Assessment of the bioenergy policy for the sustainable
development of rural-based bioenergy systems in Zambia

M Kaoma 1,2* and S H Gheewala 1,2

1 The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, 126 Prachauthit Road, Bangkok 10140, Thailand
2 Centre for Energy Technology and Environment, Ministry of Education, Bangkok, Thailand

*Email: mwansa.ka@gmail.com

Abstract. Traditional biomass remains the primary energy source in rural Zambia – providing 98% of the energy needs. Its use is unsustainable, inefficient, and leads to harmful emissions with serious health implications, and deforestation. Modern bioenergy systems offer viable energy supply alternatives - but only if sustainably developed. Among other causes, the limited provision of modern bioenergy in rural areas is attributed to an ineffective public policy for promoting these systems in Zambia. Accordingly, this study evaluates the policy in place that seeks to promote sustainable bioenergy systems for rural areas in Zambia through the analysis of related strategies. It is observed that one of the significant weaknesses of the bioenergy policy framework is its lack of consideration of the bioenergy supply chains. These are influenced by four main elements – i.e., feedstock availability, conversion technology, intermediate energy carriers, and energy service demands - that considerably differ across rural localities within districts. Thus, the bioenergy policy-making process should be considered at such subnational levels (district). A suggestion that is well-aligned with the country’s decentralized governance agenda that is being implemented. Considering that there are numerous rural communities within a district and that information regarding the different elements of the bioenergy supply chain is required for the local government policy-making process, a framework to guide the generation of such information has been proposed.

Keywords: Bioenergy policy, Rural Zambia, Bioenergy systems, Districts, Sustainable

1. Introduction
Currently, less than 5% of the rural population has access to electricity in Zambia [1]. Traditional biomass in the form of charcoal and firewood are the dominant fuels that are used to provide 98% of the cooking and heating energy needs of these areas [1]. Their use has serious negative consequences, such as indoor air pollution and related health effects, deforestation and the labor-intensive and sometimes dangerous process of firewood collection [2]. It is well-documented that when correctly produced and used, modern bioenergy has the potential to not only curb such negative consequences but also contribute to a broader range of...
economic, social, and environmental objectives, hence facilitating sustainable development in the rural areas [3–5]. Therefore, the promotion of bioenergy technologies as a means of improving access to modern energy in rural areas should be prioritized in the energy planning processes of developing countries.

The successful deployment of sustainable bioenergy for rural areas is mainly dependent on sound bioenergy policy frameworks [6]. The reportedly low dissemination of modern bioenergy systems in rural Zambia [7] indicates that the current policy framework for their promotion is weak. Identification and analysis of barriers that hinder the effectiveness of this policy framework is an essential step towards formulating strategies for strengthening it. Accordingly, this study aims to assess the effectiveness of the existing policy framework for promoting sustainable rural-based bioenergy in Zambia by conducting a gap analysis of relevant policy objectives and strategies. In doing so, insights into appropriate remedial measures that can be undertaken to bridge gaps between these policy objectives and strategies, and the ‘practical impacts on the ground’ are provided. In this case, the ‘practical impacts on the ground’ refers to the increased access to modern energy in the rural areas of Zambia. Access to modern energy in this study (as defined by the UN-AGECC [8]) refers to access to: safer and more sustainable cooking and heating fuels, and stoves; energy that enables productive economic activity; and energy for public services.

2. Methodology
A qualitative analysis was used to assess the effectiveness of the existing policy framework for promoting sustainable rural-based bioenergy systems in Zambia. For this purpose, a gap analysis of relevant bioenergy-related policies was conducted in two steps. First, a review of key policies was carried out through desk-based documentary analysis to identify and analyze the objectives and strategies of sectoral policies that are relevant to the promotion of sustainable bioenergy. And second, through the interpretation of these policy objectives and strategies from the viewpoint of stakeholders' perception. In this study, stakeholders comprise actors that affect or are affected by decisions taken in the country's bioenergy policy context with a direct or indirect interest in activities related to developing bioenergy in rural areas. They were identified via desk research and snowballing until no additional participants were identified by the interviewees; and their perceptions obtained through semi-structured interviews. They included: i) bioenergy actors (7) from relevant policymaking bodies and research institutions who provided insights into the bioenergy policy process challenges in the country, ii) bioenergy developers and promoters (5) who provided insight into aspects related to bioenergy provision in rural Zambia, and iii) energy end-users (9) from rural communities who provided insight into energy supply challenges and the role of bioenergy in addressing such challenges.

