Towards Life Cycle Sustainability Management
LEMBAR PENGESAHAN

Judul : Sustainability Assesment of Biomass Utilisation in East Asian Countries

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Preface

Towards Life Cycle Sustainability Management

The global society has undergone a paradigm shift from environmental protection towards sustainability. Sustainability does not only focus on the environmental impact, it rather consists of the three dimensions “environment”, “economy” and “social well-being”, for which society needs to find a balance or even an optimum. Sustainability has become mainstream these days. It is accepted by all stakeholders - be it multinational companies, governments or NGOs. Unfortunately, this common understanding merely relates to the general concept rather than actions. But lip service is not enough to achieve a sustainable development of our societies. If we want to make sustainability happen as concrete reality in both public policy making and corporate strategies, sustainability cannot please everybody. To make it happen, we have to be able to discern good and evil. This requires that we are able to address the question, how sustainability performance can be measured, especially for companies, products and processes. We have to be smart enough to be able to measure it or the real and substantial implementation of the sustainability concept will remain just wishful thinking.

In order to achieve reliable and robust sustainability assessment results it is inevitable that the principles of comprehensiveness and life cycle perspective are applied. The life cycle perspective considers for products all life cycle stages and for organisations the complete supply or value chains, from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end of life treatment and final disposal. Through such a systematic overview and perspective, the unintentional shifting of environmental burdens, economic benefits and social well-being between life cycle stages or individual processes can be identified and possibly avoided. Another important principle is comprehensiveness, because it considers “all” attributes or aspects of environmental, economic and social performance and interventions. By considering all attributes and aspects within one assessment in a cross-media and multidimensional perspective, potential trade-offs can be identified and assessed.

This is where life cycle assessment (LCA) and life cycle management (LCM) come into play. LCA is the internationally accepted method for measuring environmental performance and LCM is in a nutshell about the application of LCA or rather life cycle thinking (LCT). It is still a relatively young concept in the environmental community with pioneering work done by a Working Group of the Society of Environmental Toxicology and Chemistry (SETAC) at the end of the last century. At that time, my definition of LCM was “a comprehensive approach towards
product and organisation related environmental management tools that follow a life cycle perspective.” The United Nations Environment Programme (UNEP) and SETAC later launched the Life Cycle Initiative to enable users around the world to put life cycle thinking into effective practice and introduced LCM as one of their areas of work.

While the measurement of the environmental dimension of sustainability with LCA is well established, similar approaches were developed more recently for the economic (life cycle costing – LCC) and the social (social LCA – SLCA) dimensions of sustainability. This development is crucial, because it fosters the opportunity for life cycle based sustainability assessments. Walter Klöpffer put this idea into the conceptual formula:

\[
\text{LCSA} = \text{LCA} + \text{LCC} + \text{SLCA}
\]

\[
\text{LCSA} = \text{Life Cycle Sustainability Assessment}
\]

\[
\text{LCA} = \text{Environmental Life Cycle Assessment}
\]

\[
\text{LCC} = \text{Life Cycle Costing}
\]

\[
\text{SLCA} = \text{Social Life Cycle Assessment}
\]

Even though there is definitely still room to improve and expand the implementation of LCA as part of an environmental LCM approach, I believe the time has come to expand the concept to include the other pillars of sustainability in a more explicit way. This is reflected in our choice of the title of this book “Towards Life Cycle Sustainability Management”. Life Cycle Sustainability Management or LCSM is the implementation of life cycle based sustainability assessment or LCSA into real world decision making processes, be it on the product, process or organisation level. In a nutshell, LCSM aims at maximising the triple bottom line (3BL) and is based on LCSA as one key element of a broader toolbox:

\[
\text{LCSM} = f(\text{LCSA}) = \max(3\text{BL})
\]

This book is a selection of the most relevant contributions to the LCM 2011 conference in Berlin. The Life Cycle Management conference series is established as one of the leading events worldwide in the field of environmental, economic and social sustainability. The unique feature of LCM is practical solutions for the implementation of life cycle approaches into strategic and operational decision-making. The 2011 conference motto “Towards Life Cycle Sustainability Management” was chosen to address and to focus on the implementation challenge of sustainability as outlined above. In total, 414 abstracts representing more than 1100 authors from 47 countries were submitted.

