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# Converting Waste Agricultural Biomass into an Energy Source: A Policy Framework

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***Abstract*—The importance of the management of waste agricultural biomass is highlighted and a generic methodology for the development of policy framework in the promotion of waste agricultural biomass to energy conversions is presented. A stepwise process covering data collection and review, policy drivers, policy recommendations and policy coherence, with monitoring and continuous improvements is proposed. It is concluded that the establishment of a sound policy framework would enhance the benefits of the sector development, particularly contributing to the achievement of national development targets in general.**

***Keywords*—*waste agricultural biomass*, policy framework, waste mangement, renewable energy.**

## I. Introduction

The world has an abundance of waste agricultural biomass (WAB) from variety of sources including agricultural, forest, and urban waste streams. Sustainably collected biomass can be used to produce renewable energy (RE), such as electricity, heat or transport fuels. WAB is a flexible energy resource that is ideal for distributed generation or local applications, which preserves local wealth while stimulating job growth and economic development [1]. Using biomass to produce energy reduces the need for traditional disposal options for WAB such as landfill disposal or open burning, while reducing dependence on fossil energy sources. However, the governments and local authorities in developing countries are largely unaware of the immense potential of converting WAB to energy (WAB2E). Sound technologies have been developed for converting WAB2E, but most of these technologies have not been demonstrated in developing countries. The countries also lack knowledge and the capability to assess different technology options in order to select those which will be most suitable for local application [2].

Interest in biomass energy, including WAB2E, has increased globally as governments are trying to reduce their greenhouse gas (GHG) emissions and identify alternative energy sources to increasing populations. Policy and regulatory frameworks are important factors that influence the successful adoption and implementation of WAB2E technologies as well as the availability of specific feedstock materials. Well-developed policy and regulatory frameworks encourage owners and developers to implement WAB2E conversion systems. Policies are translated into regulatory and economic instruments for their implementation.

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There may also be some voluntary instruments agreed upon by the stakeholders [3]. Under the circumstances highlighted above, undertaking policy studies to identify appropriate policy measures become an essential requirement for successful development and implementation of WAB2E conversion systems.

## II. Methodology for the Development of Policy Framework

### A. *Key Steps*

Compared with any other area of RE, bioenergy is the most complex due to its numerous inter-linkages, touching on many policy areas. Thus, while led by RE goals, the task of promoting WAB2E requires an inter-sectoral response. Bioenergy is unique due to its multi-sectoral, multi-level and multi-disciplinary nature. In case of WAB, situation becomes more complex as it is presently considered to be a waste, and therefore requires additional policy fields to be accounted for, and thus more strategic policy framework compared to other REs [4]. Accordingly, the stepwise process illustrated in Figure 1 is recommended for the establishment of a sound policy framework for the development of the sector [5], and each step is explicated in the following sub-sections:

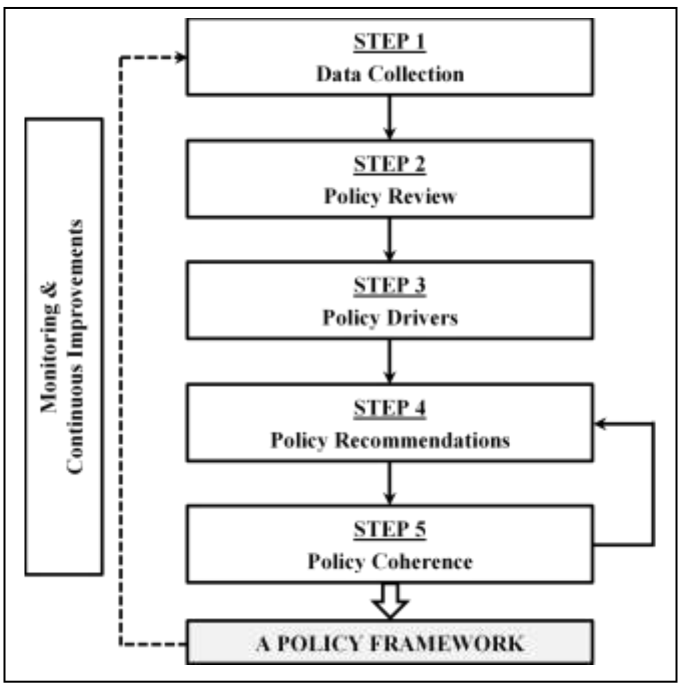


Figure 1. Key steps of the development process of policy framework.

