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Lessons learned in testing the Global Bio-Energy Partnership sustainability indicators

- Final Report –

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Date: 1 November 2013

Project number: BIENL13268

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Summary

In May 2011 the Global Bioenergy Partnership (GBEP) Task Force on Sustainability agreed on a first set of 24 relevant, practical, science-based, voluntary sustainability indicators for bioenergy. Several countries are undertaking pilot projects to test the feasibility and practicality of the indicators as a tool for policymaking. This report aims to bring together the lessons learned to date from the GBEP pilots, using the outcomes available so far and focused discussions at the GBEP meeting in Berlin in May 2013. This report is intended as a guide to help the GBEP community to further develop the indicators and enhance the practicality of the tool.

Key achievements: Pilot countries have benefited from gaining a good overview of current data availability within their country that enables the monitoring of the bioenergy sector, and have been able to identify options to improve data collection methodologies and data infrastructure. Organisations and stakeholders who previously did not work together have been brought together through the pilots, enhancing the capacity within countries to work with the GBEP indicators. Challenges have been identified, and through the process, countries have been able to identify opportunities and solutions to further develop the methodological guidance provided for the GBEP indicators to enhance their practicality.

Pilot approach: This report focuses primarily on the pilots undertaken in five countries: Colombia, Germany, Ghana, Indonesia, and the Netherlands, with inputs also from countries present at the Berlin workshop and from a project-scale pilot in Japan. The pilots varied in their approach taken, specifically on aspects such as the geographical and sectoral scope chosen and the selection of indicators. The relevance of the indicators varies in different country contexts, but data availability and quality also played a key role in scope selection.

Lessons learned and recommendations: This report presents detailed lessons learned and recommendations per indicator. In addition several recommendations are identified that are common to the GBEP indicators more generally:

- **Attribution of data to bioenergy** is challenging, especially since data may be monitored already, but not specifically related to bioenergy (e.g. data related to agriculture or jobs). It is recommended to provide guidance regarding attribution to bioenergy.
- The appropriate **geographical scope** of the indicator is not always clear, especially when data crosses country boundaries (e.g. a watershed) or involves imported feedstocks. For individual indicators, it should be explained when and how imported feedstocks, intermediates and bioenergy carriers should be included.
- Further guidance would be valuable on how to deal with **data gaps** and how to reduce the uncertainty of the indicators.
- Some indicators were found to be too **focused on agricultural feedstocks**, or lacking in specific details on how to treat, for example residue feedstocks. Indicator methodologies should be reviewed to ensure that appropriate reference is made to all types of biomass.

- For a number of indicators, particularly in the environmental pillar, the development of "**factors"**, (similar to the concept of emissions factors for GHG) could help to make consistent and simple approximations for some indicators where there is currently low data availability.
- Guidance should be developed on **how to present the results of the indicators**. For some indicators the results are more meaningful if they are presented spatially in the form of maps (e.g. soil quality).

In the context of the approach to the pilots more generally, additional guidance for countries undertaking pilots would be valuable. Such guidance should cover, for example, the importance of appropriate stakeholder involvement and ownership of indicators throughout the process, how to prioritise the most relevant indicators in their context, how to identify which methodology option(s) within the GBEP indicators is most appropriate to choose in which situation, and how to present the results.

The way forward: Short, medium and longer term recommendations are provided to the GBEP community to take on board to enhance the practicality of the GBEP indicators as a tool for policy making. In the short term, the development of a concise guidance for pilots would be valuable, building on the findings of the present report. Challenges such as attribution to bioenergy and the geographical scope should be prioritised for further detailed guidance in the medium term, with other aspects such as the development of emission factors being desirable, but which might require a longer development and consensus process.

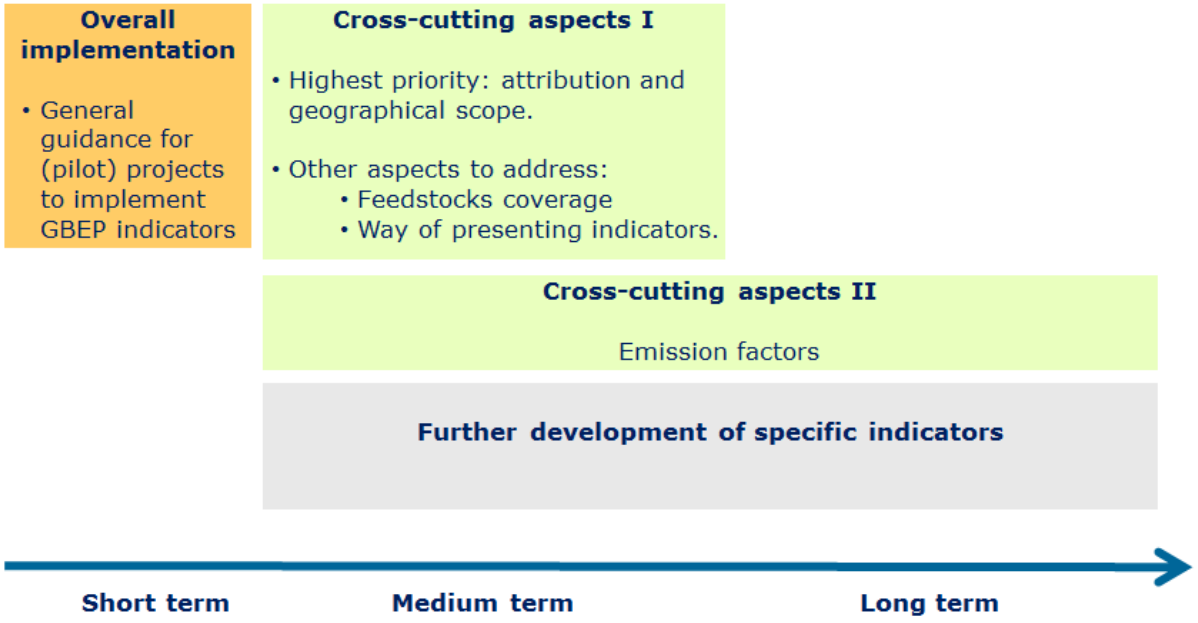

Figure: Proposal to incorporate options for improvement

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1 Introduction

This report is prepared by Ecofys on behalf of NL Agency to identify the lessons learned from the first country pilots of the Global Bioenergy Partnership (GBEP) sustainability criteria and indicators. This report summarises the lessons learned from the GBEP pilots, aiming to assess the applicability of the GBEP indicators and their practicality as a tool for policy makers, and furthermore to explore options for future improvements of the indicators, based on the information yielded by the pilots.

1.1 Background

The Global Bioenergy Partnership (GBEP) aims to promote the sustainable development of bioenergy and provides a platform for cooperation and knowledge exchange between national governments, international organisations and other partners. The GBEP Task Force on Sustainability has been working towards consensus amongst national governments and international organisations on practical and effective ways to secure the sustainable development of bioenergy. In May 2011 the GBEP Task Force on Sustainability agreed on a first set of 24 relevant, practical, science-based, voluntary sustainability indicators for bioenergy.

The GBEP indicators are now moving from the negotiation table into the field. Several countries are undertaking pilot projects to test the indicators in practice. The aim of these pilots is to establish the feasibility of the GBEP indicators and their practicality as a tool for policymaking, testing their relevance, exploring the challenges of implementing them in practice and proposing solutions to improve the indicators for the future.

The pilots are at different stages and vary in the approach taken, but all are beginning to yield valuable insights on how to implement the GBEP indicators in practice and how the outcomes can be used by policy makers. The GBEP meeting in Berlin in May 2013 dedicated time to sharing lessons learned from the pilots that have been undertaken so far.

1.2 Goal of the assignment

This assignment aims to bring together the lessons learned to date from the GBEP pilots. Using the outcomes of the pilots available so far and the discussions at the Berlin meeting, we aim to assess the applicability of the GBEP indicators and the practicality of the GBEP indicators as a tool for policy makers.

We aim to collate and present options for future development of the GBEP indicators, based on the information from the pilots. Some of the outcomes will be country specific, but there will also be lessons learned that can be more generally applied. This report is intended to provide

recommendations to be taken forward by the GBEP community to further enhance the practicality of the tool.

1.3 The assessed pilots

This report focuses primarily on the pilots undertaken in five countries: Colombia, Germany, Ghana, Indonesia, and the Netherlands. Insights are also included from a project-scale pilot undertaken in Japan. At the time of writing the outcomes are not completed for all pilots, but we draw together the lessons learned to date, and include also lessons learned from other countries who took part in the May 2013 GBEP meeting in Berlin, for instance Argentina and the US who have already started processes to implement (some of) the indicators.

1.4 How to read this report

This report is structured in four chapters. After the introduction in Chapter 1, Chapter 2 gives an overview of the main lessons learned, divided into lessons learned on the overall implementation, aspects common to several indicators (cross-cutting aspects) and specific detailed lessons learned *for each indicator*. Chapter 3 then contains options for improvement with regard to the overall process of implementation, recommendations to address cross-cutting issues and again specific recommendations for individual indicators. The final chapter proposes a way forward to incorporate these recommendations in the GBEP process.

Those interested in findings and recommendations for specific indicators should read this report alongside the detailed methodology sheets for each indicator contained within the First Edition of the GBEP Sustainability Indicators for Bioenergy[1].

[1] The Global Bioenergy Partnership Sustainability Indicators for Bioenergy, First Edition, December 2011. Available from : http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

2 Overview of lessons learned

This chapter gives an overview of the main lessons learned from the pilots, divided into lessons learned on the overall implementation, aspects common to several indicators (cross-cutting aspects) and specific detailed lessons learned for each indicator. The overall lessons learned will be of interest to the whole GBEP Community. The detailed lessons learned per indicator are intended to aid the further development of individual indicators and their methodologies. Chapter 3 then contains recommendations for improvement.

2.1 Overall implementation of the GBEP methodology

2.1.1 Goal of the pilots

A common aim of the pilots is to test the GBEP indicators to establish their feasibility and their practicality as a tool for policymaking, evaluation and monitoring. Several of the pilots also aim to assess and enhance the capacity of the country to use the indicators. GBEP brings together public, private and civil society stakeholders from around the world, who face different challenges in the development of sustainable bioenergy. It is therefore vital to be able to test the indicators that have been developed in different country contexts to ensure that they provide a relevant and practical tool for policy makers in different national contexts.

2.1.2 What were the main achievements?

"A pilot project approach is very valuable as a first step in a country" [2]

Pilot countries have benefited from gaining a good overview of current data availability within their country that enables the monitoring of the bioenergy sector. Countries have been able to use the pilot to identify options to improve data collection methodologies and data infrastructure, and in several identified the need to collect data that are currently non-existent (e.g. Ghana).