Because of the excellent overall quality of the contributions it was quite a challenge to select the 56 papers for this book. They are structured in nine Parts. The first four Parts focus on the more general, methodological topics, Part I
addresses general LCSM approaches that go beyond the more traditional LCM methods and tools which are covered in Part II. Part III deals with water footprinting as specific and emerging topic. LCM applications for processes and organisations are the content of Part IV. The remaining five Parts deal with the implementation of LCM approaches in relevant industrial sectors, namely the agriculture and food sectors (Part V), the packaging sector (Part VI), the energy sector (Part VII), the electronics and ICT sectors (Part VIII) and the mobility sector (Part IX).

The authors of this volume come from 29 countries including Africa, Asia, Europe and the Americas. They represent the developed and the developing world as well as a variety of stakeholders from multinational companies, academia, NGOs to public policy. I am very grateful for their excellent and timely contributions.

In addition to the core contribution of the authors this book was only possible due to the efforts of many colleagues and friends. I am very grateful for the support of the co-chair of the LCM 2011 conference, Stephan Krinke, and all members of the scientific committee: Carina Alles, Emmanuelle Aoustin, Pankaj Bhatia, Clare Broadbent, Andrea Brown Smatlan, Maurizio Cellura, Roland Clift, Mary Ann Curran, Ichiro Daigo, James Fava, Jeppe Frydendal, Pere Fullana, Gerard Gaillard, Mark Goedkoop, Minako Hara, Michael Hauschild, Jens Hesselbach, Arpad Horvath, Atsushi Inaba, Allan Astrup Jensen, Anne Johnson, Juha Kaila, Gregory Keoleian, Henry King, Walter Klöpffer, Annette Koehler, Paolo Masoni, Yasunari Matsuno, Llorenç Milà i Canals, Nils Nissen, Philippa Notten, Erwin Ostermann, Rana Pant, Claus Stig Pedersen, Gerald Rebitzer, Helmut Rechberger, Klaus Ruhlman, Günther Seliger, Guido Sonnemann, Nydia Suppen, Ladji Tikana, Sonia Valdivia, Paul Vaughan and Harro von Blottnitz. Their efforts in soliciting and selecting the right mix of contributions were extremely valuable.

I particularly like to thank my Sustainable Engineering group at TU Berlin for all their support. Special thanks have to go to the core editing team consisting of Annekatrin Lehmann, Laura Schneider and Marzia Traverso for their generous commitment on top of their regular duties. I also like to acknowledge the technical support of Robert Ackermann, Adrian Caesar and Martina Creutzfeldt.

Last, but not least, sincere thanks to my family for their courtesy and patience.

Berlin
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Sustainability Assessment of Biomass Utilisation in East Asian Countries

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Abstract In order to provide decision-making methodology to evaluate sustainability of biomass utilisation in East Asian context, an expert working group has been formed since 2007 and has been conducting researches to assess the sustainability of biomass utilisation with the concept of triple bottom line focusing on environmental, economic and social pillars of sustainability. Based upon the methodology developed in 2008, the WG had conducted four pilot studies in India, Indonesia, Thailand and the Philippines in 2010 to field-test the methodology developed and investigate the sustainability of various feedstocks utilisation for biomass energy. This paper aims at introducing the sustainability assessment methodology the WG developed and addressing experiences and lessons learned through the pilot studies.

