field agents consist of local women recruited, trained and mentored by Solar Sister to set up their independent clean energy micro-enterprises. This focus on woman-to-woman sales is an innovative way of introducing new technology in rural households where women are the primary users and managers of household energy. It has been recommended that there should be promotion of the biogas technology through empowering females and female headed households by providing access to credit and income beyond promoting adoption of biogas technology (Getachew et al. 2016).

The production of biogas can be resource-efficient and viable for cooking when arranged at a village scale in a co-digestion mode. Arranging co-digestion at the village scale enables use of any available organic wastes. This approach is helpful to avoid inter-household variation and resource scarcity owing to sharing of resources and increasing performance efficiency of the digester. Co-digesting different waste also streams increases the performance efficiency of the digester and its biogas yield (Giuliano et al. 2013), thus improving the productivity of the system and reducing the amount of feedstock needed to meet the demand. Furthermore, applying co-digestion at a village scale provides the possibility of using any organic wastes such as human excreta and crop residues.

A community biogas system established on shared household resources may involve several challenges since households have vested interests in their resources. Households living in rural areas tend to have strong family cohesion, and a culture of social cooperation and dependence. Socio-cultural bonds are powerful in influencing the individuals' living conditions and to solve any societal problems. Households generally closely follow the rule of socio-cultural obligation or else they are considered deviant. This dynamic can be harnessed in the development of the community energy system, to embrace households and influence them to follow the rules of the system. A community biogas system in rural India serves as a good example in which households within the village shared their resources for the common benefits (Reddy 2004). In this project, households contributed their cow dung for communal biogas digester installed to provide light energy for the village. Households can find a solution for their problems if they are allowed to participate in decision processes. For instance, inequality in resource sharing can be easily avoided through the exchange of labour. This means that households with small amounts of feedstock can contribute labour for the collection of feedstocks and feeding of the digester. This approach is essential to reduce the costs of distribution and labour for collection of feedstocks. Accordingly, households can hand-over

their bio-wastes and collect biogas in return. Hence, households do not necessarily settle densely in a village to qualify for a pipeline distribution system. Households living nearby can cooperate and install the technology to get the energy and slurry benefit out of it. A communal energy system may not be affected by inequality among households and their living conditions.

The sustainability of biogas production depends on the labour spent on daily collection of feedstock, water and removal of its slurry (Tucho et al. 2016). Yet the issues of labour are not a significant concern with a community biogas system, given that the working load is well distributed. What is more, a larger reduction of resources and labour can also be achieved through biogas system integration. The integration of latrine and livestock farming with a biogas digester, for example, can reduce the demand for additional feedstock and water. With this, biogas production will become part of livestock farming, where the water used for the cleaning purpose can be directly applied to the digester. This mechanism also reduces operational costs that would be incurred when run as an independent system. In this way, biogas system integration helps to overcome possible limitations related to resources and operation of the system (Chen et al. 2010). This means that provision of technical and financial support is easier to arrange at a community level than at individual household level.

The integration of energy systems into income generation activities can also be a better approach to enhance the households' financial capacity to afford related costs (Brew-Hammond 2010). This approach can be vital for improving the economic capacity of the households, and especially that of women through provision of targeted financial support to activities contributing to both income and energy. Livestock smallholder businesses can be a better option to provide sufficient dung and urine at nearby locations in addition to income. These businesses are best known for their pro-poor, less capital-intensive, quick economic return, and sustainability in addition to the benefit for energy provision and use (Wambugu et al. 2011). Transforming and improving feeding from field grass to stall-fed conditions would substantially improve the quality of dung and provide easy access to the livestock's urine. The income generation activities can be applied at a household scale but are easier to apply at a community scale in many aspects (labour, technical and financial support). The application of a community energy system may not be straightforward, but it is critical. In general, an enabling policy with better understanding of local resources, demands, business, social relation and customs is needed.

7.9 Conclusion

The provision of modern energy access to people in developing countries requires a better understanding of the local socioeconomic, cultural, availability of resources and capacity and needs to adopt the technology. Many of the past policies tried to

solve the energy problems through top-down project implementation approach. This approach neglects the needs of the people, ignores their participation in planning and decision-making. As a result, many of these projects were not successful in their goal to provide modern energy access to the poor. It is apparent that provision of modern energy access to the poor requires an understanding of their needs and thorough integration into income generation activities. An integration of energy supply with income generation will be achieved by involving households (and particularly women) in the process of planning, local resources mobilizations, decision-making and implementation. As a result, the integration of the energy supply with income generation streams will help towards poverty alleviation and improve the economic capacity of the households for better technology adoption and realization of energy transition: key developments towards the attainment of the Sustainable Development Goals.

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