### B. Data Collection and Review

First step of the development of policy framework is to perform a comprehensive collection of information on existing policies and related aspects covering all areas and sectors, including laws, acts, regulations, economic instruments, etc. In general, the policy objectives of WAB2E conversion sector relate to core areas such as sustainable development, green growth, climate change (CC), agriculture, and solid waste management (SWM); thus reflect in a variety of policy documents. The main policy documents to be covered include:

- National development policies and strategies.
- Energy policies (including RE, and energy efficiency).
- Green growth, environment, CC, SWM policies.
- Other related policies such as agriculture, industry, science & technology.

The second step is the in-depth review of policy elements and associated instruments, together with the levels of progress and enforcement to identify the gaps and barriers. More descriptions of the barrier analysis are presented in Section III. Once the policy review is done, measures should be formulated to bridge the gaps and enhance the solidarity and effectiveness of the policy framework.

### C. Policy Drivers

As the policies related to WAB are linked to core economic policies that have engaged central planning, finance and sectoral ministries and agencies in their formulation, there could be a number of national level policy drivers in each area. Identification and establishment of linkages with such policy drivers will provide a sound platform for the development specific policy elements. Therefore, it is important to identify whether such driving factors have been encompassed into the present policy framework and how they have been effectively used for the promotion of the sector. The followings are the main policy drivers recommended to be investigated for developing specific policy elements [5]:

- Energy security: Heavy dependency on imported fossil fuels and limited commercialized RE options are among the key factors influencing the energy security of many developing countries. Basically, availability, sufficiency, affordability and sustainability of energy supply are interlinked facets of energy security. The WAB2E conversions could diversify the energy resources and enhance the indigenous resource base, while contributing the replace fossil fuels.
- Rural development: WAB2E conversion systems provides access to energy for rural and regional industries and communities, stimulating their economic development, while enhancing employment, entrepreneurial and market opportunities in biomass business.
- Climate change: With many countries committed to reduce GHG emissions under the Kyoto Protocol of the UNFCCC, WAB2E conversion provides a source of RE for in place of fossil fuels; thus contributing to the mitigation of CC impacts of energy sector. In addition, there are possible future business opportunities for carbon offsets.
- Environment effectiveness: Increased use of WAB for productive applications helps to mitigate local waste issues, particularly adverse environment impacts of present improper management systems such as open burning or open dumping.
- Economic efficiency: WAB2E conversion systems offer opportunity to improve economic efficiency of energy and raw material use in households and industry via reducing cost of the disposal and replacing non-renewable products or raw materials.
- Market innovations: The development of WAB2E systems has to be ensued through technological advancements and process improvements; thus acts as an engine of growth and market innovation. This can offer possibilities in developing local solutions to energy needs and industrial development.
- Knowledge society: The development of WAB2E conversion systems represents extraction of an indigenous resource to resolve local issues (e.g. energy, waste) involving utilization of local expertise for design, manufacture, operate and manage. There is a tremendous opportunity for knowledge development -sharing-application; thus allowing all stakeholders to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future.

### D. Policy Options

The next step is to propose and promote targeted policy options and market approaches (new or revisions), across all sectors of importance, that encourage industry innovations and provide maximum long-run benefits to the society, rather than continuing with a policy strategy that just seeks to close the gap between WAB2E conversion options and alternative (fossil fuel) options. At present, most countries employ policy tools using financial supports that often unrelated to the externality benefits of avoided emissions. This approach, however, is likely to lead to market distortions and long term market dependence on subsidies. Alternative approach could be to focus policies on encouraging technological innovations and reducing technology costs [6]. The formulation of policies will have major influence on the selection of WAB2E conversion options and to the extent to which introduced technologies contribute to the underlying policy objectives. Such policy elements and their essential attributes are presented in Section IV as general and specific policy recommendations.

### E. Policy Coherence

Policy coherence is required to ensure that different actors and issues concerning WAB2E conversions work together for common goals and results, while minimizing contradictions between different policy aims, prioritizing economic, social, and environmental objectives and capturing synergies [7]. Further, policy consistency, integration and coordination are vital elements of a sound policy framework. All these aspects have to be considered when proposing new policy elements or revising the existing ones, which is illustrated in Figure 1 through a feedback loop. Then combined effects of various policy sectors need to be considered in decision making.