Countries taking part in the pilots have an enhanced capacity to work with the GBEP indicators, often bringing together organisations and stakeholders that have not previously worked together but who each have a role to play in monitoring the development of the bioenergy sector. Measuring the GBEP indicators has provided the space needed for communication and exchange of information between these organisations.

[2] From the pilot in Ghana

Challenges have been identified, and through the process, countries have been able to identify opportunities and solutions to further develop the methodological guidance provided for the GBEP indicators to enhance their practicality.

2.1.3 Scope

The pilots vary in their **geographical approach**: some opted for a national scope, others focus on specific case studies (e.g. Japan), others focus on specific cases which are then scaled up to the national level (e.g. Indonesia). The selection of one or other scope dictates the overall approach used. Pilots using case studies opted for a bottom-up approach, i.e. aiming to collect project-specific data from the different parts of the bioenergy supply chain. In Indonesia, for example, the aim was to establish a typology of national production systems, measure the indicators for a sample of each of the typology classes, and then scale up the values to give the national result. The pilots that opted for a national scope used a more top-down oriented approach.

The pilots vary in their **sectoral scope**: the part of the bioenergy industry most relevant for the pilot (e.g. biofuels for transport, biomass for electricity, heat etc) depended on the country, the specific situation and priorities and on data availability. The sectoral scope also varied often between indicators *within* individual pilots, as the data availability and appropriateness also varies. This highlights the need to be very clear when designing and using the indicators and when communicating the pilot results, for which sectors of the bioenergy industry the results are relevant. The GBEP indicators are intended for modern bioenergy. Some countries piloted (e.g. Ghana) have little modern bioenergy deployment currently and faced challenges implementing the indicators because of this.

The pilots also vary in their **temporal scope**: the timeframe of the data used varies between pilots and between indicators, due to a combination of the approach and timing of the pilot and data availability.

2.1.4 Pilot's approach

All the pilots used desk-top research. Ghana combined this with interviews and Germany with stakeholder workshops. Indonesia collected primary data through case studies and national surveys and is complementing these with information from desk-top research.

2.1.5 Indicator selection

Not all indicators were calculated by all countries. The selection of which indicators to test was mostly based on relevance for the country. The relevance was established in part based on consultation with key stakeholders (as in the case of Ghana). Data availability, however, also played a key role.

It can be difficult to assess the relevance of an indicator in a country before it is measured, although the involvement of a representative group of stakeholders in prioritising indicators does aid this to a

certain extent. Also data availability is not always a good proxy for the importance of an indicator. Nevertheless, where resources are limited, it is of course logical to prioritise indicators and start by testing those indicators for which data are available. Where data are not currently available, countries can start to mobilise the appropriate organisations and put in place programmes to collect the necessary data. The further development of a step-wise approach to implementing indicators may help countries to start measuring all indicators, even those for which few data are available. Taking a first implementation step for all indicators can help to further prioritise indicators for more detailed measurement based on their relevance.

An overview of the indicators covered by each pilot in each pillar is provided at the beginning of the subsections in Section 2.2 (Table **1**, Table **9** and Table **17**).

2.1.6 Data availability and quality

Data availability was generally judged to be high in Germany and the Netherlands. Germany and the Netherlands reported that they were able to make significant use of existing data reporting formats and respective information prepared for reporting under the United Nations Framework Convention on Climate Change (UNFCCC), and European Union reporting requirements (e.g. the Renewable Energy Directive Member State reporting requirements). For the other pilots, the availability differed depending on the indicator; for some indicators data availability was good, but for others less so. Importantly data was often not available in the form required in the methodological guidance for the GBEP indicators. A common issue was that bioenergy specific data was available at a project level, but not possible to aggregate up to a national level (e.g. Japan). Data that was available at a national level (e.g. on the agricultural system) was typically challenging to attribute specifically to the bioenergy sector. In some cases it was possible to manipulate the data to transform it into useable data, but in other cases countries would have to adapt their data collection methodologies to fit the GBEP format. Recommendations are also given for ways in which the methodological guidance could be adapted to fit the data currently collected or to provide more flexibility in the methodologies (for further details see section 3.2).

Similarly the **data quality** differed between the different pilots and the different indicators. Where (good quality) data was not available, or not in the form required, countries put in resources to try to fill those **data gaps**. A range of approaches was employed, depending on the indicator, such as extended literature reviews, interviews, or expert estimations. As an example, in Colombia the intention was (as for Indonesia), to establish a typology of national production systems, to measure the indicators for a sample of each of the typology classes, and then scale up the values to national context. However, difficulty accessing production sites led to a shift towards using more secondary and tertiary national level studies (themselves undertaken partly through collecting data in a bottom-up manner). In the longer term data collection programmes can be introduced or adapted to collect good quality data, but this was usually not feasible within the timeframe of the pilots.

2.2 Specific lessons learned of the implementation of indicators

This section presents specific lessons learned from the implementation of the indicators. We start describing aspects that were common to several indicators. Then, for each pillar, we provide an overview of the indicators implemented and a summary of the major lessons learned for each indicator.

2.2.1 Cross-cutting aspects

Attribution of data to bioenergy

Often, the parameters needed to calculate the indicators are regularly measured but not specifically for bioenergy purposes. This is especially the case for indicators that involve parameters associated with agricultural and forestry feedstock production in general (e.g. soil quality, water use and efficiency, water quality and land use / land use change, productivity) and social and economic indicators (e.g. jobs or health and safety) when they are calculated using national statistics. Being able to attribute the data available specifically to the bioenergy industry is a challenge that requires further attention.

Geographical scope

The GBEP approach is intended to assess indicators at the domestic (national) level. However, in several indicators the geographical scope is not sufficiently clear either because they refer to a "life cycle" approach which implies including effects outside the country boundaries (e.g. greenhouse gas emissions, air pollution, water quality and water use efficiency) or because it is not explicit how imported feedstocks/intermediates/biofuels should be addressed (e.g. productivity). For some countries imports can make up a significant proportion of the bioenergy, so it is very important to address imported bioenergy in a proper and transparent manner (e.g. in Japan an estimated 98% of biofuels are imported currently).

Temporal scope

The GBEP indicators are intended to be measured over a period of a year. Pilot countries have reported data for different years, because of a combination of the approach and timing of the pilot and data availability. The ideal situation would be for countries to develop a common base year of data, e.g. 2010, and then aim to collect annual data each year to build up a time series of data, which would enable the development of the indicator to be viewed over time.

Dealing with data gaps

In several cases, there were no data for some of the parameters needed to calculate the indicator. Pilot teams used different strategies to deal with this, for instance using data from the literature or carrying out expert interviews. Guidance on how to deal with data gaps and what to do to reduce the uncertainty of the indicators was missed. Additionally the further development of a step-wise approach to implementing indicators, even those for which few data are available, would help countries to start measuring all indicators.

Focus on agricultural feedstocks

Most of the indicators were formulated to be applied to any kind of feedstock. However, in some of the indicators the wording is too focused on agricultural feedstocks. In others, it is not fully clear how to deal with non-agricultural feedstocks. For example for indicator 17 on productivity, it is unclear how to apply the indicator when biomass residues are used as the feedstock. (See detailed tables on lessons learned for individual indicators.)

How to present the indicators

In most cases, indicators are required to be presented in the form of tables and figures. The pilot teams realised that a number of indicators are more meaningful if they are presented spatially in the form of maps (e.g. soil quality). Remote sensing and geographic information systems (GIS) approaches would be useful in this regard. The importance of accompanying the tables or figures with a description of the context was also highlighted.

2.2.2 Environmental pillar

The indicators included in the environmental pillar have been fully covered by most of the pilots (see Table 1 below). The exception was Ghana, which does not include indicators for which it was known upfront that the data availability was not satisfactory.

Table 1 Environmental pillar – indicators covered in the pilots

	Colombia	Germany	Ghana	Indonesia	Netherlands
1. Lifecycle Green House Gas (GHG) emissions					
2. Soil quality					
3. Harvest levels of wood resources					
4. Emissions of non-GHG, air pollutants, including air toxics (NOx, SO_2, ...)			Lack of data		
5. Water use and efficiency			Lack of data		
6. Water quality			Lack of data		
7. Biological diversity in the landscape			Lack of data		
8. Land use and land-use change related to bioenergy feed stock production					

Included
Not included

Table 2 to Table 8 below summarise the lessons learned from the pilots regarding the approach, the data availability, the approach to fill in the data gaps and the use of the indicator for policy development and monitoring. For indicators 1, 3, 4, 7 and 8 the lessons learned are based on the

pilot reports from Ghana and the Netherlands (which were first to finish the pilot implementation) and some input from the pilots in Colombia and Indonesia. Indicators 2, 5 and 6 also involve the contributions from pilot teams participating in the GBEP workshop in May 2013. Indicators 5 and 6 specifically also involve lessons learned from the US experience.

Table 2 Lessons learned - Indicator 1. Life cycle GHG emissions

Based on	Based on pilot reports from Ghana, Germany, Colombia, Indonesia and the Netherlands
Description	*"Lifecycle greenhouse gas emissions from bioenergy production and use, as per the methodology chosen nationally or at community level, and reported using the GBEP Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy 'Version One'"*
Approach	Applied methodology largely deviates from GBEP methodology: • Pilots reported difficulty agreeing upon a methodology for the lifecycle analysis. For example in Colombia, there was recently the publication of a national (currently unofficial) methodology, but the US and EU methodologies could also be relevant for those wishing to develop an export market. • One pilot used a top-down approach based on the national GHG emissions inventory. • For some of the energy pathways other pilots applied a full life cycle approach, i.e. including the full chain and not only the stages taking place within the country. • Not feasible to differentiate between single stages of supply/production chain. • One pilot (Indonesia) developed a methodology for adding the contribution of exported biofuel to the indicator value, but this was not applied due to insufficient time. Local knowledge considered helpful to establish which oils and fuels were exported. For part of the bioenergy carriers, only avoided emissions through fossil substitution where calculated.
Data availability	Limited data availability: • Data mainly available for biofuels • Not fully possible to identify which parts of the production chain within the country.
Approach used to deal with data gaps and quality issues?	• Indicator partially calculated. • Local (expert) knowledge. • Literature.
Use for policy making/evaluation and monitoring?	Useful for monitoring and reporting in different contexts (e.g. National GHG inventories, progress reports for compliance to the European Directive 2009/28/EC).

