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BARRIERS TO WIDESPREAD BIOMASS ENERGY IN SOUTH AFRICA

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Abstract

The generation of modern biomass for energy presents an incredible opportunity for South Africa to align development and climate goals. It also improves the environment by lessening the amount of solid waste that must be landfilled and by conserving energy and natural resources as well as increasing food production. Here, the term modern biomass includes organic wastes, energy crops and forestry biomass. Biomass is an important source of energy, used both by industry and by households for domestic energy. Despite its economically and environmental benefits, modern biomass energy is not well exploited in the country due to a number of barriers. The study identifies the barriers to biomass widespread and suggests the measures to overcome them. This study discusses the opportunities and risks that are related to the production of biomass for energy. The informal discussions and semi-structured interviews were conducted with the some renewable energy experts who were willing to participate in the study. Research findings revealed that inadequate renewable energy policies, political interests, unavailability of feedstock and water scarcity, poor institutional framework, lack of local expertise, weak dissemination strategies, high initial capital cost and lack of funds to expand investment on biomass projects, among others are the barriers to widespread modern biomass energy in South Africa. The study suggests the need for paradigm shift in the perceptions of renewable energy, government commitment and set policies to eliminate barriers as well as providing incentives measures to promote modern biomass energy production and developing public-private partnerships in the modern biomass projects.

Keywords: *Modern Biomass Energy, sustainability, barriers, measures to overcome barriers, South Africa*

1. Introduction and Background

In the last two decades many international bodies have taken initiatives in relation to energy policies in an effort to deal with the overwhelming issues of energy faced by many countries around the world. Policy makers have looked to a variety of low carbon technologies to help reduce reliance on fossil fuels and decrease greenhouse gas emissions which is changing climate (Guillinghan and Sweeney, 2012). Accordingly, the Africa Union Assembly of Head and the Government in 2009 called for political will to develop renewable energy resources to provide clean, reliable, affordable and environmentally friendly energy. This was reaffirmed in the 2010 African Union Maputu Declaration, which created the Conference of Energy Ministers of Africa (CEMA). One year later in July 2011, the African Ministers of energy and African Union met in Abu Dhabi at the invitation of the International Renewable Energy Agency (IRENA) and they called for the promotion of the use of Africa's vast renewable energy resources to boost the continent's sustainable development.

Recently, Africa has experienced economic improvements; these can be sustainable only through the access of modern renewable energy. The continent has abundant renewable energy resources that can accelerate its economic growth, create job opportunities for poor communities, while improving life conditions of population by providing universal energy access. As indicated by Ouattara, (2011), Africa has renewable energy potential estimated at more than 1000 times higher than its current needs, while 75% of Africans still have no access to electricity. Due to the increasing costs of fossil fuels and the continued prominence of global warming; access to renewable energy is becoming increasingly crucial not only for making our economies work, but also reducing greenhouse gas emissions that put our climate at risk. Renewable energy technologies produce little or no greenhouse gases and rely on virtually inexhaustible natural elements for their fuel (Foster-Pledley and Hertzog, 2006). Renewable energy resources include biomass, hydrology, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

The penetration of modern biomass for power generation in Africa in general and South Africa particularly is very slow; despite socio-economic and environmental benefits that it presents to both low income communities and plants. However, few scholars engage with this field of research and there is no significant scientific literature for Africa to date. This paper focuses on modern biomass which is among one of renewable energy sources often promoted as the solution to the global warming problem; and it is seen as the most promising energy source to mitigate greenhouse gas emissions (Khan *et al.,* 2009). It examines the barriers to the adoption and use of modern biomass energy in as well as devising possible measures to overcome them. Therefore, the paper is structured as below. The following section provides a detailed research method used in the collection, analyzing, interpreting and presenting the data. Section three provides a review of the literature around biomass energy in the African continent in general and in South Africa in particular. The paper examines the potential of both traditional and modern biomass energy. Section four focuses on the status of modern biomass energy in South Africa. Section five will develop a framework for identification of barriers; discuss the barriers to

modern biomass and the measures to overcome them. The final section will conclude with policy recommendations.