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1 Introduction

It is generally acknowledged that biomass energy can make a significant contribution to environmental improvement, energy supply diversity from fossil fuel and socio-economic development goals both in the developed and developing world owing to the following reasons. Firstly, biomass energy developments offer the opportunity for enhanced energy security and access by reducing the dependence upon fossil fuels. Secondary, biomass energy has the potential to contribute to environmental matters including the GHG emissions reduction. Thirdly, biomass energy development can create employment that will positively affect agricultural and rural incomes, poverty growth and economic growth.

On the other hand, there is a rising concern for life cycle GHG reduction effect of biomass energy, food versus fuel problem and environment disruption caused by the expansion of biomass resources production and use as energy. In view of these, there is also widespread recognition that biomass energy must be produced and used in a sustainable way, considering all the positive and negative effect from environmental, economic and social pillars of sustainability.

There are several initiatives working to develop sustainability criteria and indicators for biomass energy and their feedstocks for use in certification schemes. Several national governments had defined their own sustainability criteria especially for liquid biofuels (e.g. the UK’s Renewable Transport Fuels Obligation [1], Germany’s Biomass Sustainability Ordinance – BioNachV [2] or the USA’s Renewable Fuel Standard [3]). The European Union is in the process of agreeing a common set of sustainability criteria through Renewable Energy Directive [4] to achieve significant greenhouse gas savings and to prevent negative effects upon biodiversity by the use of biomass energy. There are also international frameworks to discuss the sustainability of biomass energy. The Roundtable on Sustainable Biofuels (RSB), a multi-stakeholder initiative hosted by the Energy Centre of École Polytechnique Fédérale de Lausanne (EPFL), has developed a global sustainability standard and certification system for biofuel production since 2007 [5]. The Global Bioenergy Partnership (GBEP) [6], a forum where national governments, international organisations and other partners seek to facilitate effective policy frameworks and suggest rules and tools to promote sustainable biomass energy development through voluntary cooperation, has been working to develop a set of relevant, practical, science-based voluntary sustainability criteria and indicators under the Task Force on Sustainability since 2008. The criteria and indicators are intended to guide any analysis undertaken of biomass energy at the domestic level with a view to informing decision making and facilitating the sustainable development of biomass energy in a manner consistent with multilateral trade obligations [7]. International Organization for Standardization (ISO) is also under development of “Sustainability criteria for bioenergy” to bring
together international expertise and state-of-the-art best practice to discuss the social, economic and environmental use of bioenergy, and identify criteria that could prevent it from being environmentally destructive or socially aggressive [8]. Although there is high biomass energy potential in East Asia, most of the counties in this region are heavily dependent upon fossil fuel imports to meet their energy needs. Governments in this region are looking for various energy alternatives and in this regard biomass energy has emerged on the forefront, which may assure social benefits due to employment generation through its development as well as GHG reduction and energy security. Taking into these backgrounds into consideration, an expert WG (working group) has been formed under the support of ERIA (Economic Research Institute of ASEAN and East Asia) since 2007 and has been conducting researches to assess the sustainability of biomass utilisation. In our 2007 discussions upon ‘Sustainable Biomass Utilisation Vision in East Asia’ [9], we suggested policy recommendations and framed “Asia Biomass Energy Principles”, which were endorsed by the Energy Ministers Meeting of East Asian Summit at Bangkok in August 2008 [10]. In response to the request from Energy Ministers of the region to develop a methodology to assess the sustainability of biomass utilisation for energy production by considering specific regional circumstances, our WG started investigations to ‘Guidelines for Sustainability Assessment of Biomass Utilisation in East Asia’ [11] in 2008. In 2009, our WG field-tested the guidelines developed in four pilot studies conducted at India, Indonesia, Thailand and the Philippines and investigated the sustainability of various feedstocks utilisation for biomass energy [12].

This paper aims at introducing the sustainability assessment methodology of biomass utilisation our WG developed and addressing the experiences and lessons learned through the pilot studies.

2  WG methodology to assess sustainability of biomass utilisation

In this chapter, the WG methodology to assess sustainability of biomass utilisation is addressed. Please refer to WG reports [11-12] for the details.