Table 3 Lessons learned - Indicator 2. Soil quality

Based on	Based on pilot reports from Ghana and the Netherlands, presentations from Germany, Colombia and Indonesia, and contributions from pilot teams and GBEP members participating in the GBEP workshop in May 2013.
Description	*"Percentage of land for which soil quality, in particular in terms of soil organic carbon, is maintained or improved out of total land on which bioenergy feedstock is cultivated or harvested."* *To maintain or improve soil quality on land used for bioenergy feedstock production, it is necessary to address the effects of soil and crop management, and in some cases forest and woody vegetation management, on five key factors that contribute to soil degradation:* *1. loss of soil organic matter, leading to decreased carbon and soil fertility;* *2. soil erosion, leading to soil loss (especially of fertile topsoil);* *3. accumulation in soils of mineral salts (salinisation) from irrigation water and/or inadequate drainage, with possible adverse effects on plant growth;* *4. soil compaction, reducing water flow and storage, and limiting root growth;* *5. loss of plant nutrients, e.g. through intensive harvest.* *Alternative approach (see page 42 GBEP methodology):* *"...percentage of the land used for bioenergy production where practices that help to maintain or enhance soil quality are in place."*
Approach	All pilots (Germany, Colombia, Indonesia, Ghana and the Netherlands) aimed at the full implementation of the indicator and reported their experience: • Partial implementation of the methodology was possible in one of the pilots (Netherlands) based on land use scenarios and soil carbon storage rates per crop combined with a qualitative description. • In another pilot (Germany) three options that deviate from GBEP approach are being assessed: risk based approach combining soil quality maps with high risk crops; combining data on crop cultivation and humus balances; monitoring of soil organic carbon. • Implementation of GBEP alternative approach based on identification of good agricultural practices through surveys is deemed to be a good alternative. This approach is being used in Colombia and Indonesia combined with the use of maps to identify high risk areas. Insufficient baseline and monitoring of SOC and other soil quality parameters to allow evaluation of changes beyond a small sample, but good mapping of risks to soil quality. Other experiences outside the five pilots: • In Brazil local field assessments are needed, which requires time and resources. Studies are ongoing.
Data availability	Data as required in GBEP approach were partially available:

	• Area on which feedstocks production for bioenergy not directly available from statistics (as crops are also grown for non-energy purposes). Estimations were needed.
	• Soil carbon content:
	  ○ Monitoring data as required in GBEP, only available for one (ongoing) pilot. Attribution to bioenergy is difficult because crops are grown also for non-energy purposes and data do not differentiate between them.
	  ○ Data available for other methods based on humus building/depletion potential by crop and data on crop rotation/land use.
	  ○ When no monitoring data are available, not possible to identify where soil organic carbon (SOC) has been improved or maintained.
	Alternative GBEP methodology (based on use of good agricultural practices:
	• This was implemented in Indonesia where most large plantations employ soil management practices such as the use of organic residues as mulching and green manure. Indonesian smallholders, however, hardly engage in soil management practices. In Indonesia attempts to identify implementation of good practices through surveys, local knowledge and literature were relatively fruitful. In one of the ongoing pilots, soil quality risk maps are available.

Approach used to deal with data gaps and quality issues?	• Deviation from GBEP approach to fit to data available (surveys, local knowledge). • Use of data from literature.
Use for policy making/evaluation and monitoring?	• Indicator deemed as highly relevant, in particular for feed producing countries. Useful for monitoring and reporting in different contexts (e.g. National GHG inventories, progress reports for compliance to the European Directive 2009/28/EC).

Table 4 Lessons learned - Indicator 3. Harvest levels of wood resources

Based on	Pilot reports from Ghana, Colombia, Indonesia, Germany and the Netherlands
Description	*Annual harvest of wood resources by volume and as a percentage of net growth or sustained yield, and the percentage of the annual harvest used for bioenergy*
Approach	• GBEP methodology could be applied. • Although it was questioned whether this should only be applied to managed forests and only to modern bioenergy.
Data availability	Almost all data as required in GBEP approach were available: • Almost all data available for the pilots that implemented the indicator. Two of the pilots from national statistics and surveys. For the other, from the FAO Global Assessment Report. • For the FAO Global Forest Assessment report, not always clear if methodology consistent with GBEP requirements (e.g. not clear if the if the

	definitions for 'net growth' and 'sustained yield' are identical in the GBEP and FAO methodologies). • In Indonesia and Colombia, data on sustained yield were not available.
Approach used to deal with data gaps and quality issues?	Use of data from the FAO Global Forest Assessment report. Quantitative data on harvest levels of wood resources in Indonesia were established through direct surveys.
Use for policy making/evaluation and monitoring?	Depends on the national context. Highly relevant for countries using wood resources, less relevant for countries with a limited use. Question whether this should only apply to managed forests and only to modern bioenergy.

Table 5 Lessons learned - Indicator 5. Water use and efficiency

Based on	Pilot report from the Netherlands, Colombia, Indonesia and presentation from the Netherlands/US and contributions from pilot teams and GBEP members participating in the GBEP workshop in May 2013.
Description	*5.1 Water withdrawn from nationally determined watershed(s) for the production and processing of bioenergy feedstocks, expressed :* • *(5.1a) as the percentage of total actual renewable water resources (TARWR)* • *(5.1b) as the percentage of total annual water withdrawals (TAWW), disaggregated into renewable and non-renewable water sources;* *(5.2) Volume of water withdrawn from nationally determined watershed(s) used for the production and processing of bioenergy feedstocks per unit of bioenergy output, disaggregated into renewable and non-renewable water sources.*
Approach	• The GBEP methodology is clearly described. Implementation partially feasible as not all data required were available: ○ 5.1a Indicator per watershed not feasible due to lack of data. ○ 5.1b Indicator per watershed and distinction between renewable and non-renewable water not possible due to lack of data. ○ 5.2 Rough (indicative) estimation. • Indicator should appropriately capture the substantial spatial variability in water use. Hence, the spatial presentation of the indicator, as suggested in the GBEP methodology (see page 63 of the methodology), is recommended. • It is helpful to use the risk based approach (focus on watersheds with the highest water stress risk) suggested in the GBEP methodology (page 63).
Data availability	Sub-indicator 5.1: • TAWR and TAWW available at national level (FAO), but not at watershed level. To determine both at watershed level would be highly demanding. • There is no practical way to distinguish between renewable and non-renewable water (see definitions of renewable and non-renewable water on page 62 of the GBEP methodology). • Data on water withdrawal per watershed is available for the whole agricultural sector. Water use monitoring usually does not distinguish

	between crops. Sub-indicator 5.2: Data are not directly available.
Approach used to deal with data gaps and quality issues?	Sub-indicator 5.1: • Aggregation at national level instead of at watershed level (as required in the GBEP methodology). • Distinction between surface and groundwater (instead of renewable and non-renewable water) • Water withdrawal for bioenergy feedstock (crop) production: estimation based on total withdraws for agriculture and share of agricultural land used for bioenergy. This approach assumes that all crops have similar water requirements. Sub-indicator 5.2 • No quantification, indicative figure based on water footprint
Use for policy making/evaluation and monitoring?	Relevance is moderate for countries with high feedstock importing rates and/or high shares of external water. Involving both would increase the relevance of indicator.

Table 6 Lessons learned - Indicator 6. Water quality

Based on	Pilot report from the Netherlands and contributions from pilot teams, including Colombia, Germany and GBEP members participating in the GBEP workshop in May 2013.
Indicator description	*(6.1) Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock production, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed* *(6.2) Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed*
Approach	6.1 The GBEP approach provides three methodological options: based on monitoring, on detailed physically based hydrological models and use of export coefficients. They could be partially applied: • The two first approaches could not be implemented in the Netherlands, as data on pollutant loads (either actual or from models) were not available. • The Netherlands used an approach similar to the export coefficient approach but using the maximum allowed load instead of export coefficients. • In Indonesia, field surveys and laboratory analysis were used to produce baseline values. These were consequently checked against pollutant load values as set by national specific regulation and present in the relevant literature. • Attribution to bioenergy very difficult.

	6.2 In the one pilot that already completed the implementation, indicator could not be calculated due to data constraints (see data availability below)
Data availability	6.1 • Availability of monitoring data varies among pilots: Largely available in Germany, but difficult to attribute data to bioenergy feedstocks; poorly available in Colombia and Indonesia and non-available in the Netherlands. • Modelling: Germany assessed option of adding a bioenergy module to an existing model. Modelling is possible but not feasible within the scope of the pilot. 6.2 For the one pilot that finalised the implementation of indicator (the Netherlands), data were available at economic sector level, but it was not feasible to attribute pollutant emissions to bioenergy .
Approach used to deal with data gaps and quality issues?	6.1 Estimations based on allowed water pollutant loads.
Use for policy making/evaluation and monitoring?	Relevance varies from country to country and depends on to what extent water quality is an issue and sufficient measures are in place to prevent water pollution.

Table 7 Lessons learned - Indicator 7. Biological diversity in the landscape

Based on	Pilot report from the Netherlands, Colombia and Indonesia.
Description	*(7.1) Area and percentage of nationally recognised areas of high biodiversity value or critical ecosystems converted to bioenergy production;* *(7.2) Area and percentage of the land used for bioenergy production where nationally recognised invasive species, by risk category, are cultivated;* *(7.3) Area and percentage of the land used for bioenergy production where nationally recognised conservation methods are used.*
Approach	There were some difficulties implementing the methodology. Identified issues: • GBEP methodology refers to national definitions of "areas of high biodiversity value" and "critical ecosystems". In Colombia such a definition did not seem to exist and could not be agreed upon within the timeframe. Pilots used own interpretation. Indicators can vary highly depending on national interpretation (e.g. whether natural grasslands are included or not). • The fact that conservation areas can be used for bioenergy production is not sufficiently reflected in the indicator.
Data availability	In the Netherlands most of the data were available. In Indonesia, nationwide high resolution maps for the localisation of bioenergy feedstock plantation surface and the quantification of their surface were not readily available.

Approach used to deal with data gaps and quality issues?	Remote sensing.
Use for policy making/evaluation and monitoring?	Not reported

Table 8 Lessons learned - Indicator 8. Land use and land-use change related to bioenergy feed stock production

Based on	Pilot report from Ghana, Germany, Indonesia and the Netherlands.
Description	*(8.1) Total area of land for bioenergy feedstock production, and as compared to total national surface and (8.2) agricultural land and managed forest area* *(8.3) Percentages of bioenergy from:* *(8.3a) yield increases,* *(8.3b) residues,* *(8.3c) wastes,* *(8.3d) degraded or contaminated land* *(8.4) Net annual rates of conversion between land-use types caused directly by bioenergy feedstock production, including the following (amongst others):* • *arable land and permanent crops, permanent meadows and pastures, and managed forests, natural forests and grasslands (including savannah, excluding natural permanent meadows and pastures), peatlands, and wetlands*
Approach	8.1, 8.2 and 8.4 GBEP provides the following methodological alternatives: 1) Surveys; 2) Geospatial information; and 3) Estimations based on bioenergy production and productivity. All pilots examined used the last one. The first and second approaches could not be applied within the framework of the pilots: • In the Netherlands, the second approach is deemed feasible, since data exist. However, the attribution of the data to bioenergy is problematic. Additionally, additional resources would be needed to acquire them. • Germany used the third approach which uses also data from national surveys, and geospatial data. • Ghana finds both approaches sound, but a lot of efforts and resources would be needed to implement them. 8.3 GBEP suggests the use of surveys of bioenergy feedstock producers. None of the pilots used this approach, but used existing data sources (see data availability below). It is assumed this was due to prioritisation of time and resources.
Data availability	8.1 and 8.2 • Actual data (surveys, terrestrial information, GIS) available only available for Germany. Quantification of indicator possible using statistics and

	literature. • In Germany and the Netherlands, GIS data exist but were not available for the pilot (as not available free of charge). Additionally, they are not specific for bioenergy. 8.3. Actual data (surveys) not available. Quantification of indicator possible using statistics and literature. 8.4 • Actual data (surveys, terrestrial information, GIS) available in Germany only. Quantification of indicator possible using statistics and literature. • Land use categories partly differ from the ones proposed by GBEP (e.g. peatland area is not a land use but a soil type in the Netherlands).
Approach used to deal with data gaps and quality issues?	International statistics (FAO, World Bank), interviews, national statistics, literature.
Use for policy making/evaluation and monitoring?	Highly relevant. Useful for planning future bioenergy developments.