2. Methods

This paper is a qualitative research based on formal and informal discussions with renewable energy experts in South Africa who were willing to participate in the study. All respondents were knowledgeable about the renewable energy sector and familiar with biomass energy generation technologies, market and the barriers hindering their widespread adoption in South Africa. The experts are mainly from South African Department of Energy, ESKOM, a South African electricity public utility, PIKI TUP South Africa waste management public utility and the renewable energy scholars and other stakeholders. The discussions were based on the five biomass energy variables barriers as identified by experts during the discussions include: Political interferences, poor profitability and funding issues, scarcity of water for energy crops, unavailable land for crops production and feedstock and uncertainty about the energy institutions.

The fundamental question of barriers analysis is why modern biomass energy is not widespread in South Africa, despite being socio-economically and environmentally endowed? This question requires the examination of all identified variables to understand the barriers for widespread of modern biomass energy in South Africa and eventually propose the measures to deal with them. The approach is a qualitative evaluation based on experts' opinions. In addition to this approach, a review of local and international renewable energy policies, strategies, studies and reports, their assessments, existing renewable energy projects, reasons for their success and failures were used to identify barriers for biomass energy use and adoption in South Africa. The experts' opinions were used as criteria to identify and discuss modern biomass barriers in the country. The study assumed that all barriers are serious and there is a need to take all of them into consideration. The study identified categories of barriers and discusses some barrier elements according to the experts' opinions as well as local and international renewable energy policy and strategy reports. The study will make recommendations and measures to overcome the barriers based on barriers categories orders of analysis.

3. Biomass Energy in Africa

In Africa, about 80% of a total of 657 million people rely on traditional use of biomass for cooking (IEA, 2010). This trend is expected to increase from 583 million to 823 million, which is an increase of about 27% in Africa between 2000 and 2030 (Stecher K, *et al.,* 2013). Generally, there are two forms of biomass energy including traditional and modern (Goldenberg and Coelho, 2004). The percentage is greater in Sub-Saharan Africa (SSA) where roughly 80 to 90% use traditional biomass energy as primary domestic energy supply and consumption, and up to the equivalent of one third of the total household economy (Ouattara, 2010). The trend is even elevated in countries characterized by high levels of poverty such as Burundi, Central Africa Republic (Stecher K, *et al.,* 2013) and the D.R. Congo. This deepens poverty among African women who are more vulnerable given their traditional domestic roles. Accordingly, Larson and

Kartha, (2000) indicated that a considerable number of women and children of developing countries spend a considerable amount of time collecting daily bases to cater for their energy needs and suffer the brunt of indoor air pollution caused by direct combustion of biomass for cooking and heating.

Many African countries still have difficulties conceiving biomass as a modern source of energy, given the role that it has played, and continues to play in most developing countries today. Modern biomass represented in 2000 was only 2% in Africa (Larson and Kartha, 2000). The trend has not changed much until today. Such traditional use of biomass fuels is typically inefficient, relying largely on low-cost sources such as forests and other natural vegetation including use of fuel wood, charcoal, tree leaves, animal dung and agricultural residues for cooking, lighting and space heating can have serious negative impacts on health and living conditions, e.g. pneumonia, chronic obstructive pulmonary diseases or lung cancer (IPCC, 2011). Conversely, modern biomass is able to provide an important contribution to future energy systems of sustainable energy supplies; while creating opportunities for increased food production, especially in rural areas (Eleri and Eleri, 2009). Modern biomass resources are abundant, sustainable, can be quickly implemented, offer work opportunities and have a much lower impact on the environment. Furthermore, modern biomass is projected to contribute about one half of the total energy demand in developing countries by the year 2050 (IPCC, 2007). It will become a source of energy which will be available locally, renewable and of wide origins, and therefore, giving the opportunity to be used for fuels, power production and products that would otherwise be made from fossil fuels.