### F. *Policy Framework*

Successful accomplishment of the key steps described above would facilitate the establishment of a policy framework for the advancement of WAB sector. A well-design system for monitoring and continuous improvement is also required (as illustrated in Figure 1). In the development of policy elements, it is useful to recognize the essential features of a sound policy framework in general. It is recommended to embrace the following key features when formulating specific policy elements [4]:

- Forward looking: Clear definition of policy outcomes and a long-term view based on statistical trends and informed predictions of social, political, economic and cultural trends.
- Outward looking: Consideration of influencing factors in the national, regional and international spheres and how policy will be communicated with the public; drawing on experience in other countries. This includes both external analysis (i.e. the examination of the industry and socio-economic environments) and internal analysis that focuses on identifying the institution's resources, capabilities and competencies.
- Joined up: Linkages to the policies in the other related sectors; a holistic view of looking beyond institutional boundaries to the strategic objectives and seeking to establish the ethical, moral and legal base for policy.
- Inclusive: Process that considers the impact on and meets the needs of all community affected by the policy; and involves key stakeholders. The first step is often to build communication channels among stakeholders. Planning or decision making should include both top-down and bottom-up processes.
- Continuous improvement: Knowledge is passed through feedback loops between the final and the first stage, and become an input for the next planning round; continuous learning, adaptation and improvement in the policy process.

## III. Barriers for the Promotion of Waste Agricultural Biomass to Energy Conversion

Even with many benefits, commercialization and large scale dissemination of WAB2E conversion technologies faces several barriers related to technical, financial, policy, information, institutional, capacity, and regulatory. Appropriate policy frameworks and economic instruments could be used to overcome those barriers. As the policy contexts are country specific and unique, clear understanding of the barriers as well as instruments that could be used to tackle the specific barriers is required. Such type of barriers could be categorized as techno-economic and non-economic [7]. The techno-economic barriers are present if the cost of a given WAB2E conversion technology is above the cost of competing alternatives, even under optimal market conditions. Technological maturity and economic barriers are directly connected. The non-economic barriers relate to factors that either prevent deployment altogether or lead to higher costs than necessary or distorted prices. These barriers can be differentiated further as given below:

- Regulatory and policy uncertainty: These relate to bad policy design, discontinuity and insufficient transparency of policies and legislation.
- Institutional and administrative: These include the lack of strong, dedicated institutions, lack of clear responsibilities, and complicated, slow or non-transparent permitting procedures.
- Market: Market barriers include inconsistent pricing structures that disadvantage WAB2E conversion options, asymmetrical information, market power, subsidies for fossil fuels, and the failure of costing methods to include social and environmental impacts.
- Financial: These are associated with an absence of adequate funding opportunities and financing products for RE.
- Infrastructure: These are mainly focused on the flexibility of the energy system, e.g. the power grid, to integrate/absorb RE.
- Lack of awareness and skilled personnel: These relate to insufficient knowledge about the availability and performance of WAB2E conversion technologies as well as insufficient numbers of skilled workers.
- Public acceptance and environmental: These linked to regulations and public acceptance of WAB2E conversions.

Different types of barriers are closely related and no single barrier appears to be most critical but the interactions among different barriers impedes rapid deployment of technologies. The relative importance of the barriers hinges on the particular value chain and context considered. Further, the importance of the barriers differs for each technology and market, and the priority changes as a technology matures.

## IV. Policy Recommendations

### A. *General Policy Recommendations*

Many countries have employed a range of policy tools and adopted policy strategies in RE sector in general, and bioenergy sector in particular (including WAB). There is a vast volume of knowledge and experience on the policy issues in the sector, and based on those, several general recommendations can be made for sensible policy making in WAB sector, as listed below [4], [9]:

- A policy initiative for WAB2E conversions is most effective when it is part of a long-term vision for the sector. Such a vision should be clear about its motivation. The vision should also identify the specific national or regional strengths that bioenergy options could build on. Almost all successful bioenergy policies were able to open up opportunities that were already partly available in the country.
- Persistent and stable policy support is essential for successful development of WAB2E conversion options. As such, policies should take into account the specific characteristics of the options involved and provide sufficiently long-term measures to address them.
- Policy coordination, integration, and coherence are central to a sound policy framework.
- The policies should take into account the development stages of specific WAB2E conversion technologies, and provide incentives consistent with the barriers that an option is facing. Factors such as technology maturity, market transparency, the allocation of market power and the split between investment and variable costs need to be taken into consideration.
- Access to markets is critical for almost all WAB2E conversion technologies. For electricity generation, connection to the grid is the key issue that needs to be addressed at the power distribution network level. For biofuels, standardization of biofuels and of vehicles (in the case of higher blends) is essential for reliable market access.
- As all WAB2E conversion options depend on feedstock availability, the policy framework should pay attention to the agricultural, forestry and waste sectors from which feedstock is expected to come. In the long-term, specific support for productivity improvement in these sectors will be pivotal for reconciling feedstock demand.
- As with any policy related to technology development, a policy strategy on WAB2E conversion should meet several standard criteria such as credibility, enforceability, clarity, simplicity, and transparency.
- A long-term successful policy framework will also need to take into account sustainability issues. Sustainability criteria for bioenergy are currently in rapid development. Important issues are energy and GHG emissions, direct and indirect impacts, and other environmental, social, and economic impacts.
- Finally, support policies are a precondition, but not a guarantee for the successful development of WAB2E conversions. Other critical factors include the legal, administrative, technological, and cognitive framework. Unforeseen barriers can affect the introduction of installations, and also the set-up of feedstock supply and reliable logistics; both essential for successful bioenergy initiatives. As such factors are often affected by other governmental departments, internal streamlining and checking of policies for consistency are crucial.