2.2.3 Social pillar

The coverage of social indicators is lower than for the environmental pillar (see Table 9 below). In the Netherlands and Germany, some indicators were not included because of the relatively low relevance within the country context. Ghana included only those indicators for which it was known upfront that data were available. All indicators, however, were included in Colombia and Indonesia. (In the Colombian case two turned out to have zero values: zero is still a valid answer, however!)

Table 9 Social pillar – indicators covered in the pilots

	Colombia	Germany	Ghana	Indonesia	Netherlands
9. Allocation and tenure of land for new bioenergy production		Less relevant	Lack of data		Less relevant
10. Price and supply of national food basket		Less relevant			Less relevant
11. Change in income			Lack of data		
12. Jobs in the bioenergy sector					
13. Change in unpaid time spent by women and children collecting biomass		Less relevant	Lack of data		Less relevant
14. Bioenergy used to expand access to modern energy services		Less relevant			Less relevant
15. Change in mortality and burden of disease attributable to indoor smoke		Less relevant	Lack of data		Less relevant
16. Incidence of occupational injury, illness and fatalities	Data collection ongoing		Lack of data		

Included
Not included

Table **10** to Table **16** present the lessons learned for all indicators (excepting indicator 13 for which there was insufficient information in the pilot reports available at the time of writing). The lessons learned are based mainly on the reports from the pilots in the Netherlands and Ghana (which were first to finish the pilot implementation), with also inputs from the pilots in Colombia and Indonesia. Indicator 10 also includes inputs from all pilot teams participating in the GBEP workshop in May 2013. Other indicators that are being tested but for which reports are not available at the time of writing, are not included.

Table 10 Lessons learned - Indicator 9. Allocation and tenure of land for new bioenergy production

Based on	Presentation on the Colombia and Indonesia pilots.
Description	*Percentage of land – total and by land-use type – used for new bioenergy production where:* • *a legal instrument or domestic authority establishes title and procedures for change of title; and* • *the current domestic legal system and/or socially accepted practices provide due process and the established procedures are followed for determining legal title.*
Approach	• The indicator as formulated may not point towards means of obtaining the most reliable information about land tenure impacts of agricultural expansion for bioenergy: this may require interviews in areas where such expansion has taken place, though these may be difficult/dangerous to conduct.
Data availability	Accurate information very difficult to obtain due to security reasons in the areas in question.
Approach used to deal with data gaps and quality issues?	Interviews required, but very difficult to conduct.
Use for policy making/evaluation and monitoring?	Highly relevant, but highly sensitive.

Table 11 Lessons learned - Indicator 10. Price and supply of national food basket

Based on	Pilot report from Ghana and inputs from all pilot teams participating in the GBEP workshop in May 2013.
Description	*Effects of bioenergy use and domestic production on the price and supply of a food basket, which is a nationally defined collection of representative foodstuffs, including main staple crops, measured at the national, regional, and/or household level, taking into consideration:* *10.1 changes in demand for foodstuffs for food, feed, and fibre;* *10.2 changes in the import and export of foodstuffs;* *10.3 changes in agricultural production due to weather conditions;* *10.4 changes in agricultural costs from petroleum and other energy prices; and* *10.5 the impact of price volatility and price inflation of foodstuffs on the national, regional, and/or household welfare level, as nationally determined.*
Approach	The GBEP approach consist of two steps: • "Step 1: Determine the relevant food basket(s) and its components"; and • "Step 2: Assessing the links between bioenergy use and domestic production

	and changes in the supply and/or prices of relevant components of food basket(s)". For step 2, countries can choose between three methodological options or tiers: ○ Tier I: "Preliminary indication" of changes in the price and/or supply of the food basket(s) and/or of its components in the context of bioenergy developments resulting from collecting data on price and supply; ○ Tier II: "Causal descriptive assessment" of the role of bioenergy (in the context of ○ other factors) in the observed changes in price and/or supply; and ○ Tier III: "Quantitative assessment" using approaches such as time-series techniques and Computable General Equilibrium (CGE) or Partial Equilibrium (PE) modelling. The lessons learned include: Step 1 of the approach • Feasible to apply Step 2 of the approach • Tier I could be partially applied in Ghana (which already completed the implementation). In countries with government price support (e.g. Colombia), Tier I might not reflect the potential impact. • Tier II is deemed to be a sound approach to identify risks which can then be subject to more analysis. However, it is a complex approach. • Two pilots (Colombia, Indonesia) intend to implement Tier II and III in follow-up work.
Data availability	In Ghana, data availability varies from good (data to estimate food demand) to poor (for data such as calorie contribution by crop, energy costs and their impact on agricultural production and distribution costs, price inflation, change in demand for foodstuffs, shares of main staple crops used for food, feed, fibre and fuel).
Approach used to deal with data gaps and quality issues?	In Ghana, only data that are currently available were used.
Use for policy making/evaluation and monitoring?	Ghana found that when the bioenergy sector is not (well) established, indicator can contribute to estimate potential for bioenergy.

Table 12 Lessons learned - Indicator 11. Change in income

Based on	Pilot report from the Netherlands and Colombia.
Description	*Contribution of the following to change in income due to bioenergy production:* *(11.1) wages paid for employment in the bioenergy sector in relation to comparable sectors*

	(11.2) net income from the sale, barter and/or own-consumption of bioenergy products, including feedstocks, by self-employed households/individuals *Measurement unit(s):* • *(11.1) local currency units per household/individual per year, and percentages (for share or change in total income and comparison)*
Approach	For Colombia wages was found to be the only aspect that was of real significance: wages in formal sector could be compared with other sectors. For the Netherlands: • Based on statistics for the overall agricultural, energy and transport sector. • Survey (as recommended by GBEP) considered to be less practical and time intensive for monitoring this indicator. • Sub-indicator 11.2 was interpreted as the incomes of all households due to the use of bioenergy (wood stoves). This is a different interpretation as in GBEP methodology.
Data availability	There are no statistics available for the bioenergy sector within this pilot. Bioenergy activities are integrated in other sectors. Change in wages due to bioenergy is more difficult to assess: Colombian wages in the sugar sub-sector were seen to increase in line with increases in international sugar prices, which themselves could be due to increase in demand for sugar due to biofuel consumption around the world. So further analysis is required to better understand the impact on Colombian wages due to Colombian biofuel production or consumption, which seems to be required by the indicator.
Approach used to deal with data gaps and quality issues?	• Statistics for broad sector (agriculture and forestry, energy supply, transport and storage) were used. • 1.2 It is assumed that use of wood stoves generates additional incomes to individual households.
Use for policy making/evaluation and monitoring?	• 11.1 Relevant for the Dutch context. • 11.2 Less relevant for the Dutch context. Companies consume the majority of the bioenergy in the Netherlands. The use of bioenergy by households (stoves) is generally not driven by a cost saving perspective.

Table 13 Lessons learned - Indicator 12. Jobs in the bioenergy Sector

Based on	Pilot reports from Ghana and the Netherlands.
Description	*Net job creation as a result of bioenergy production and use, total (12.1) and disaggregated (if possible) as follows:* *(12.2) skilled/unskilled* *(12.3) indefinite/temporary.* *(12.4) Total number of jobs in the bioenergy sector; and percentage adhering to nationally recognised labour standards consistent with the principles enumerated in the ILO Declaration on Fundamental Principles and Rights at Work, in relation to comparable sectors (12.5)*

Approach	• Based on existing bioenergy socio-economic indicators assessment and statistics (one of the approaches suggested in the GBEP methodology). • Incorporation in national survey processes is a suitable approach when data are non-existent.
Data availability	Varies from pilot to pilot. Relatively good for the Netherlands. Poor for Ghana.
Approach used to deal with data gaps and quality issues?	Assumptions based on literature (Netherlands)
Use for policy making/evaluation and monitoring?	Most of the sub-indicators are considered highly relevant: • Sub-indicators 12.4 and 12.5 are deemed to be the most relevant to measure in a first phase in Ghana. • Sub-indicator 12.5 consider less relevant for Dutch context.

Table 14 Lessons learned - Indicator 14. Bioenergy used to expand access to modern energy services

Based on	Pilot report from Ghana, Colombia and Indonesia.
Description	*(14.1) Total amount and percentage of increased access to modern energy services gained through modern bioenergy (disaggregated by bioenergy type), measured in terms of (14.1a) energy and (14.1b) numbers of households and businesses* *(14.2) Total number and percentage of households and businesses using bioenergy, disaggregated into modern bioenergy and traditional use of biomass*
Approach	GBEP approach for the sub-indicators for which data were available.
Data availability	For Ghana data availability was poor. Data on use of solid biomass available. Further data not available.
Approach used to deal with data gaps and quality issues?	Only sub-indicators for which data were available were measured. For them, some assumptions and extrapolations were needed.
Use for policy making/evaluation and monitoring?	Indicator is very relevant for the pilot countries (Ghana, Colombia and Indonesia) that implemented it. However, in light of the low level of modern bioenergy development, not all sub-indicators are necessary currently in the context of the country.

Table 15 Lessons learned - Indicator 15. Change in mortality and burden of disease attributable to indoor smoke

Based on	Pilot report from Colombia and Indonesia.
Description	*Change in mortality and burden of disease attributable to indoor smoke from solid fuel use, and changes in these as a result of the increased deployment of modern bioenergy services, including improved biomass-based cookstoves.*

Approach	GBEP approach followed, although for Indonesia also respiratory diseases from palm oil mill facilities were also studied.
Data availability	Data was available in Colombia and the value was estimated as zero. Data availability in Indonesia was scarce.
Approach used to deal with data gaps and quality issues?	Direct interviews were performed to study this indicator in Indonesia (palm mill workers and local clinics).
Use for policy making/evaluation and monitoring?	Household air pollution is estimated to be the fourth highest risk factor for disease burden in Indonesia.