Policy instruments and policy coherence are among the crucial factors that are considered to influence the effectiveness of an enabling environment for bioenergy systems [6,9]. Hence, these were the aspects that were considered in this study’s gap analysis. Policy instruments are techniques that are used in accomplishing policy objectives and strategies [9]. In this study, they have been categorized as regulatory and economic support.

3. Results
3.1 Gap analysis of policy instruments for sustainable rural bioenergy production
The following policies that articulate objectives and/or strategies that directly or indirectly promote the deployment of sustainable rural bioenergy were identified: Biomass Policy [10]; Rural Electrification Master Plan (REMP) [11]; the National Forest Policy (NFP) [12]; Renewable Energy Feed-in Tariff Plan (REFIT) [13]; Zambia Sustainable Energy for All initiative (SEforALL) [7]; and the National Agriculture Policy [14]. Table 1 shows the identified existing gaps that negatively impact the effectiveness of the identified policy objectives and strategies, including recommendations to respectively address them. They were associated with barriers that hinder the effectiveness of the relevant policy strategies, but could not be addressed due to the lack of appropriate instruments. The main barriers that were identified included
economic and financial barriers (high cost, lack of credit, and availability of cheaper fuels); and technical barriers (technology-design, installation, and maintenance). It was observed that the Biomass Policy articulates several measures and strategies that are aimed at promoting (indirectly or directly) all the three energy services associated with ‘access to modern energy’ (i.e., cooking and heating, productive and public energy services). However, since the same strategies are mentioned in the SEforALL initiative and the REMP, they were addressed under these sectoral policies. The two strategies unique (in the context of this study) to the Biomass Policy are: development of a regulatory framework and the provision of financial and fiscal incentives to promote bioenergy carriers for rural areas. One of the weaknesses that these strategies have and should be addressed before the development of instruments (i.e. those recommended in Table 1) is the exclusion of the intended bioenergy end uses. One way to deal with this issue could be by incorporating them into the other policy measures and strategies that specify bioenergy end uses.

Woodfuel use was identified to be one of the major hindrances to the promotion of alternative fuels such as biogas, briquettes, and pellets. This is because there are minimal costs associated with woodfuel production or collection - the majority of the rural end-users produce or collect it for themselves. The rural end-users interviewed were skeptical about adopting such alternative fuels that they have to pay for. The enforcement of regulatory mechanisms such as licenses and penalties related to woodfuel use could discourage the use of such fuels and in turn, promote the alternative fuels. However, this does not tackle the problem associated with the affordability of these alternative fuels. Two recommendations were made to address this issue. First, it is through the awarding of capital subsidies and grants to rural producers/end-users to reduce the investment costs (by the government). Second, is the internalization of external costs (including deforestation, time spent collecting woodfuel, and indoor air pollution) into the production and use of woodfuel to make the alternative fuels cost-competitive.

Respondents highlighted that high investment costs and the perceived high risks associated with investing in new technologies were the two main barriers that hindered the promotion of biomass-based power technologies. Capital and grant subsidies and tax waivers are two instruments that could help reduce the high investment costs. As indicated by FAO [15], capital and grant subsidies are well-suited for reducing investment costs associated with new technologies – in this case, biomass-based power technologies. Currently, only photovoltaic equipment receives tax exemption by the government in Zambia [16]; however, this should be extended to biomass-based power technologies. Despite the introduction of the REFIT strategy, there has not been any uptake of biomass-based power systems in the country. Among other reasons, respondents attribute this to the lack of a guaranteed selling price per unit of electricity generated. The setting of mandatory targets that are technology-specific is one regulatory instrument that was identified to be essential for promoting such technologies. This is because in contrast with aspirational targets (as is the case with the targets set in the REMP and REFIT strategy), making targets mandatory increases their credibility and longevity and reassures investors that a local market will continue to exist for their product in the future [17].