Generally, there are three categories of modern biomass which include: woody biomass from forestry, woody and herbaceous energy crops from agriculture, and organic waste. Duku *et al.,* (2011: 406) identified some major categories of biomass feedstock including the forest products (e.g. wood, logging residues, trees, shrubs and wood residues, sawdust, barks, roots, etc.); bio renewable wastes (e.g. agricultural wastes, crop residues, mill wood wastes, urban wood wastes, urban organic wastes, municipal solid wastes, domestic solid wastes); energy crops (e.g. short-rotation woody crops, herbaceous woody crops, grasses, starch crops, sugar crops, forage crops, oilseed crops); aquatic plants (e.g. algae, water weed, water hyacinth, reed and rushes); food crops (grains, oil crops); sugar crops (sugar cane, sugar beets, molasses, sorghum); landfill; industrial organic wastes (e.g. yard trimmings from private gardens, waste wood and demolition wood); algae and mosses and kelps and lichens. There are plenty technologies involved for modernized conversion of biomass energy as indicated in table 1 below.

Table1: Technologies for Modernized Conversion of Biomass Energy

Technology	Scale	Energy services provided
Biogas	Small	Electricity (local pumping, milling, lighting, communications, refrigeration, etc. and possible distribution via utility grid Cooking and heating
Producer gas	Small to medium	Electricity (local pumping, milling, lighting, communications, refrigeration, etc. and possible distribution via utility grid Cooking and heating
Ethanol	Medium to large	Vehicle transportation Cooking
Stream turbine	Medium to large	Electricity (for industrial processing & grid distribution) Heating process heat
Gas turbine	Medium to large	Electricity (for industrial processing & grid distribution) Heating process heat

Source: Kartha and Larson, (2000)

South Africa has the highest energy consumption in Africa with more than 50% of overall energy consumption in Africa (Marcelle, 2013). Historically, South Africa post-apartheid economy has relied on the mining activities and this requires intensive energy (Haw and Hagues, 2007). Thus, the country's economic development strongly depends on energy. Mining aimed to resolve the inherited financial crises and promote a developmental agenda intended to accelerate economic growth and the regime's social inequalities (*ibid*).Consequently, South Africa has extensively engaged in the mining of coal as energy source which in 2001 represented about 93% of electricity generation, which was the highest in world (NER, 2001). , and tToday more than 75% of primary energy requirement are from fossil fuels, ranking the country the 12th in the world in terms of top greenhouse gas emitters (Marcelle, 2013). In 2004, coal comprised 70% of the country's energy demand, crude oil around 23%, nuclear energy accounted 3% and only 8% for renewable energy (DME, 2004). South Africa's energy consumption is summarized as follow: 27% electricity, 26% consumer coal combustion, 32% liquid fuels, 14% biomass and the balance (1%) from other renewable sources Ward, (2002: 18).

Recently, government embarked on a program of funding options to help provide a cost cushion to the economy during the transition from the current coal-based system to one that included the introduction of some 17 800 MW of renewable by 2030 (Jacobsson, and Bergek, 2004) . Besides, several energy polices and strategies have been adopted and developed by government departments and agencies to promote renewable energy systems including: National Energy Research, Development and Innovation Strategy (developed by Department of Minerals and Energy, Department of Science and technology and other stakeholders; National target – Renewable Energy Production of 10 000 GWh by 2013 development by the Department of Minerals and Energy; Biofuels Industrial Strategy 2007 – 2% penetration by 2013, EE (efficient

energy) target - energy demand reduction of 12% by 2015 SWH National Target – 1 000 000 by 2014 and Ten-Year Innovation Plan for South Africa (5 Grand Challenges – Energy Security, Farmer to Pharma); Long Term Mitigation Strategy (scenarios to mitigate greenhouse gas emission); IRP Integrated Resource Plan for electricity 2010 (42% by 2030) and National Energy Act (No 34 of 2008 Renewable Energy Bidding (REBID) Program.