Table 16 Lessons learned - Indicator 16. Incidence of occupational injury, illness and fatalities

Based on	Pilot report from the Netherlands and Colombia.
Description	*Incidences of occupational injury, illness and fatalities in the production of bioenergy in relation to comparable sectors. Measurement unit(s):* • *Number/ha (for comparison with other agricultural activities) or number/MJ or MW (for comparison with alternative energy sources)*
Approach	• Estimation based on overall statistics for the "industry and energy" sector and share of the total employees working in the bioenergy sector. • Measurement using surveys deemed to be less feasible. • Forestry sector is missed in the GBEP methodology. • Not fully clear whether the indicator refers only to direct or also to indirect employment. • In Colombia data are usually collected for accidents at work, but not necessarily shared with government. However, attribution to bioenergy sector is difficult since many will be recorded by hospitals or health centres that are not only caring for those working in the sector.
Data availability	Poor. No data specific for bioenergy sector available.
Approach used to deal with data gaps and quality issues?	• Use of overall statistics for the "industry and energy" sector and share of the total employees working in the bioenergy sector (Netherlands).
Use for policy making/evaluation and monitoring?	In the Netherlands, indicator is less relevant, as no differences with other sectors are expected.

2.2.4 Economic pillar

The indicators in this pillar were relatively well covered in the pilots (see Table 17 below). Indicators were excluded either because it was known upfront that the data availability is poor or due to the lower relevance of the issue within the national context.

Table 17 Economic pillar – indicators covered in the pilots

	Colombia	Germany	Ghana	Indonesia	Netherlands
17. Productivity					
18. Net energy balance					
19. Gross value added			Lack of data		
20. Change in the consumption of fossil fuels and traditional use of biomass					
21. Training and re-qualification of the workforce		Less relevant	Lack of data		Less relevant
22. Energy diversity			Lack of data		
23. Infrastructure and logistics for distribution of bioenergy					
24. Capacity and flexibility of use of bioenergy			Lack of data		

Included
Not included

Table **18** to Table **24** below present the lessons learned for all indicators excepting indicator 21. They are based mainly on the pilot reports from Ghana and the Netherlands, with inputs also from the pilots in Colombia and Indonesia. Indicator 17 also includes the experience of Argentina as well as experiences from all pilot teams participating in the GBEP workshop in May 2013. Indicator 21 was not included, since it is being implemented only in pilots for which the report was not available at the time of writing.

Table 18 Lessons learned - Indicator 17. Productivity

Based on	Pilot report from Ghana, Colombia, Indonesia and the Netherlands; presentations from Ghana and Argentina and inputs from all pilot teams participating in the GBEP workshop in May 2013.
Description	*(17.1) Productivity of bioenergy feedstocks by feedstock or by farm/plantation* *(17.2) Processing efficiencies by technology and feedstock* *(17.3) Amount of bioenergy end product by mass, volume or energy content per hectare per year* *(17.4) Production cost per unit of bioenergy*
Approach	All indicators: • Based on available statistics and literature. No data collection was carried out. 17.1 • Unclear how to report productivity when the feedstock is a residue or a co-product. • Spatial and temporary variability of yields need to be taken into account in the indicator. • Attribution to bioenergy is an issue. • Focus is on agricultural feedstocks. Unclear how to deal with non-agricultural feedstocks. 17.2 • For biogas, estimating processing efficiencies per feedstock is complex. • Geographic scope is not sufficiently clear. Does the indicator include all feedstocks processed in the country? Or only feedstocks that are also produced in the country? 17.4 • In Colombia modelling was used to estimate production costs and this was compared with policy that restrained certain components of the price and with expert knowledge.
Data availability	• 17.1. In general good (included in national statistics) for agricultural feedstocks (without including residues). • For remaining sub-indicators: data are normally not systematically collected. Pilot(s) used data available from the literature. Commercial sensitivity of the data might be a constraint for data collection.
Approach used to deal with data gaps and quality issues?	Literature, interviews, extrapolations
Use for policy making/evaluation and monitoring?	Relevant. Level of relevance varies from country to country and is different for different sub-indicators. For countries with an immature bioenergy sector, the indicator is highly relevant for policy development.

Table 19 Lessons learned - Indicator 18. Net energy balance

Based on	Pilot report from Colombia, Ghana and the Netherlands.
Description	*Energy ratio of the bioenergy value chain with comparison with other energy sources, including energy ratios of* *(18.1) feedstock production,* *(18.2) processing of feedstock into bioenergy,* *(18.3) bioenergy use; and/or* *(18.4) lifecycle analysis*
Approach	• Is scope for using different approaches, similar to GHG LCA. • Approach is easy to understand, but calculating all ratios for all bioenergy pathways is not feasible within the scope of an annual report due to the very large amount of bioenergy pathways • 18.1 GBEP approach could be used • The Netherlands combined 18.2 and 18.3 in a single sub-indicator due to data availability constrains. • 18.4 could not be implemented due to poor data availability.
Data availability	Varies from country to country. Low for Ghana. For the Netherlands, good for the combined approach for indicators 18.2 and 18.3, low for sub-indicator 18.1 and non-existent for 18.4.
Approach used to deal with data gaps and quality issues?	Literature, interviews, own assumptions.
Use for policy making/evaluation and monitoring?	Relevant. Level of relevance varies from country to country and is different for different sub-indicators.

Table 20 Lessons learned - Indicator 19. Gross value added

Based on	Pilot report from Colombia, Indonesia and the Netherlands.
Description	*Gross value added per unit of bioenergy produced and as a percentage of gross domestic product*
Approach	Gross value added as calculate in national accounts. Optional further extensions mentioned in the GBEP methodology (Net value added (NVA), Green Accounting and Net Change in Value-Added) were not calculated. For Colombia and Indonesia, was some difference of opinions over whether to include all of agricultural phase of bioenergy production or just the value added to agricultural production through conversion of feedstock to bioenergy.
Data availability	High
Approach used to deal with data gaps and quality issues?	No data gaps in the Netherlands.
Use for policy making/evaluation and	Medium. The outcome of this indicator does not fully represent the added value of bioenergy to the national economy in the pilot country (Netherlands) because part

monitoring?	of the GDP is spent on bioenergy subsidies.

Table 21 Lessons learned - Indicator 20. Change in the consumption of fossil fuels and traditional use of biomass

Based on	Pilot reports from Colombia, Ghana, Indonesia and the Netherlands.
Description	*(20.1) Substitution of fossil fuels with domestic bioenergy measured by energy content (20.1a) and in annual savings of convertible currency from reduced purchases of fossil fuels (20.1b)* *(20.2) Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content.*
Approach	• The methodology is, in general, clear and transparent. Implementation is straightforward, when data are available. • It is not sufficiently clear how to deal with the import of fossil energy and of biomass. • Some difficulty in estimating how much of which fossil fuel product was displaced by modern bioenergy and in assigning ever-changing prices to the displaced products
Data availability	Differs from country to country (good in the Netherlands, poor in Ghana).
Approach used to deal with data gaps and quality issues?	• Filled in for the portion of the indicator that was deemed of more relevance. • Literature, interviews, expert opinion.
Use for policy making/evaluation and monitoring?	• 20.1. Relevant for countries where bioenergy is already (well) established. Less relevant, when bioenergy is at a very early state. • 20.2 Less relevant when programs to substitute traditional biomass are based on energy sources other than bioenergy (e.g. LPG).

Table 22 Lessons learned - Indicator 22. Energy diversity

Based on	Pilot report from the Netherlands.
Description	*Change in diversity of total primary energy supply due to bioenergy* *Measurement unit(s):* • *Herfindahl Index (in the range 0-1)* • *MJ bioenergy per year in the Total Primary Energy Supply (TPES)*
Approach	• GBEP methodology straightforward to use. • The chosen number of categories to calculate the Index generates uncertainties. This also complicates the comparison of the results to other countries as categorisation may differ from country to country.
Data availability	Good
Approach used to deal with data gaps and quality issues?	No data gaps
Use for policy	Medium for the Netherlands, since energy security is not an issue.

making/evaluation and monitoring?	For countries where modern bioenergy use is relatively low, the value of the indicator may lie in highlighting the extent to which bioenergy production is diversified, rather than focusing on 'change in diversity'.

Table 23 Lessons learned - Indicator 23. Infrastructure and logistics for distribution of bioenergy

Based on	Pilot reports from Colombia, Ghana and the Netherlands.
Description	*Number and capacity of routes for critical distribution systems, along with an assessment of the proportion of the bioenergy associated with each.*
Approach	• Pilots intended to apply the GBEP methodology but the poor data availability does not allow for a full test. In the Netherlands, specific data for bioenergy are not available since feedstocks have also other uses and also because infrastructure (e.g. pipelines) is used for multiple purposes. In Ghana, only data on overall road transport are available. • In the case of Colombia, road transport is the main route for transporting biomass and biofuels. It is difficult to use this indicator as formulated, since a more qualitative assessment of the risks faced through road transport would seem appropriate. • The criteria for the selection of critical distribution systems are unclear. The identification of the critical systems is actually considered a result of calculating the indicator.
Data availability	Although general data on infrastructure is in partly available, data regarding bioenergy are non-existent or have insufficient quality.
Approach used to deal with data gaps and quality issues?	Literature, interviews and own assumption based on punctual data.
Use for policy making/evaluation and monitoring?	• Less relevant in countries with well-developed infrastructure and logistics. • Relevance in countries with an emerging bioenergy sector is expected to increase.

Table 24 Lessons learned - Indicator 24. Capacity and flexibility of use of bioenergy

Based on	Pilot report from Colombia, Indonesia and the Netherlands.
Description	*Capacity and flexibility of use of bioenergy* *(24.1) Ratio of capacity for using bioenergy compared with actual use for each significant utilisation route* *(24.2) Ratio of flexible capacity which can use either bioenergy or other fuel sources to total capacity*
Approach	• GBEP methodology was applied. • There was some confusion whether the indicator refers to the flexibility of use or flexibility of production (although the indicator description states focus should be on 'use'). • Question how to apply this indicator to cases other than flex-fuel vehicles and

	how to account for flexibility in both directions, i.e. from fossil fuel towards bioenergy (e.g. co-firing limits of power plants) and vice versa.
Data availability	Data partially available. No data were found about the exact capacity versus the actual use of wood boilers for heat in companies, of the total wood stoves in households and of biogas.
Approach used to deal with data gaps and quality issues?	Own assumptions.
Use for policy making/evaluation and monitoring?	Low relevance in the Dutch context. This indicator was deemed to be less relevant for industrialised country with a dense and well-developed distribution network for different types of biomass, bioenergy and fossil energy.

3 Options for improvement

This chapter contains recommendations on the overall process of implementing the indicators and options for improvement specific to each of the indicators tested in the pilots. The recommendations on the overall implementation are based mainly on the discussions and exchange with the pilot teams in the GBEP workshop in May 2013. For individual indicators, we include the options for improvement identified by the pilot teams and Ecofys' recommendations as well.