As observed, none of the objectives or strategies identified in this study considers a criterion that ensures that the deployment of rural bioenergy systems is sustainable. The respondents attributed this to the general lack of information/knowledge on appropriate bioenergy sustainability standards within the relevant institutions. This calls for capacity building in this area.
Table 1. Gaps existing in policy strategies and the recommended remedial measures

| Policy instruments | Sectoral policy | Policy strategies | Gaps | Recommendation remedial/instruments |
|--------------------|-----------------|-------------------|------|------------------------------------|
| Regulatory support | Biomass policy  | The regulatory framework for bioenergy production | Lacks appropriate instruments to implement it. | Instruments such as mandatory targets, licenses, and quotas. |
|                    | SEforALL initiative | Promote biomass pellets and briquettes, biogas as woodfuel alternatives | Availability of free woodfuel not addressed. | Use of regulatory mechanisms on woodfuel use. |
|                    | REMP             | Rural electrification using bioelectricity technologies. | Lack of private sector investment. | Formulate mandatory targets |
|                    | NFP              | Promote the use of biomass pellets and briquettes | Availability of free woodfuel | Strengthen existing regulatory instrument |
| Economic support   | REFiT            | Promote bioelectricity generation | Lacks a guaranteed selling price per unit of electricity supplied | Set tariffs and provide economic incentives. |
|                    | Biomass policy  | Provision of financial and fiscal incentives | Lacks instruments to implement the strategy | Economic incentives such as subsidies, tax waivers, grants, etc. |
|                    | SEforALL        | Promote biomass pellets and briquettes as woodfuel alternatives | Availability free woodfuel; and non-internalization of externalities | Internalization of external costs; and introduction of incentives |

3.2 Policy coherence

There were three sectoral policies identified that were relevant to the promotion of bioenergy from the viewpoint of dictating the use of biomass resources – the Biomass Policy, the Forest Policy, and the National Agriculture Policy. The objectives and/or strategies of these policies must be coherent with the objective of deploying bioenergy in rural Zambia so that conflicting regulations by relevant government agencies are avoided. It was observed that at objective level, the Biomass Policy and Forest Policy contain strategies that are both aimed at promoting bioenergy carriers as alternative cooking and heating fuels [10,12] – thus rendering them coherent. However, the Biomass Policy lacks implementation mechanisms for the promotion of these alternatives fuels while the Forest Policy seeks to attain its objective (i.e. of promoting alternative cooking and heating fuels) through the enforcement of regulations such as licenses and penalties on the use of woodfuel [12]. For this reason, coherence at the level of implementation practices between these policy strategies could not be assessed. Contrary, one of the policy strategies in the National Agriculture Policy conflicts with the objective of promoting bioenergy in rural areas. It seeks to promote conservation farming – a practice that involves the retention of crop residues in the fields and hence hinders their availability for bioenergy generation. It is worth noting that the respondents indicated that there was an ongoing discussion among relevant authorities regarding the need for tradeoff that makes crop residues available for both energy and farming purposes. Generally, there is a need for government to reinforce the above-mentioned policy actions that are related to the promotion of rural bioenergy.
3.3 Evidence-based bioenergy policies