2.1 WG aim and concept

The WG adopted the definition of “sustainable development” from “Our Common Future” of the UN world Commission on Environment and Development report published in 1987 [13], i.e., “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.
The triple bottom line approach, focusing upon “people, planet, profit” is based upon social, environmental and economic criteria. To ascertain the sustainability of biomass energy development, these aspects are necessary and must be considered to overcome and minimise the problems that may occur with the expansion of biomass energy utilisation. In view of these, the WG has developed a methodology to assess sustainability of biomass utilisation in East Asian context from environmental, economic and social pillars.

2.2 Environmental indicator

Life cycle assessment (LCA) is increasingly being promoted as a technique for analysing and assessing the environmental performance of a product system and is suited for environmental management and long-term sustainability development. Although LCA can be used to quantitatively assess the extent of impact of a product system towards environmental issues of concern such as acidification, eutrophication, photooxidation, toxicity and biodiversity loss, these impact categories are currently not in the limelight as compared to climate change, a phenomenon that is associated with the increasing frequency of extreme weather conditions and disasters. Effects of climate change have been attributed directly to the increased atmospheric concentration of GHG released by anthropogenic activities. Taking other standards or frameworks for biomass energy sustainability into consideration, the WG had adopted life cycle GHG emissions that can be quantified through life cycle inventory analysis (LCI) using the collected foreground and background data as the indicator to evaluate sustainability of biomass energy utilisation.

The system boundary for LCI is consisted of three stages: feedstock cultivation, feedstock collection and biomass energy production. There is a wide recognition that the effect of land use change (LUC) towards the LCGHG emissions is significant. Although their effect can be calculated using equations and default values proposed by the International Panel on Climate Change [14], the WG recognises that there still lies uncertainties for the calculations and standardised methodologies for GHG emissions from LUC are not yet to be established. Hence the emissions from LUC are excluded from the system boundary of the WG’s methodology.

The LCI for biomass energy should cover CO₂ and non-CO₂ GHGs, namely CH₄ and N₂O that are released directly and indirectly from agricultural activities. The GHG inventory is calculated as CO₂-equivalent (CO₂e) and the summation of
contribution from non-CO₂ GHGs are based upon the IPCC Fourth Assessment Report (AR4) Global Warming Potential (GWP) value for a 100 year horizon.

### 2.3 Economic indicator

Economic sustainability of biomass utilisation relates to the exploitation of biomass resources in a manner by which the benefits derived by the present generation are ascertained without depriving such opportunity to the future generation. In the assessment of sustainability, it is equally important to determine the actual level and degree of the economic benefits brought about by the biomass industry. Specific economic indices would have taken into consideration to measure the scope of the benefits. Existing methodologies in quantifying such indicators would have to be adopted and evaluated as well. Economic indicators ultimately provide for an accurate measurement of the economic performance of a particular industry such as biomass. Based upon the various literature reviewed, the most common economic contributions of biomass utilisation are value addition, job creation, tax revenue generation and foreign trade impacts. The same indicators were taken into consideration to evaluate economic sustainability of biomass energy utilisation in WG’s methodology: 1) total net profit accumulated from product conversion or processing; 2) personnel remuneration created by employment at the biomass industry; 3) tax revenues generated from the different entities within the industries; 4) foreign trade impacts in terms of foreign exchange earnings and savings; and 5) total value added, which is the sum of all the previous indicators. Each indicator can be calculated by the following equations:

$$\text{Total net profit (TNP)} = \text{Total returns} - \text{Total costs}$$  \hspace{1cm} (1)

where

$$\text{Total returns} = \text{Sales from primary output} + \text{Sales from by-products}$$  \hspace{1cm} (2)

$$\text{Total costs} = \text{Amount of material inputs used} + \text{Labour costs} + \text{Overhead costs}$$  \hspace{1cm} (3)