The policies and strategies aimed to promote diversification of energy supply, ensure emerging energy technologies are incubated and commercialized and ensure appropriate human capital is developed to support new industries. Despite policy changes and government efforts toward sustainable energy and moving away coal energy; renewable energy was still viewed as an economic cost (NER, 2001). There are still doubts and hesitations for the South African government on the capacity of renewable energy to provide job opportunities and boost economic growth to respond to apartheid challenges.

4. Potential of Modern Biomass in South Africa

Renewable energy including modern biomass is still in its infancy stage in South Africa (Winkler, 2005). South Africa's biomass energy resources are restricted due to limited water, only the energy from waste is more readily available and exploitable, but still have barriers. There are still doubts and hesitations for the South African government on the efficiency of renewable energy including modern biomass to provide job opportunities and boost economic growth to respond to apartheid challenges. The White Paper on renewable energy's target of 10 000GWh renewable energy contribution to final energy consumption by 2013 was confirmed to be economically viable with subsidies and carbon financing. The approved Strategy suggests a 2% biofuel penetration to the current fuel pool by 2013 which will slightly contribute to energy security, create 25 000 jobs in rural farming, and achieve a balance of payments saving of R1.7 billion (DME, 1998). South Africa has moved from traditional biomass to modern biomass with a demographic trend for people to migrate from the rural to the urban areas. Traditional biomass in South Africa accounted in 2002 for 4.4% of total primary energy supply (DME, 2002), which is much lower compared to other developing countries. This shows the importance South Africa has given to develop modern biomass.

The country already has significant experience of power generation from biomass. Some sugar mills burn bagasse, and paper and packaging mills use waste biomass to generate process steam, and generating approximately 210 GWh of electricity per year (DME, 2004). However, the country has dry land, with about half of its area consisting of desert or semi desert and only 1.2% under forest, so conditions for building up and sustaining biomass are generally poor (Haw and Hagues, 2007). Biomass is an important source of energy by households for domestic energy and in industries such as sugar refining and paper and pulp. In South Africa, modern biomass is used for heating, lighting and cooking in the poor areas, while the industrial use is small but significant. Accordingly Winkler *et al.,* (2007) indicates that the country's sugar cane harvested, of 20 million tons 7 million tons is bagasse with a heating value of 6.7 MJ/kg; the sugar industry produced 2 32 million tons of pulp and 2.34 million tons of paper in 2003.

Table 2: Summary of Energy Potential from Biomass in South Africa

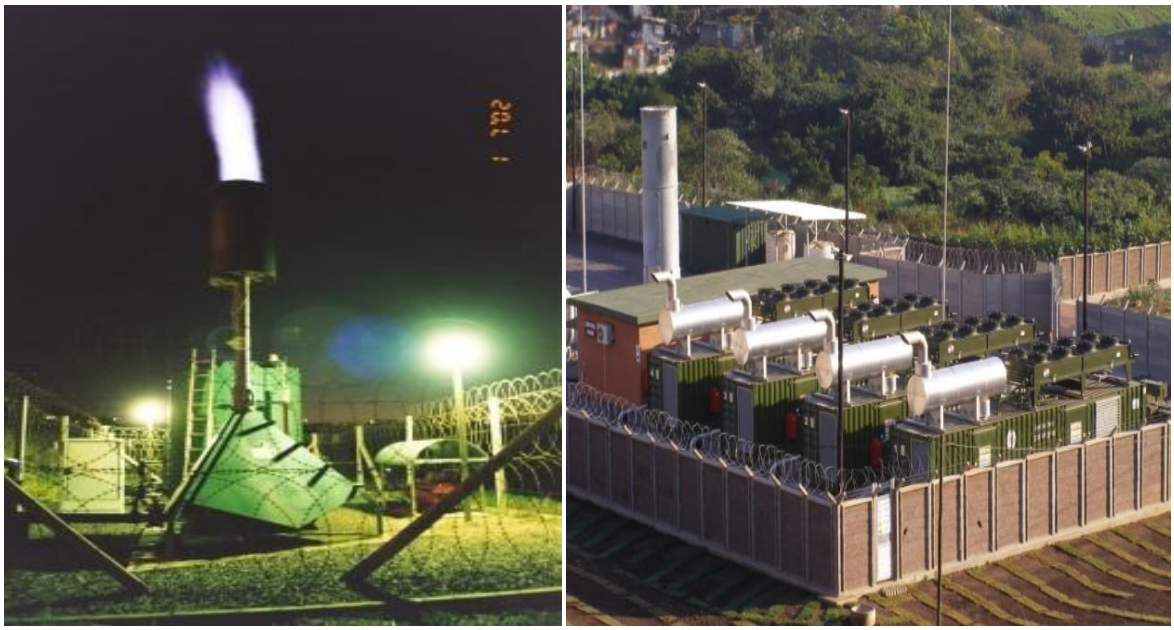
Industry	Biomass	NCV (MJ/t)	Mass (1000 t)	Energy Content (TWh/yr)	Power Potential (GWh/yr)
Sugar	Field Residue Bagasse	6894 7117	5336 6136	10.21 12.12	2553 3031
Forestry	Softwood Hardwood	13016 11820	1588 1555	5.74 5.11	1650 1073
Saw Mill	Chips Dust Bark	10316 10611 10135	1433 730 443	4.11 2.15 1.25	1162 608 353
Pulp & Paper	Black liquor Sludge Bark	6243 5777 7975	5206 234 345	9.03 0.38 0.76	2257 94 191
Total		7958	23006	50.86	12972