3.1 Overall implementation

Stakeholder involvement
It is highly recommended to ensure all relevant actors are involved in the process of implementation of the indicators, including not only the bioenergy sector but also actors that generate or manage data related to the indicators or have the mandate to do so. These actors should take ownership of the indicators and ideally take care from the very beginning of the calculation of the indicator baseline and monitoring. This helps to ensure the continuity in the process of implementation.

Capacity building
It is essential to focus the implementation on creating or improving the capacity of national (governmental) institutions for the calculation and monitoring of indicators. External support is generally useful to facilitate the process, but the aim should be to enable local institutions to carry out the calculation by themselves.

Indicator prioritisation
For several of the indicators the GBEP methodology already provides different calculation options depending on the availability of information. The GBEP Community should develop a simple methodology for each indicator that could be used where data availability is low. This will enable all countries to make an approximation for all indicators in a first phase in an efficient way, which will give an objective basis to determine the relative importance of each indicator in their national context. As not all indicators will be equally relevant in all countries, each country can then continue to prioritise time and effort on detailed measurement of the indicators that are most relevant for them, whilst also having an overview of all indicators.

Optimal use of countries' data infrastructure
The implementation of the indicators should be aligned to make maximum use of existing information, and adapt it, if necessary, for the purpose of measuring the indicators. In case there is no data or when the existing data are representative or have high uncertainty, it will be necessary to initiate processes for systematic data collection embedded in the existing infrastructure (e.g. collection of data regarding feedstock could be done by expanding the scope of existing country agricultural surveys).

Dealing with data gaps

Provide a general guidance on options to deal with data gaps, which options should be used in which cases and methodological considerations to apply them. These options could be, for instance, aggregated in the following categories:

- Use of literature. For this option, guidance should be given on when it should be used and provide criteria to ensure that reliable literature sources are selected and are properly used.
- Expert opinion. It would be useful to indicate in which cases experts' opinions are useful, provide criteria to select the experts and guidance on documenting their inputs.
- Data collection via surveys and field measurements. This is, in general, a medium or long-term option that will require a clear action plan and also the allocation of personnel and financial resources. It is recommended to provide general guidance on the basis of such an action plan.

Exchange of information between experts

Experts in different countries responsible for implementing specific indicators would benefit from being able to learn from others facing similar challenges in different countries. An international internet-based platform could facilitate exchange of contact details and information between such experts in different countries to facilitate sharing of lessons between countries.

3.2 Recommendations for further development of indicators

Building on section 2.2 on the lessons learned, this section presents recommendations for the GBEP Community. Recommendations cover cross-cutting aspects common to several indicators. Then, for each pillar, we provide more detailed recommendations specific to each indicator.

3.2.1 Cross-cutting aspects

Attribution of data to bioenergy

Provide detailed guidance regarding the attribution of data to bioenergy as a part of the overall agricultural or forestry sector, taking into account aspects such as crop rotation and when the same agricultural crop is used for both bioenergy and other uses. The guidance should indicate when attribution is feasible or even needed and provide methodological options to do it. Some brief hints towards attribution are presented on page 26 of the GBEP report on the indicators and this could serve as a point of departure for more detailed guidance.

As a general principle, attribution based on shares of non-bioenergy and bioenergy outputs can be performed. For example, the respective values for e.g. land use, GHG emissions, jobs etc. could be attributed based on the energy content shares which are determined by the respective mass flows times the lower heating values of the biomass.

Allocation of data to bioenergy

Further to this, detailed guidance on allocation should be provided, including general co-product allocation plus the two specific topics of allocation of impacts to wastes and residues and allocation of impacts when there are multiple bioenergy products from the same crop or farm. For example, guidance on how to deal with a situation where bioethanol, cogenerated electricity, biogas from vinasse are all produced from the same system.

Specific guidance on how to deal with residues would be of benefit more broadly, including how to determine what is a residue (acknowledging that some jurisdictions have legal definitions of residues, which may or may not be relevant to the specific bioenergy context) and whether and how impacts of bioenergy production from residues should be allocated to the bioenergy product. The ISO life cycle assessment guidance can provide an outline, but leaves scope for interpretation, which should be further specified in the GBEP guidance.

Geographical scope

- The GBEP approach is meant to assess indicators at the domestic (national) level. The GBEP community should define for which indicators this should not be the case and state this clearly in the approach. For example, water-related indicators are more appropriately measured at the watershed level, which may cross (inter)national boundaries.
- For individual indicators, it should be explained when and how imported feedstocks, intermediates and bioenergy carriers should be included (see specific recommendations in the sections below). One suggestion was that over time countries could increasingly share their national results of the GBEP indicators to enable those results to be taken into account for their exports.

Focus on agricultural feedstocks

To ensure that the scope of the indicators covers (when applicable) all types of biomass, it is recommended to:

- Check the wording of the indicator methodologies to ensure that appropriate reference is made to all types of biomass.
- Provide, when needed, additional guidance on the implementation of the indicator for forestry biomass, for residues, and for biogas/biomethane (see specific recommendations provided for each indicator).

How to present the indicators

- The GBEP approach should indicate that, when reporting on the indicators, it is important that the tables and figures are presented together with a brief description or commentary.
- For indicators including parameters with high spatial variability, the figures could be presented for example as a map. Remote sensing and GIS systems would add a further dimension to the indicator.
- Guidance should be given how to present the outcomes of the indicators. What information is important to put the outcomes in the right perspective.

- Guidance on how to assess and present synergies and trade-offs between indicators would also be useful.

Emission factors

For a number of indicators, especially but not only in the environmental pillar, the development of "factors", similar to the concept of emissions factors for GHG, could help to make simple approximations of indicators more consistent and straightforward when data availability is low. This could be as part of a step-wise approach to measuring indicators, to start with simple approximations or proxies before more detailed actual data is used to refine indicators in a second step. However, suitable emission factors are scarce and would therefore have to be developed. The GBEP community could create an initiative to guide the development of emission factors and create a database that could be used by the community. Emission factors could be developed at a national, regional or, for example, watershed level. For example, an emission factor approach is similar to the development of default and typical values on GHG emissions in the European Renewable Energy Directive.

3.2.2 Environmental pillar

Table 25 to Table 32 present recommendations from the pilot teams and GBEP community for the further development of the indicators as well as additional inputs from the Ecofys team.

Table 25 Recommendations for further development - Indicator 1. Lifecycle GHG emissions

Recommendations for further development	• It is difficult to provide aggregated figures per step of the bioenergy chain aggregated at national level. It would be better to report average emissions per group of technologies. • Provide further guidance on how to deal with international trade of bioenergy feedstocks and intermediates. Alternatively, the scope of GBEP should be extended to include imported feedstocks and also international transport. • Start including the most relevant biomass pathways in the country and extend, step-wise, the sectoral scope to cover all pathways. • Attempts to harmonise or reduce further multiplication of methodologies should be accompanied by further work on training in different methodologies and implications of their difference and calculators that can convert activity data and best available emissions factors into LCA results under major methodologies.
Recommendations Ecofys	• The GBEP methodology requires the use of the "(…) Common Methodological Framework for GHG Lifecycle Analysis of Bioenergy". It would be useful to explain the purpose of it (i.e. documenting the methodology used to calculate the emissions), as this is not explicit in the current document. • The system boundaries for the calculation of the indicator are not sufficiently clear. While the GBEP indicator document refers to a national scope, the methodological framework suggests that parts of the chain taking place outside the country could also be included.

Table 26 Recommendations for further development - Indicator 2. Soil quality

Recommendations for further development	• Take into account not only the effect of cultivation, but also the effect of [removal of] agricultural residues. • Include "qualitative approach". E.g. overlaying of soil quality (or risk assessment) maps with maps of actual agricultural land used for bioenergy. • The alternative approach is seen as a good option. Further guidance on how to apply it - how to use good agricultural practices as a proxy for measuring changes in soil quality – would be useful, since there is often a tendency to think only in terms of biophysical measurements. • This is a spatial indicator. Hence, figures need to be accompanied by maps.
Recommendations Ecofys	• Provide further guidance on how to deal with attribution to bioenergy for multiple use feedstocks. • After a data availability assessment, countries are recommended to decide between the "full" implementation of the methodology and the "alternative" approach. Both are provided in the GBEP methodology. Further guidance on when to use each of them and how to move from the alternative to the full implementation is recommended. • Both, full and alternative approach might focus on high risk areas. The current GBEP methodology suggests this for the full approach. We recommend explaining that the alternative approach can also be focused on high risk areas. • Guidance is needed on how to proceed when no data on soil quality are available at all and when bioenergy developments are at an early stage or non-existent in the country.

Table 27 Recommendations for further development - Indicator 3. Harvest levels of wood resources

Recommendations for further development	• Further guidance is needed to clarify the scope, in particular on:
	  ○ Whether the indicator focuses on modern energy or on traditional biomass consumption.
	  ○ Whether the indicator refers to harvested wood products/forestry residues used for bioenergy within the country or also exports.
	• In some countries, imported energy wood is much more relevant than domestically harvested wood. Guidance is needed on how to address imports.
	• For the further development of the indicator, differentiation between forestry biomass from certified and non-certified sources is recommended.

Recommendations Ecofys	• According to the principles of the GBEP approach and on the methodology of the indicator, the scope of the indicator is the domestically produced wood. This should be highlighted as it was not fully clear for the pilots. • Wood importing might be offered the option to report about wood imports for energy.

Table 28 Recommendations for further development - Indicator 4. Emissions of non-GHG air pollutants, including air toxics

Recommendations for further development	• Expressing each pollutant as a percentage reduction or increase compared to the displaced fossil fuel is a much clearer indicator of sustainability. • Sub indicator 4.4 (emissions during use) expressed as change (and not per MJ) caused by substitution of fossil energy by bioenergy would be more interesting. • Indicator expressed as emissions per MJ is not expected to change significantly from year to year, as technology changes take time. Instead calculating the indicator from year to year, emission factors could be sampled and verified in practice. A database could be built within GBEP for default values with emission factors per processing technology. • Focus should be set on the phases of the supply/production chain with the greatest impact. • Include additional examples of pollutants that are relevant, such as CO (biomass burning) and H_2S (biogas plants).
Recommendations Ecofys	• The geographical scope of the indicator needs to be clarified. This is common to other indicators. Assessing life cycle emissions might imply also involving emissions generated outside the national boundaries. • If GBEP opts for a national scope (national boundaries), it must be highlighted that this refers to all biomass produced and/or processed and/or used in the country.