$$\text{Overhead costs} = \text{Taxes and duties} + \text{Interest} + \text{Depreciation}$$  \hspace{1cm} (4)

$$\text{Personnel remuneration} = \text{Total man-days (Employment)} \times \text{Average wage per man-day}$$  \hspace{1cm} (5)

where

$$\text{Wages} = \text{Wage rate} \times \text{Labour requirement}$$  \hspace{1cm} (6)

$$\text{Tax revenue} = \text{Total taxable income} \times \text{Tax rate}$$  \hspace{1cm} (7)

where
Total taxable income
\[= \text{Income from main product} + \text{Income from by-product} \]
\[= \text{Income of main product} \]
\[= \text{Income of byproduct} \]
\[= \text{Profit per unit of main product} \times \text{Volume of A} \]
\[= \text{Profit per unit of byproduct} \times \text{Volume of B} \]
\[\text{Total value added (TVA)} \]
\[= \text{Total net profit} + \text{Personnel remuneration} + \text{Tax revenue} \]

2.4 Social indicators

Social issues in the growing markets for biomass energy are expected to become prominent as the producers and consumers of biomass energy may belong to different countries. Major social benefits of biomass energy include greater energy security, employment opportunities and improved health from reduced air pollution. On the other hand, possible negative social impacts of biomass energy, such as food insecurity, need to be considered seriously. While there could be some relief on energy front, the food insecurity and food prices, particularly in developing economies, may aggravate the negative social impact on people.

Measurement of social development significantly differs from economic development. Also, compared to social indicators, a plenty of economic indicators are more frequently available for all countries. However in many cases, particularly in case of some developing economies, they reflect a rosy picture that is far away from the reality. To capture the holistic picture of development across countries, the United Nations Development Programme (UNDP) has used the human development index (HDI). This essentially takes into account the measures for living a long healthy life (by life expectancy), being educated (by adult education and enrolment at primary, secondary and tertiary levels) and having a decent standard of living (by purchasing power parity). The WG had adopted HDI as the indicator to evaluate social sustainability of biomass energy utilisation. The calculation of HDI can be described as equation (12) and Table 1.

\[\text{HDI} = \frac{1}{3} \times (\text{Life expectancy index} + \text{Education index} + \text{GDP index}) \]
Tab. 1: Calculation of HDI

<table>
<thead>
<tr>
<th>Index</th>
<th>Measure</th>
<th>Minimum value</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy</td>
<td>Life expectancy at birth (LE) [ LE index = \frac{(LE-LE_{\text{min}})}{(LE_{\text{max}}-LE_{\text{min}})} ]</td>
<td>25 years</td>
<td>85 years</td>
</tr>
<tr>
<td>Education</td>
<td>Education index = ALI×2/3+GEI×1/3 [ \text{Adult literacy index (ALI)} = \frac{(ALR-ALR_{min})}{(ALR_{max}-ALR_{min})} ] [ \text{Gross enrolment index (GEI)} = \frac{(GER-GER_{min})}{(GER_{max}-GER_{min})} ]</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>GDP</td>
<td>GDP index [ = \frac{\ln(GDP)-\ln(GDP_{\text{min}})}{\ln(GDP_{\text{max}})-\ln(GDP_{\text{min}})} ]</td>
<td>100 USD</td>
<td>40,000 USD</td>
</tr>
</tbody>
</table>

3 Results of testing WG methodology

Four pilot studies have been implemented by designated organisations under the ERIA’s framework to apply and field-test the assessment methodology developed by the WG. One case study was implemented in each selected East Asian country, namely, India (Andhra Pradesh), Indonesia (Lampung), the Philippines (Quezon) and Thailand (Khon Kaen), as shown in Figure 1.
In each pilot study, more than hundred sets of data were obtained through interviews, calculations based upon primary data collected from pilot study sites, and secondary data from elsewhere to calculate the environmental, economic and social pillars of sustainability of biomass energy utilisation according to the WG methodology. The brief summaries of each pilot study are addressed in this section. Please refer to the WG report [12] for the details. For the economic pillar of sustainability, the original data in monetary unit were collected in each currency. Also please note that economic effect by biomass energy utilisation had been converted in terms of US dollar (USD) using the following currency conversion rates in this article: 1 USD = 48 Indian Rupee (IDR) = 9,200 Indonesian Rupiah (IDR) = 45 Philippine Peso (PHP) = 32 Thai Baht (THB).