Source: Haw and Hagues, (2007)

Table 2 above shows the importance and the significance the country gives to the modern biomass energy sector. Furthermore, modern biomass processed fuels including ethanol, biodiesel; methanol and hydrogen are produced from modern biomass. Bioethanol fuels for instance is processed from wheat, sugar beet, sugar cane and sweet sorghum whereas biodiesel is produced from ripe oilseed, sunflower oil, jatropha and a new technology that uses a lipid-rich type of algae (Haw and Hagues, 2007).

Furthermore, landfill conversion to electricity is also playing a role in energy generation in South Africa. South Africa's total estimation of domestic and industrial waste disposed in landfill sites has an energy content of about 11 000GWh per annum, which can be converted into biogas and methane for electricity production (*ibid*). There are some ongoing landfills conversions to energy projects in the country with the more important ones located in Durban and they include the Mariannhill and Bisasar Landfill Sites. The World Bank's Prototype Carbon Fund has funded some ongoing projects in the Durban Metropolitan Municipality (including the Mariannhill Landfill and Bisasar Landfill Sites) which consist of improving landfill gas to generate up to 10 MW of electricity; it has already purchased the greenhouse gas reductions of 68, 833 metric tons $C0^2$ equivalent per annum (DSW & PCF, 2006).

Figure 1: Illustration of Bisasar Road Landfill Sites Engines



Source: EMCSWU, (2006)

Despite the development of modern biomass as a source of energy in the country, the unregulated use of natural vegetation such as forest or local plants are cut down for fuel wood and unsustainable practices which lead to erosion, desertification are still used in many rural areas of South Africa.

5. Barriers to Penetration of Modern Biomass Energy in South Africa

The production of modern biomass for energy presents incredible opportunities for South Africa to align development and climate goals if it is implemented in a sustainable manner. Despite the enormous benefits from modern biomass, their use in the country is not as widespread as expected due to several constraints. These barriers substantially reduce the probability of modern biomass technologies and widespread market and, if they remain may keep the market penetration of modern biomass technologies beyond when compared to other forms of the renewable energies. Several barriers have prevented the widespread of renewable technologies which have been discussed in the recent literature (Painuly J P, 2001, Foster-Pedley and Hertzog, 2006, Gets and Mhlanga, 2012, Haw and Hugues, 2007, Nhan T. Nguyen *et al*., 2010, Willis Joha, et al., 2012). Some barriers may be specific to technologies due to the categories of biomass, while some may be specific to a province or area. Barriers were also briefly discussed in the Intergovernmental Panel for climate change (UNFCCC, 1998) second and third assessment reports are discussed in details in the following section.