Table 29 Recommendations for further development - Indicator 5. Water use and efficiency

Recommendations for further development	• Provide more extensive definitions of "renewable" and "non-renewable" water. Check the practicality of distinguishing between both.
	• Give more guidance on how the FAO methodology (TARWR and TAWW) relates with other available approaches.
	• The indicator should take into account time variability. Annual figures could mask seasonal water stress, so the indicator should distinguish between different seasons.
	• The geographical scope of the indicator has to be reviewed:
	  ○ For feedstock/bioenergy importing countries, impacts on water availability are beyond country borders. Indicator should reflect this.
	  ○ Watersheds are often shared by several countries. For example for the EU, this indicator could be calculated at a regional level (i.e. the region covered in the watershed).
	• Working on the basis that first it is important to establish whether there is a risk, it is worth noting that the first analysis does not need to attribute water use to bioenergy, but rather look at total water use in the watershed. (If a risk is detected, more detailed analysis of the role of biofuels can take place.)
	• Provide further guidance on how to integrate available indicators to calculate the GBEP indicator. E.g. water footprint (WFP).
	• An international GBEP database with information about the water use for the most important processing technologies could be of use to deal with data gaps on

	water use for processing.

Recommendations Ecofys	• The GBEP methodology already suggests spatial presentation of the results and the use of a risk based approach to reduce data collection efforts. We suggest:
	  ○ Structuring the text in such a way that these aspects become more visible.
	  ○ Require spatial representation of the results in addition to the national aggregated figures. Currently, GBEP includes this as a suggestion.
	  ○ Highlight the need of connecting the indicator with the data stress level of the region or water shed. This not only important to optimise data collection when data availability is poor, but also for policy making.
	• Dealing with feedstock and biofuel import and exports. See section 3.2.1.
	• Time variability is a key additional aspect that should be taken into account in the indicator methodology.
	• Creating a database with default water use values for different bioenergy conversion technologies will greatly support the implementation of the indicators. For this purpose, cooperation with, for instance, the UNESCO Water Education Program and with water footprint community who may also need similar data for their calculations could be organised.
	• Although the indicator applies to all bioenergy feedstocks, the focus of the methodology is mostly on agricultural feedstocks. To better reflect water use for type of feedstock, we suggest to clearly indicate which parts of the methodology applies to which type of biomass, i.e. to explain that the guidance given in the paragraph "Water requirements of rain-fed alien species" also applies for forestry biomass.

Table 30 Recommendations for further development - Indicator 6. Water quality

Recommendations for further development	Both sub-indicators: • Review the scope of the indicator to ensure that positive effects of bioenergy on water quality are also involved and provide respective guidance (e.g. biogas produced from waste water treatment plants; feedstock cultivation in strategic places to act as buffer zone). • Watershed boundaries are usually different to national boundaries. Provide respective guidance. An option could be estimation of indicator at regional (e.g. EU) level. • Model-heavy indicator. It could instead focus on measures to promote best practice and monitor risk. E.g. N – focus on fertilizer use. P – focus on erosion control. • In the absence of an adequate baseline or monitoring data for plants, plant technology/set-up must be taken into account when attempting to model this indicator, since water flow/recycling is an important factor. Suggestion to identify major sources of pollution in the lifecycle; establish a baseline through two lifecycles cane; and compare pollution to local and international

	legislation/standards. • 6.1 • Differentiate among crops, as pollutant loads might highly differ from crop to crop. 6.2 • Biochemical oxygen demand (BOD) loadings from bioenergy processing are to be compared with the total loadings from agricultural processing. Most of the processing takes place, however, within other economic sectors. It is recommended to review this. • Differentiation among different processing technologies.
Recommendations Ecofys	• The current approach includes both, methodologies to estimate the indicators and methodologies to model the dispersion of pollutants in water. The latter is useful information but not necessary to calculate the indicator. We suggest to explain this to avoid misunderstandings. • Although the indicator applies to all bioenergy feedstocks, the focus of the methodology is mostly on agricultural feedstocks. Since fertilizers and pesticides are also used in the forestry sector, the scope should also include the forestry sector. 6.1 • Provide more guidance on which approach to use depending on data availability. An overview table providing the data requirements of each approach could help. 6.2 • The pilot shows that it is unclear which sector the polluting loads from bioenergy should be compared to. To solve doubts, we recommend first clearly defining "agricultural processing". Once defined, assess whether this comparison is sensible or whether comparison against other sectors would provide a better picture of the impact. • As for other indicators including data from processing, creating a database with default for different bioenergy conversion technologies would be a good option to support the implementation of indicators.

Table 31 Recommendations for further development - Indicator 7. Biological diversity in the landscape

Recommendations for further development	• Provide definitions of "areas of high biodiversity value" and "critical ecosystems" and guidance on how they are connected to definitions used at the national level. At least more guidance could be provided on the kinds of places where you might find nationally recognised definitions and what to do if none exist. • Highlight the use of GIS to calculate and present the indicator.
Recommendations Ecofys	The section "Application of the indicator" provides a list of potentially invasive species. It would be useful to add a sentence to explain that invasiveness of a species depends on the region (i.e. a species that is not invasive in a region could be invasive in a different region and the other way around).

Table 32 Recommendations for further development - Indicator 8. Land use and land-use change related to bioenergy feed stock production

Recommendations for further development	• 8.2 Clarify that the indicator is divided in two indicators: i) forestland for bioenergy as compared to total forest area and ii) agricultural land for bioenergy as compared to the total. • 8.3.b, c. For countries importing feedstocks, consider reporting import of residues and wastes as well. • 8.4 Review the use of the category "peat land", since this is not deemed to be a land use.
Recommendations Ecofys	GBEP recommends using surveys and geospatial data for sub-indicators 8.1, 8.2 and 8.3. The pilots that already implemented them found the methodology suitable, but not feasible to implement within the framework of the pilot either due to the lack of a proper data infrastructure or lack of accessibility to existing data. • It would be useful to provide guidance or create a working group on integration of bioenergy land use data in overall land use data gathering systems.

3.2.3 Social pillar

Table 34 to Table 40 present recommendations from the pilot teams and GBEP community for the further development of the indicators as well as additional inputs from the Ecofys team.

Table 33 Recommendations for further development - Indicator 9. Allocation and tenure of land for new bioenergy production

Recommendations for further development	• Indicator requires methodological improvement as sensitivity of topic makes it very difficult to collect information in areas where there is potentially an issue. The indicator as formulated may not point towards means of obtaining the most reliable information about land tenure impacts of agricultural expansion for bioenergy: this may require interviews in areas where such expansion has taken place, though these may be difficult/dangerous to conduct. Indicator needs to be objective yet measurable even in insecure areas.
Recommendations Ecofys	No further recommendations.

Table 34 Recommendations for further development - Indicator 10. Price and supply of national food basket

Recommendations for further development	• Focus on main components of food basket • To use time and resources as efficiently and effectively as possible, a critical selection of the usefulness and practicality of each of the sub-indicators is recommended. E.g. in Ghana, indicators 10.2 and 10.3 were found to be the most relevant, as the bioenergy sector is in a very early stage of development.
Recommendations Ecofys	In addition to monitoring impacts on food prices and supply, the indicator was found to be useful to support bioenergy policy developments in countries where bioenergy is in an early stage of development. This aspect should be addressed in the "relevance" section of the methodology.

Table 35 Recommendations for further development - Indicator 11. Change in income

Recommendations for further development	• Surveys are considered to be less practical to quantify this indicator. An alternative approach is suggested. • If an alternative approach using statistical data is proposed, it is necessary to give guidance on the processing of data for those countries where the bioenergy sector is not considered as a separate sector in the statistics. • The indicator methodology could benefit from further clarity on what is meant by "change in" and how this should be measured or deduced.

Recommendations Ecofys	• A step-wise approach (as provided in the GBEP methodology for indicator 12) is recommended:
	  ○ Step 1. Use of existing statistics or other secondary data.
	  ○ Step 2. Carry out surveys, which ideally will be incorporated to existing official surveys (e.g. national agricultural surveys, national industry surveys).
	• The GBEP methodology also provides guidance to estimate "Change in income

	distribution" (page 146, three last paragraphs). This is actually an additional sub-indicator. We recommend either to add it to the list of sub-indicators (as sub-indicator 11.3) or to explain that this is additional an optional.
	• Indicator 11 is closely related to indicator 12. It is recommended to highlight that "incomes" in indicator 11 need to be consistent with the categories used in indicator 12, i.e.:
	  ○ For sub-indicator 11.1, wage and salaried workers (also known as employees);
	  ○ For sub-indicator 11.2, self-employed workers that include self-employed workers with employees (employers), self-employed workers without employees (own-account workers) and members of producers' cooperatives; and contributing family workers

Table 36 Recommendations for further development - Indicator 12. Jobs in the bioenergy Sector

Recommendations for further development	• Provide guidance on approach to use when no data are available. E.g. step-wise approach with initial focus on most relevant sub-indicators and bioenergy sectors. • Specify if MJ refers to gross final end-consumption or to total energy supply.
Recommendations Ecofys	• The GBEP methodology indicates that "…it is necessary to decide and to state whether or not jobs created in foreign countries as a result of manufacturing in the domestic bioenergy sector are to be included." • We recommend clearly setting the geographic scope of the indicator and making it consistent with other indicators.

Table 37 Recommendations for further development - Indicator 13. Change in unpaid time spent by women and children collecting biomass

Recommendations for further development	• In Indonesia it was found that in some areas it is in fact the men (fathers and sons) that collect wood for fuel. The wording of the indicator could be changed to reflect this diversity of socio-cultural norms.
Recommendations Ecofys	No further recommendations.

Table 38 Recommendations for further development - Indicator 14. Bioenergy used to expand access to modern energy services

Recommendations for further development	• Focus on sub-indicators at national and household level. • Focus on the most promising bioenergy sectors for example: forest residues, agricultural residues, biogas (agriculture and kitchen waste and human excreta, household waste) • Provide more guidance on how to calculate expansion of access to modern bioenergy.
Recommendations Ecofys	The indicator refers to increased access to modern energy services. In the methodology it is explained that it "…includes use in households and businesses that

	are deemed not to have adequate access to these services at the start of the measurement period." At the same time, it is pointed out that "(…) it is not intended to include new use of bioenergy by a household or business for modern energy services that were previously accessed through use of other energy sources, such as fossil fuels.". This is not fully clear. It would be useful to explain whether the indicator refers to: • New energy production including the fraction of the households and business that had no access at all (since households or business that had previous access through the use of other energy sources are excluded) **and** also additional energy demand (indicator 20 mentions but does not include it); or • Only the fraction of the households and business that had no access at all; or • Only additional energy demand. It is also recommended to explain the relation to indicator 20.

Table 39 Recommendations for further development - Indicator 15. Change in mortality and burden of disease attributable to indoor smoke

Recommendations for further development	• The indicator could be expanded to cover broader mortality and disease attributable to bioenergy, for example for workers in the bioenergy supply chain.
Recommendations Ecofys	No further recommendations.