### 3.1 Pilot study in Andhra Pradesh, India

In case of India, economic assessment indicates that cost incurred during the Jatropha cultivation stage is much higher than the revenue generated, which is not economically viable. In biodiesel production stage, both TVA and TNP are quite attractive, provided the raw material is available at a reasonable price. During the lifecycle of biodiesel production process, a TVA of 10,886,859 USD and a net profit of 5,840,068 USD per year were estimated. On environmental fronts, companies expect some carbon saving and an additional revenue from carbon credits. GHG saving potential estimated during the process shows a net carbon saving of 2,771,681 t CO₂eq per year. On social fronts, several positive results are visible during various stages of biodiesel production, the main being employment generation for local people increasing their income, which may result in an overall improvement in their living standard.

### 3.2 Pilot study in Lampung, Indonesia

Biomass energy program in Indonesia was carefully designed but was not running as smoothly as planned originally. It was observed that the cassava utilisation for ethanol in Lampung Province is facing a competition for raw material from tapioca factories. Environmental assessment shows that during bioethanol production GHG emissions depend upon whether the biogas from wastewater treatment is flared or not. Economic assessment indicates that processing cassava for bioethanol increased the value added of cassava by about 0.103-0.120 USD per
L of bioethanol or about 0.0159-0.0186 USD per kg of cassava. On social assessment, the HDI values for cassava farmers in the study region were estimated lower than the HDI values for North Lampung, in general. In case of Jatropha biodiesel, although farmers in the target village receive a very low benefit from cultivation stage, utilisation of Jatropha waste increased their earnings significantly. Environmental assessment indicates that GHG emissions from Jatropha plantation and crude Jatropha oil processing were 59% and 82%, respectively. HDI estimates for Jatropha farmers in North Lampung indicate that life quality, education, and income for the people in the village were quite low.

### 3.3 Pilot study in Quezon, the Philippines

Economic analysis of the Philippines study shows that considering the production costs and revenues for each product, the net profit per unit of product is highest for copra production (at 0.150 USD per kg) and lowest for coconut methyl ester (CME, biodiesel from coconuts) production (at 0.122 PHP per L). The cumulative total profit for all product forms is about 844 USD per ha and the TVA from the biodiesel industry in the province of Quezon would be 305 million USD. The use of coconuts methyl ester to replace petro diesel will result in net savings or GHG emission reduction of 2,823.97 kg CO₂ per ha per year. In terms of social indices, the computed HDI is 0.784 while the change in HDI is 0.004 indicating a higher level of social development. In terms of living standard, the majority (66%) of coconut farmers perceived that there has been an improvement in their living conditions due to coconut farming. In general, the results show that majority of the employees benefited from their respective employment in the biodiesel production chain.

### 3.4 Pilot study in Khon Kaen, Thailand

In Thailand study, environmental assessment for the lifecycle of ethanol production indicates that the overall GHG emissions associated with the ethanol production and consumption stages are slightly lower but not significantly different from that of gasoline. Increasing the utilisation of the materials produced during various unit processes in the biorefinery complex results in reducing the GHG emissions. Economic assessment of the overall process of bioethanol production indicates that the TVA for the whole biorefinery complex amounts to 116,108,080 USD and it is economically viable. For social assessment, the HDI of
the sugarcane plantation, biorefinery complex, and Khon Kaen were observed as 0.736, 0.797 and 0.763, respectively. Thus, although sugarcane farmers have a lower social development than an average person in Khon Kaen or employee at the biorefinery complex, they still benefit from a steady income as a result of the contract farming, which links them to the sugar mill and guarantees an annual income. Employees at the biorefinery have a higher social development (shown by a positive change of 0.034 in HDI) as compared to the Khon Kaen.