Widespread modern biomass energy in South Africa is being held back by several barriers. These are frequently discussed in South Africa literature (Foster-Pedley and Hertzog, 2006, Gets and Mhlanga, 2012, Haw and Hugues, 2007, Banks & Schaffler, 2006), but can be presented as follow:

- **High price of energy and equipment resulting poor profitability:** This is due to very low coal prices, South African coal prices are among the lowest in the world (Haw and Hugues, 2007), because it is highly subsidized by the government; this makes it difficult for people to invest on renewable energy including modern biomass in which the production costs are higher. Also the upfront costs for modern biomass devices are presently beyond the reach of the poor communities for which it is intended and this serves as a barrier to the adoption of biomass technology.
- **Scarcity of water for energy crops:** Large-scale modern biomass based energy generation raise concerns about water given the fact that South Africa is a water stressed country and energy crops are known to require more water than native species and also there is a risk for food security if land is taken up with energy crops rather than food crops.
- **Unavailable land for energy crops production:** South Africa is an arid country. Availability of land for energy production ranges from 2% (1.3 Mha) of the total semi-arid and arid area in South Africa; it is restricted mainly by agricultural land use, but also by steep slopes and biodiversity protection (Wicke *et al.,* 2011). Modern biomass is highly dependent on available land and the level of production yields.
- **Political interferences:** Fossil fuel and nuclear based power is strongly lobbied for and political interests which support and subsidize those industries. However, it is also being considered as privileged insensitive energy source which can sustain the national economy and therefore allow post-apartheid government to achieve development goals (economic growth and jobs creation).
- **Uncertainty about the institutional structure of the energy sector:** A lack of adequate institutional frameworks and weak or inexistent policies to support biomass initiatives. Large-scale participation by private investors in the electricity sector as announced by government is still unclear, with significant ambiguity about the conditions under which Independent Power Projects (IPPs) would participate (Haw and Hugues, 2007).
- **Poor dissemination and lack of local expertise:** There is a lack of awareness and information on supply and sources availability.

Most modern biomass projects are managed by expatriates, who lack component for skills transfer and local human resources necessary to lead the projects.

- Finally, the concern from modern biomass is the **cost and availability of the feedstock**, the sufficient and cheaper feedstock can reduce the production cost and help make biomass energy more competitive.

It has been noted in the research method section that the study has considered all experts' opinions on barriers to modern biomass as important. The questionnaire was structured in way that each expert was able to provide some solutions to the barriers identified. Therefore, stakeholders were not involved only in identifying the problems but also in proposing the solutions.

6. Measures to Overcome Barriers

This section deals with developing enabling policies and strategies to remove or reduce the above mentioned barriers. This will allow the modern biomass to become more completive and gain its full potential in market. Penetration of modern biomass energy offers prospect of reducing greenhouse emissions while providing environmental friendly sustainable energy to poor communities and provide job opportunities. In general, the experts have highlighted the role of the government in removing the barriers. Furthermore, many other stakeholders including civil society, local community, private business and international partners (financial institutions and donors) may play a vital role in promoting the adoption of use of modern biomass in South Africa.

Accordingly, the Intergovernmental Panel for Climate Change (IPCC) has detailed the role of government in the environmental protection and technology transfer of renewable energy including generic actions to remove barriers, enabling policies and strategies, building human and institutional capacity, setting up research and development infrastructure, creating an enabling environment for investment, and providing information and mechanisms to promote renewable energy technology and market (IPCC, 2011). This requires a firm commitment and concrete actions from South African government in removing modern biomass barriers.