Empirical evidence should be used in developing instruments such as the above-mentioned ones to increase their effectiveness in promoting bioenergy. To achieve this, evidence-based information is required. Maltosoglou et al. [3], indicates that such information should provide a clear understanding of the following aspects: (i) feedstock production potential, (ii) how and where the feedstock can be sourced and (iii) what conversion technology is the most efficient to fulfil the specific energy demands. Currently, this information is lacking in the country and the respondents considered this to be one of the main challenges faced in the bioenergy policy process. A framework shown in Figure 1 has been proposed to guide bioenergy policymakers to generate such information. It considers the heterogeneity of technology-feedstock combinations and associated environmental and socio-economic impacts that exist across Zambian districts. By doing so, the generation of evidence-based information (i.e., information that provides an understanding of the three aspects of evidence) is considered at the district-level. This aligns with the decentralized governance agenda that is being implemented in the country [18]. It is anticipated that through this agenda, local bioenergy policies can be formulated by a proposed Biomass Unit that will be accommodated in the offices of the local government institutions (at the district-level) but operating under the jurisdiction of the Ministry in charge of bioenergy (the Ministry of Energy in this case). In this framework, it is proposed that the District Agriculture Coordinating Office (DACO) and the Forest Department are two existing government agencies that are well-suited to collect information on crop residues and livestock manure, and forest residues, respectively. Currently, these agencies (located in each district of the country where rural communities are found) collect information related to crop production, livestock production (using extension officers) and forest logging (using forest officers). Under the guidance of the proposed Biomass Unit, information about biomass resource availability (representing the first aspect of evidence-based information) at the district-level can also be collected by these agencies. In collaboration, the proposed Biomass Unit and the two government agencies will collect information on spatial and logistical variables, and energy demand which the proposed Biomass Unit will use to generate evidence-based information related to aspects (i) and (ii). It is recommended in this study that information regarding aspect (ii) should be determined through the design and cost optimization of biomass-to-bioenergy supply chains to ensure optimal logistical costs. This is an effort aimed at reducing the production costs of bioenergy carriers – an important consideration for rural end-users who generally have a low purchasing power. On the other hand, information regarding aspect (iii) should be based on the sustainability performances of the bioenergy production pathways under consideration. This would assist in identifying preferable biomass types, feedstock sourcing patterns and bioenergy technology options that can deliver the desired forms (in terms of their sustainability impacts) of energy in the district. The sustainability assessment of the bioenergy production pathways could be based on existing bioenergy sustainability criteria (e.g. the Global Bioenergy Partnership Sustainability Indicators for Bioenergy) or ones that are tailor-made for the country. The effectiveness of collecting such informing will require the capacity building of the recommended institutions.
4. Conclusion
Access to modern energy in the rural areas of Zambia is extremely low. Undoubtedly, the dissemination of bioenergy systems would play a key role in alleviating this challenge and subsequently contribute towards the sustainable development of these areas. However, the success depends heavily on the development and use of policy instruments that address existing gaps within the relevant policy objectives and strategies for the sustainable deployment of bioenergy in rural areas. The identified gaps are mainly associated with the lack of mechanisms to address economic and technical barriers that hinder the effectiveness of the policy strategies. The development and implementation of the recommended remedial measures (instruments) rely on clear and specific objectives of the bioenergy interventions. That said, relevant authorities must redefine the existing policy objectives and strategies for promoting sustainable bioenergy in rural Zambia. In their current state, the intervention they seek to address seems to lack clarity; there is no mention of who the bioenergy beneficiaries are or/and the purposes for the bioenergy under consideration. In part, this is attributed to the lack of evidence-based information that comprises aspects of the bioenergy value supply chain. Hence, the proposed framework could guide in the generation of such information for rural areas at the district-level. Such information would also be critical in designing bioenergy policies at the district-level, thus supporting the decentralization governance agenda being promoted in the country.

References
[1] Central Statistical Office 2016 Living conditions monitoring survey (LCMS), Lusaka.
[2] Wassie Y T and Adaramola M S 2019 Potential environmental impacts of small-scale renewable energy technologies in East Africa: A systematic review of the evidence Renew. Sustain. Energy Rev. 111 377–391.
[3] Maltsoglou I, Kojakovic A, Rincón L E, Felix E, Branca G, Valle S, Gianvenuti A, Rossi A, Thulstrup A and Thofern H 2014 Combining bioenergy and food security: An approach and rapid appraisal to guide bioenergy policy formulation Biomass and Bioenergy 79 80–95.
[4] Hayashi T, Van Ierland E C, and Zhu X 2014 A holistic sustainability assessment tool for bioenergy using the Global Bioenergy Partnership (GBEP) sustainability indicators, Biomass and Bioenergy 66 70–80.
[5] Khwaja Y 2010 Bioenergy and Food Security: The BEFS Analysis for Peru Supporting the Policy Machinery in, Rome.
[6] Melinda K, Marie-Vincente P and Spencer C 2008 Sustainable Bioenergy Development in UEMOA Member Countries, Dakar.
[7] GRZ 2019 Sustainable Energy for All Initiative, Lusaka.
[8] United Nations Advisory Group on Energy and Climate Change (UN-AGECC) 2010 Energy for a Sustainable Future New York.

[9] Thornley P and Cooper D 2008 The effectiveness of policy instruments in promoting bioenergy, *Biomass and Bioenergy* **32** 903 – 913.

[10] Ministry of Energy and Water Development 2008 National Energy Policy Lusaka.

[11] Ministry of Energy and Water Development 2009 Rural Electrification Master Plan for Zambia 2008 - 2030 Lusaka.

[12] GRZ 2017 National Strategy to Reduce Deforestation and Forest Degradation Lusaka.

[13] GRZ 2017 Renewable Energy Feed-in Tariff Strategy Lusaka.

[14] GRZ 2018 Zambia National Agriculture Investment Plan (NAIP) 2014-2018 Lusaka.

[15] FAO 2017 How to guide for roadmap development and implementation, Rome.

[16] Rahul B and Woods M 2019 Zambia : Stand-Alone Solar Businesses Development Guide Brussels.

[17] Kieffer G and Couture T 2015 Renewable Energy Target Setting Abu Dhabi.

[18] GRZ 2017 Seventh National Development Plan 2017-2021 Lusaka.