## *B. Technology Development*

WAB2E conversion technologies include a large number of different technical options, which are at very different stages of the development cycle. For each stage, specific policy instruments apply. Therefore the way in which deployment of technologies takes place over time has consequences for optimal policy interventions. In general, three different phases of technology development and deployment could be identified research & development (R&D), early market and mass market [9]. Each of these phases requires specific policy tools and economic instruments to support the technology development. Following two main mechanisms for taking bioenergy options through the R&D phase could be recommended:

- Direct or indirect R&D funding, and
- Measures aimed at reducing investment risks.

After WAB2E conversion options have passed the demonstration phase, there often remains an excess cost in comparison with existing commercial technologies. In the early market stages, a key objective of policies is to reduce this cost gap by allowing the technology to be introduced and by building up experience. Three categories of instruments could be recommended in this context:

- Measures reducing production costs, in the form of feed-in-tariffs, feed-in premiums, and tax exemptions.
- Quantity-based instruments, in the form of quota obligations and tendering schemes.
- Measures related to market access can facilitate early market penetration of new technologies by giving them preferred access to markets or infrastructure or by standardizing the product. These are typically measures that act as a prelude to early markets.

After the early market entry of a new WAB2E conversion technology, structural support may be required and should be defendable on the basis of its positive external effects. However, sustained support on a sheer production basis has its drawbacks, as it does not guarantee that the WAB2E conversion options applied align best with the background motivations for promoting it. Furthermore, pursuing diverse objectives such as energy security, environment sustainability, and socio-economic development by a single policy is rarely efficient. Policies can then provide incentives directly related to the external effects, for example in the form of $CO_2$ emission taxes or trading systems that are technology-neutral.

In addition to the technology development, policy interventions are also required in a variety of other related sectors as integral parts of the policy framework. Some of the key sector specific policy recommendations are given in the following sub-sections.

### C. National Development

Most of the countries have initiated national development policies with broader goals of energy security and socio-economic development, and also strategies for rural development as well as sustainable development in long-run. These are perfect drivers for the development of WAB2E conversion systems. In order to materialize the benefits of the large scale deployment of WAB2E conversion technologies, the policy instruments needed to be converted to strategies and action plans with specific milestones and targets. Further, setting of overall goals and objectives is also required for the sector specific interventions to follow. The policy framework could then facilitate the establishment of a strategic plan.

Another important national issue is the lack of access to energy services in rural areas, affecting the local development. In such situations, WAB2E conversion technologies could provide a sustainable, cost-effective alternative, and could be linked to the policies related to SMEs, rural development and off-grid electrification.

### D. Environment

WAB2E conversion technologies can have environmental impacts at different stages of the process: in feedstock collection, storage, transport, pre-processing, conversion, and end-use. Existing regulations may be in place to address environmental issues, but the introduction of new routes often calls for dedicated measures. In the case of new conversion technologies, for example, the lack of experience in best practices and achievable emission limits can be a barrier to introduction, as local regulators would lack reference material for an environmental permit. Guidelines from central government can help to reduce this implementation obstacle. Therefore, development and dissemination of information on success stories, best practices and relevant guideline would greatly help the sector development.

### E. Agriculture

The link between WAB and agricultural policy is strong, as the WAB feedstock is by-products of agricultural activities. Yet, in general, agricultural policy may not refer to WAB directly, except that some of the WAB generated are used as a fertilizer. However, in most cases WAB are in excess and either open burned or open dumped. Under such case, it is recommended to include relevant policy elements to address the management of WAB within agricultural sector with due consideration of other potential uses.