The experts have suggested urgent need to move from the simple declarations to act for renewable energy. Such acts include establishing renewable energy policies, regulations and institutions on modern biomass energy including price-setting and quantity forcing policies with electricity feed in laws, competitively-bid renewable resource obligation, renewable energy portfolio standards, and modern biomass energy certificate. Government's coal energy's financial support and subsidies should be stopped or reduced; alternatively these should be replaced by renewable energy particularly modern biomass. The experts have suggested the creation of incentive measures including investment subsidies and rebates, tax relief, grant, loans and carbon credit. These will stimulate local manufacturing including public investments and market facilitation activities such as carbon credit, public benefit funds, and infrastructure

polices, government procurement and customers education and mandated generation disclosure information must be directed towards investment in renewable energy sources. Finally, the experts have drawn attention on development of irrigation systems and the acquisition of land for energy crops as well as sustaining the efficacy of indigenous renewable projects under the Clean Development Mechanism and financing through public-private partnerships.

South African government should show a clear move away from fossil fuels to renewable energy including modern biomass which must be harmonized with all government policies throughout the various departments addressing energy issues. The experts recommend the establishment of adequate renewable energy institutional framework at all levels of government, but also clarity is needed around the grid tie legislation, beginning with a clear net metering programme that allows for the inclusion of small to medium renewable energy power producers. There is a need for a dedicated and maintained local content drivers to ensure that local investors, producers and manufacturers, project developers gain experience.

In addition, the experts noticed that the great potential of energy crops can only be realized through an enormous increase in agriculture production efficiency. Thus, the expansion and improvement of current agriculture production systems in South Africa will play a crucial role in the sustainable development of biomass. Given that the country is arid with water scarcity, energy crops and forestry biomass require more involvement of government to promote irrigation systems and provide more land for the cultivation of energy crops. Conversely, organic waste for gasification and power generation has huge potential because of growth in both domestic and industrial wastes in the country due to economic and population growth.

7. Conclusion

Modern biomass energy has significant potential to penetrate the South Africa energy market under strong global greenhouse gas mitigation scenarios in future and socio-economic impacts, if it is appropriately designed and implemented. However, South Africa's government through the Department of Minerals and Energy has set up a national target for a 15 year promotion of renewable energy including modern biomass by the year 2013. This seeks to integrate clean energy use into a national regulatory framework. Despite it's socio-economically and environmentally benefits for all applications, why is South Africa not a leader in the renewable energy in general and modern biomass in particular? Formal and informal discussions were undertaken with domestic renewable experts and other stakeholders to analyze the major barriers to wider adoption of modern biomass energy technology and market in South Africa. The outcomes of the experts' opinions can be summarized as follow: The most repeated barriers to the adoption of modern biomass energy under all categories are costs of productivity (financial), high price of energy and equipment resulting poor profitability, political interests, institutional constraints, poor dissemination and the lack of local expertise and deficiencies in government policies. The obstacles related to energy crops and forestry biomass is scarcity of water for energy crops, cost and availability of the feedstock and unavailable land for energy

crops production. The same experts were asked to propose the measures to overcome all barriers enumerated. Given the fact that all barriers were considered important and necessary to be addressed, and so was the case with measures to overcome the barriers, however, there were differences in the views of the different expert. The results on exploring how to overcome the barriers as identified as follow: To allow the penetration of modern biomass technology and market in South Africa, the experts recommended the establishment of renewable energy policies, regulations and institutions on modern biomass energy including price-setting and quantity forcing policies with electricity feed in laws, competitively-bid renewable resource obligation, renewable energy portfolio standards, and modern biomass energy certificate. Besides the experts have suggested the creation of incentive measures including investment subsidies and rebates, tax relief, grant, loans, carbon credit, and finally they have drawn attention on development of irrigation systems and provision of land for energy crops production as well as sustaining the efficacy of indigenous renewable projects under the Clean Development Mechanism and financing through public-private partnerships. In general, the government's intervention was clearly highlighted by the stakeholders. Government is considered by all as a key enabler for encouraging renewable energy and modern biomass technology and market in South Africa. Promotion of modern biomass energy is a responsibility of everyone including individuals, community groups, civil society organizations, investors and the external partners to voice and lobby for sustainable energy in South Africa.

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