Table 40 Recommendations for further development - Indicator 16. Incidence of occupational injury, illness and fatalities

Recommendations for further development	• Further guidance to deal with lack of specific data for the energy sector. Suggestions on where to collect best available data would be useful. • Extend the scope of the methodology to the forestry sector. • Explain whether the injuries refer to both, direct and indirect jobs in the bioenergy sector.
Recommendations Ecofys	It is highly relevant to include the forestry sector, as health and safety risks can be higher compared to other sectors, especially relating to logging.

3.2.4 Economic pillar

Table 41 to Table 47 present recommendations from the pilot teams and GBEP community for the further development of the indicators as well as additional inputs from the Ecofys team.

Table 41 Recommendations for further development - Indicator 17. Productivity

Recommendations for further development	• Provide guidance on a step-wise approach consistent with data availability and level of development of the sector in the country. • Additional guidance is needed on the geographic scope of the indicator. 17.1 • More guidance is needed on how to involve the use residues and co-products in the productivity. • Spatial and temporary variability of yields need to be reflected in the indicator. Provide respective guidance. 17.2 • Express the indicator in MJ end product (useful energy) per MJ feedstock. • Provide guidance on how to deal with processing efficiencies when multiple feedstocks are used (as in the case of biogas). 17.1 and 17.2 • Both indicators are used to calculate indicator 17.3, which is considered suitable to compare different bioenergy chains. Assess the added value of reporting them. 17.4 • Assess using market price instead of production costs as the basis for the indicator, as they are more accessible, and a good proxy. Another alternative sub-indicator is the annual turnover generated from bioenergy.
Recommendations Ecofys	17.1 • The GBEP methodology indicates that "the productivity of all agricultural production on land used for bioenergy feedstock production is to be taken into account to derive the productivity of the bioenergy feedstock". However, it does not explain how and it is also not specific on how to address the productivity of agricultural residues. Since statistics usually report the yields for the main agricultural products, such guidance is essential (e.g. using product/residue ratios). • The indicator should explicitly mention that the productivity also includes forestry biomass. Specific guidance on how to calculate the indicator using existing forestry data and how to deal with data gaps should be provided. Indicator 17.3 as described in the GBEP methodology is understood to be a combination of indicators 17.1 and 17.2. A precondition to combine them is that the geographic boundaries are the same in both indicators , i.e. that processing efficiency in 17.2 only includes domestically produced feedstocks. This makes the indicator less meaningful in countries with a significant share of imported feedstocks. To have a

	good picture of the overall productivity, we recommend:
	
	• Explain in the methodology that indicator 17.2 should cover all nationally processed feedstocks, regardless of whether they are imported or not.
	• For indicator 17.3, choose between the two options to set the scope and provide the respective guidance:
	  ○ Option 1. Calculate the indicator for all feedstocks produced in the country. In this case, the feedstock productivity of imported feedstocks needs to be used as well and the respective guidance needs to be given.
	  ○ Option 2. Calculate the indicator only for feedstocks produced and processed in the country. In this case, guidance needs to be given on how to derive the processing efficiency when both domestic and imported feedstocks are combined.

Table 42 Recommendations for further development - Indicator 18. Net energy balance

Recommendations for further development	The energy ratio for each step of the pathways using a given technology is only expected to change significantly if major technological breakthroughs are achieved. Hence: • The GBEP community could provide default values per pathway and step of the chain. • Calculation of indicator every 3 to 5 years would be enough. As for GHG LCA, there is much scope for differences in approach here. Some guidance about major choices (e.g. whether to include renewable energy inputs, how to treat use of feedstock residues for process fuel) would appear useful.
Recommendations Ecofys	No further recommendations.

Table 43 Recommendations for further development - Indicator 19. Gross value added

Recommendations for further development	This indicator is meant to give an indication of the contribution of bioenergy to the national economy. Bioenergy in the Netherlands receives, however, considerable subsidies. This is a cost to the national economy. Including subsidy information in this indicator would partially remedy this. Subsidy information as a separate economic indicator would also indicate something about the economic feasibility of bioenergy: the higher the subsidy, the less economically feasible. Guidance would be useful on whether to include all of agricultural phase of bioenergy production or just the value added to agricultural production through conversion of feedstock to bioenergy.
Recommendations Ecofys	Taking into account subsidies is useful to measure the real contribution to the gross domestic product (GDP). If subsidies are taken into account, it is necessary to ensure that for comparison purposes, subsidies are included in the calculation of the gross value added (GVA) of fossil and nuclear energy (which is in many cases higher than for bioenergy). This is to prevent the risk of unfair comparison.

Table 44 Recommendations for further development - Indicator 20. Change in the consumption of fossil fuels and traditional use of biomass

Recommendations for further development	• 20.1 More detailed guidance on how to deal with the import of fossil energy carrier and biomass. • 20.1 More detailed guidance on how much of which fossil fuel product was displaced by modern bioenergy, particularly on how to determine to what extent an increase in consumption of domestically-produced biofuels resulted in a reduction in import of fossil fuel raw materials or processed products. • 20.2 Explain that the scope of the indicator depends on specific pathways in line with national policies and programs.
Recommendations Ecofys	20.1.a explains that " new bioenergy production can create additional energy demand" and that "More sophisticated analysis would therefore involve estimating the extent to which domestic bioenergy production had resulted in an increase in total energy consumption". It is unclear, whether it is suggested that these calculations are part of indicator 20.1.a or if they should be part of indicator 14.1.

Table 45 Recommendations for further development - Indicator 22. Energy diversity

Recommendations for further development	• A more detailed explanation on how to deal with the aggregation of bioenergy categories would be of use. Insight into the impact of the categorisation on the result of the Herfindahl index would be helpful when determining the appropriate level of aggregation; • The guidelines recommend detailed analyses of the impact of physical supply disruptions on energy security. It is not clear from the methodology when such detailed analyses are required. Some additional guidance would be of help; • Making a clearer distinction between energy diversity and energy security in the GBEP guidelines.
Recommendations Ecofys	As indicated in the GBEP methodology, there are several inter-related aspects associated with energy security. Energy diversity is one of these aspects. Therefore, we suggest presenting this indicator accompanied with at least a description of the national context regarding further aspects of energy security.

Table 46 Recommendations for further development - Indicator 23. Infrastructure and logistics for distribution of bioenergy

Recommendations for further development	• Provide the option of a qualitative assessment. • Measurement every 2 - 3 years might be sufficient. • Some guidance could be offered for the case where road transport is predominant, since the indicator is currently aimed more at the case where bottlenecks are ports and pipelines.
Recommendations Ecofys	• Provide more guidance on how to select critical systems. • Include further guidance on how to estimate the capacity used by bioenergy in mixed systems. • The GBEP document indicates in the limitations, that a heuristic approach is required. It would be useful to highlight this in the methodological approach.

Table 47 Recommendations for further development - Indicator 24. Capacity and flexibility of use of bioenergy

Recommendations for further development	• The inclusion of a clear definition of flexibility would be helpful. In the GBEP indicators both flexibility of production and use are discussed; it is not clear which option is preferred and when. • Combine the results with qualitative assessments to place the results into context of the country under investigation. • The methodology sheet could benefit from more clarity, in particular with regard to how to apply this indicator to cases other than flex-fuel vehicles and how to account for flexibility in both directions, i.e. from fossil fuel towards bioenergy (e.g. co-firing limits of power plants) and vice versa.
Recommendations Ecofys	No further recommendations.

4 The way forward

Chapter 3 provided recommendations for the further development of the GBEP approach regarding the process of implementation, cross-cutting aspects and specific indicators. This chapter proposes a way forward to incorporate these recommendations in the GBEP process.

It is suggested to implement the recommendations as follows (see Figure 1 below):

1. The implementation of the overall recommendations regarding the process of implementation can be done in the short term through a concise **guidance for pilots**, building on the findings of the present report. This guidance is addressed to countries that are about to start the implementation of indicators and should cover aspects such as how to prioritise the most relevant indicators in their context and how to present the outcomes of the indicators.
2. In the medium term, the GBEP community could start to address the cross-cutting aspects with the highest priority which are according to the findings of the present assessment, the attribution and the geographical scope. The discussion on a common approach to develop emission factors might start in the medium term, but it is expected that the implementation may take too long.
3. Some of the options for improvement of specific indicators are straightforward and could be implemented in the medium term. Others, for example developing emission factors, might require a longer development and consensus process.

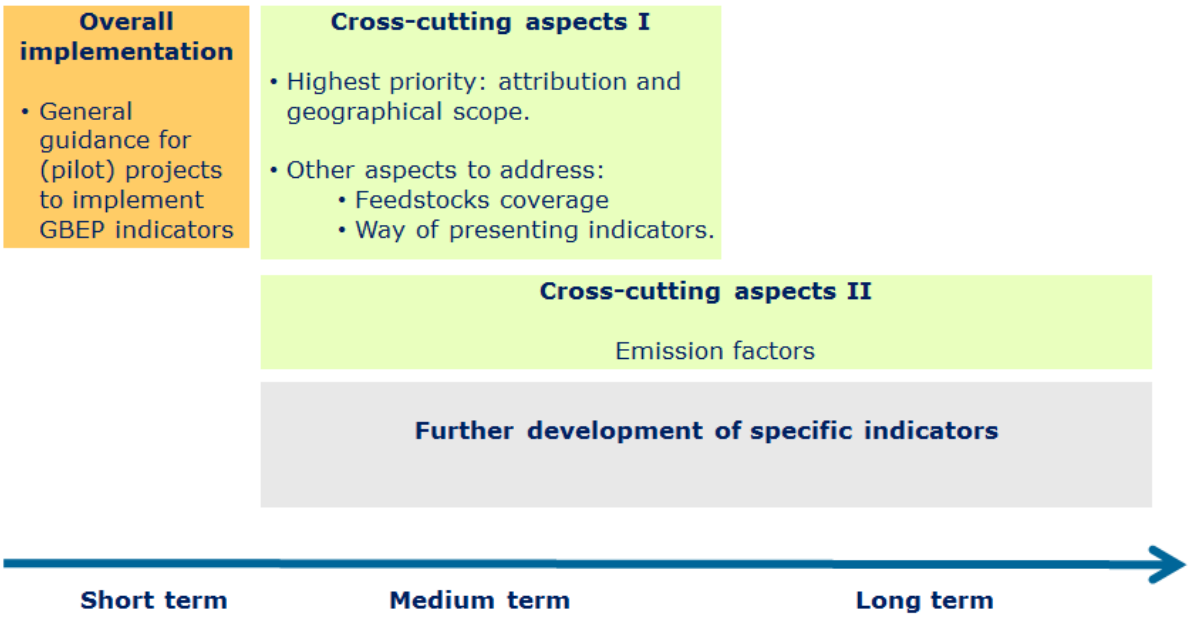

Figure 1 Proposal to incorporate options for improvement

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