### F. Climate Change

As a RE resource, WAB provides opportunities to gain CC benefits through replacing fossil fuel based alternatives. In fact, several developing countries have already formulated such projects for carbon finance, but there is a huge untapped potential for further development. Usually, carbon finance is treated as a supplement to the policies, programs, and incentives described in the national level policies and strategies. Without these fundamental supports, carbon finance will not make a significant difference to rural biomass energy development. However, carbon finance may play an important role in supporting the implementation of the projects.

### G. Sustainability and Certification

Although WAB2E conversion offers many new opportunities, and is a viable response to global themes like CC and energy security, it may also carry significant risks if not managed carefully. For this reason, several national and international certification schemes and standards related to sustainability principles and criteria for biomass and bioenergy have begun to emerge, with the efforts of different stakeholders including intergovernmental organizations and national standardization bodies. Some of the common key principles of sustainable bioenergy are:

- GHG balance: Should reduce GHG emissions compared to their fossil reference.
- Energy balance: Should generate more energy than that needed for feedstock production, conversion, and logistics.
- Biodiversity impacts: Should not negatively affect biodiversity.
- Impacts on production of food: Should not endanger the supply of biomass for food, materials, and other applications.
- Other environmental impacts: Should not lead to negative impacts on soil, water, and air quality.
- Impacts on economic development: Should contribute to local prosperity.
- Impacts on welfare: Should contribute towards social well-being for employees involved and for the local population.

It should be noted that the above list provides generic areas relevant to different biomass/bioenergy product, processes and systems, thus the applicability of each is to be looked at cautiously.

Although the certification and standardization of WAB2E conversion systems are recognized to be important to ensure the sustainability, there are several risks associated with them too, including high administrative burdens, increasing feedstock prices, location dependence of the applicability of the criteria, and further complexity arisen from the sector interaction with variety of national and regional policies and socio-economic factor. Beyond sustainability considerations, harmonization of technical aspects and quality specifications is also required. Therefore, a close following of the development of certification and standardization perspective is vital in the process of formulation and implementation of converting WAB2E conversion programmes, as this aspect may have significant influence on the sector.

## V. Conclusions

Conversion of WAB2E could play a significant role in not only as an effective waste management technique, but also as a sustainable source of energy for local socio-economic development. Yet, presence of many gaps and barriers has hindered the progression of the sector. In particular, multi-sectoral, multi-level and multi-disciplinary nature of the WAB sector poses challenges in addressing the issues. Development of a sound policy framework is thus required, for which the proposed step-wise approach could be effectively used, while giving due consideration to the country specific aspects.

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## References

[1] G. O'Neill, 2012 Bioenergy Action Plan, Efficiency and Renewables Division, California Energy Commission, August 2012.

[2] DTIE-UNEP, Policy Brief on Waste Agricultural Biomass: What, Why and How, International Environmental Technology Centre (IETC), Division of Technology, Industry and Economics (DTIE), United Nations Environment Programme (UNEP), May 2013.

[3] A. G. T. Sugathapala, Converting Waste Agricultural Biomass to Energy Source: A Guidance Document, a report submitted to IETC/UNEP under the project titled "Waste agricultural biomass for energy: resource conservation and greenhouse gas (GHG) emission reduction", May 2014.

[4] N. Kautto, Planning Biomass for Energy: Examining the why, how and what of sound biomass policy, Working paper, International Institute for Industrial Environmental Economics (IIIEE), Lund University, Sweden, 2010, ISBN 978-91-88902-67-2.

[5] A .G. T. Sugathapala, Converting Waste Agricultural Biomass to Energy Source: A Policy Analysis, a report submitted to IETC/UNEP under the project titled "Waste agricultural biomass for energy: resource conservation and greenhouse gas (GHG) emission reduction", October 2014.

[6] OECD, Biomass and Agriculture: Sustainability, Markets and Policies, Organization for Economic Cooperation and Development (OECD), 2004.

[7] T. Jones, "Policy Coherence, Global Environmental Governance, and Poverty Reduction", International Environmental Agreements: Politics, Law and Economics, Vol. 2(4), pp. 389-401, December 2002.

[8] IEA, Renewable Energy: Policy Considerations for Deploying Renewables, International Energy Agency (IEA), 2011.

[9] IEA Bioenergy, Bioenergy - A Sustainable and Reliable Energy Source: A review of status and prospects, International Energy Agency-Bioenergy, 2009.

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