4 Summary of the results and lessons learned from the pilot studies

It has been found from the field-testing that the methodology could successfully assess environmental, economic and social aspects of biomass utilisation projects. Highlights of the results and salient features of the pilot studies are summarised as follows:

- Indicators that have been adopted in WG methodology can quantify environmental, economic and social sustainability, respectively, of biomass energy utilisation.
- Environment indicator chosen in our methodology covers only GHG savings that is very relevant to current concerns on biomass energy. Evaluation of GHG emissions using LCA appropriately measures potential global warming intensity but other emissions and impacts can also be considered. Other than global warming, impact categories such as land use change, acid rain, eutrophication, ecotoxicity, human toxicity and resource depletion affect the locality where the emissions or depletion occur. Hence, ranking these impact categories according to local needs as a full LCA study up to the life cycle impact assessment stage may be appropriate, although collecting the information and data will be an uphill task for the developing countries.
- Economic indicators, namely, total net profit and total value added are internationally accepted. It should be emphasised that there should be a business component throughout the value chain and net profit is positive.
- Social indicators such as literacy rate, education enrolment, life expectancy, gender empowerment, etc., are relevant to the state of development of East Asian countries. Although HDI is widely applied to evaluate social impact at state, regional or national level, there is a need to develop an index or some indices that can better represent social impact at the community level. Some of the social indicators, that are
reported in the social LCA, such as child labour, minimum wage rates, forced hours, labour unions, etc., are excellent for developed countries but would not be applicable to developing economies that have to grapple with issues of poverty, employment and an expanding population that has to be provided with basic amenities through enhancing rural economy.

- Utilisation of all byproducts in the production of biomass energy is very much recommended to increase the sustainability of soil, reduce environmental impact, and optimise social and economic benefits.
- Sustainability can be viewed at different levels using appropriate indicators at community, regional and national levels.
- ‘Guidelines for Sustainability Assessment of Biomass Utilisation’ may be applied to each country in the East Asian region with minor locale-specific modifications. Training is recommended in order to apply the guidelines in East Asian countries properly.
- Dissemination of ‘Guidelines for Sustainability Assessment of Biomass Utilisation’ and experiences and lessons learned from the pilot studies may be helpful to other East Asian Countries and frameworks of sustainability of biomass energy such as the GBEP and the ISO.
- It must be noted the assessment methodology developed is tailored only for the biomass renewable resource and may not be applicable for comparison with other renewable energy resources such as solar energy, wind energy or wave energy. Although sustainability encompasses the three pillars of economic, environment and social, the specific indicators and mode of calculations including the boundaries and scope of comparison will differ. Such differences have not been considered by the WG whose focus is primarily on looking at options and issues pertaining to biomass utilisation.

Based upon the lessons learned from the pilot studies, the WG is now under discussion to upgrade the methodology. Major discussion points can be stated as follows:

- To simplify the methodology. For the analysts who are the users of the methodology, an easier way is required to collect data necessary for calculating the indicators for sustainability. Also for the decision makers who are the users of the results obtained through the methodology, social and regional characteristics of East Asian countries should be reflected in the results and the methodology should be more practical for decision makers to use.
- To assess sustainability of biomass utilisation at macro (national / state / province) and micro (community / project) level. The pilot studies were
carried out at specific sites and obtained results represent a micro level of events and characteristics of each study site. In the same manner, studies at macro level might be feasible by use of the methodology but would require pooling more comprehensive data such as those from various associations i.e. farmers, manufacturers, traders, etc. The WG is currently discussing indicators that are able to capture both levels of effects from biomass utilisation for energy.

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References