SUSTAINABLE BIOMASS GUIDELINES & RISK ASSESSMENT TOOL

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Objectives and Approach of the Guidelines

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- These guidelines have been prepared with the objectives to:
  - Gain an understanding on the different types of biomass and the environmental and social risks that may occur through the supply chain.
  - Support key decision-makers in selecting biomass types that are acceptable or can be acceptable with certain risk mitigation action plans and in screening biomass suppliers providing the necessary references and tools related to environmental and social (E&S) risks screening analysis.
- The target users of the guidelines are the key personnel of factories that are Tier 1 and Tier 2 suppliers of the fashion industry (clothing and footwear) including factory decision-makers, technical officers, and procurement officers.
- Building on the context of Southeast Asia, these guidelines are developed with the aim of global application and are supplemented with a user-friendly Risk Assessment Tool (RAT) to perform the first level screening of sustainability profile of various biomass sources, from production to utilization, to support the decisions-making of biomass technology and supplier selection.
- The Sustainable Biomass Guidelines and the RAT can be used at different stages of biomass adoption: when a factory is only considering biomass as a transition energy source to phase out from fossil fuels, at the stage of supplier selection or when biomass is already in use - to understand possible E&S risks and develop a risk mitigation and alternative sourcing plan.
- The Sustainable Biomass Guidelines and Biomass Sustainability Risk Assessment Tool are developed by aligning on key frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Sustainable Development Goals (SDGs) (led with the overarching SDG 7: Affordable and Clean Energy) and consolidating on existing materials related to biomass utilization, ESG criteria and reporting standards and metrics such as Roundtables for Sustainable Biofuels (RSB) or Food and Agriculture Organization (FAO). Reference and considerations related certifications developed by Forest Stewardship Council (FSC) and Roundtable on Sustainable Palm oil (RSPO) are also made in these guidelines.

Glossary

What are biomass, biofuel and bioenergy?

- **Biomass** is organic material originating from plants and animals. Biomass can be utilized as:

Raw material	Organic matter of soil amendment	Source of energy supply (biofuel)

- **Biofuel** is a fuel that is produced from biomass to produce energy (also called **bioenergy**) and that can be separated into three main families based on the biofuel form, as follows:

Solid biofuel	Liquid Biofuels	Biogas
▪ Fuels derived directly from biomass ▪ This includes feedstock derived from forestry or agricultural resources such as forestry, agricultural or agro-industrial by-products that will generally be used to produce heat from combustion, with or without prior pyrolysis.	▪ Liquid fuels converted from biomass ▪ Main liquid biofuels include bioethanol supplied from sugar or cereals crops or biodiesel from fats and oil crops to produce biodiesel respectively following fermentation/distillation and esterification.	▪ A mixture of methane (CH_4) and carbon dioxide (CO_2) used as fuel and produced by bacterial degradation of organic matters processed from anaerobic digestion of crops, animal manures or sewage sludge ▪ Solid biomass can also be gasified to produce synthesis gas and be used with equipment adapted to gaseous fuels.

- Throughout these Sustainable Biomass Guidelines and the Biomass Sustainability Risk Assessment Tool, as only biomass for energy use is considered, for the rest of the document, the term “biomass” will commonly be used with the same meaning of biofuel unless specific notice.

Most frequent biomass pathways for energy purposes

The following terms are as described:

- **Final usage**
  Final output for which the biomass is used. Examples: Heat, electricity, and transportation
- **Bioenergy carriers**
  Final product or form of the fluid carrying the energy processed from biomass. Examples: Biogas, steam, methane, biofuels, etc.
- **Conversion process**
  Key process treating the biomass feedstock into bioenergy product or carrier. Examples: Direct combustion, Gasification, Anaerobic digestion, Fermentation, etc.
- **Pre-treatment process**
  Initial treatment of the biomass in order to facilitate its storage or transportation. Examples: Compaction, drying, pelleting, etc.
- **Biomass feedstock**
  Initial source of biomass following or not pre-treatment. Examples: Wood from harvested forests, corn, oil crops, organic waste, sludge, etc.

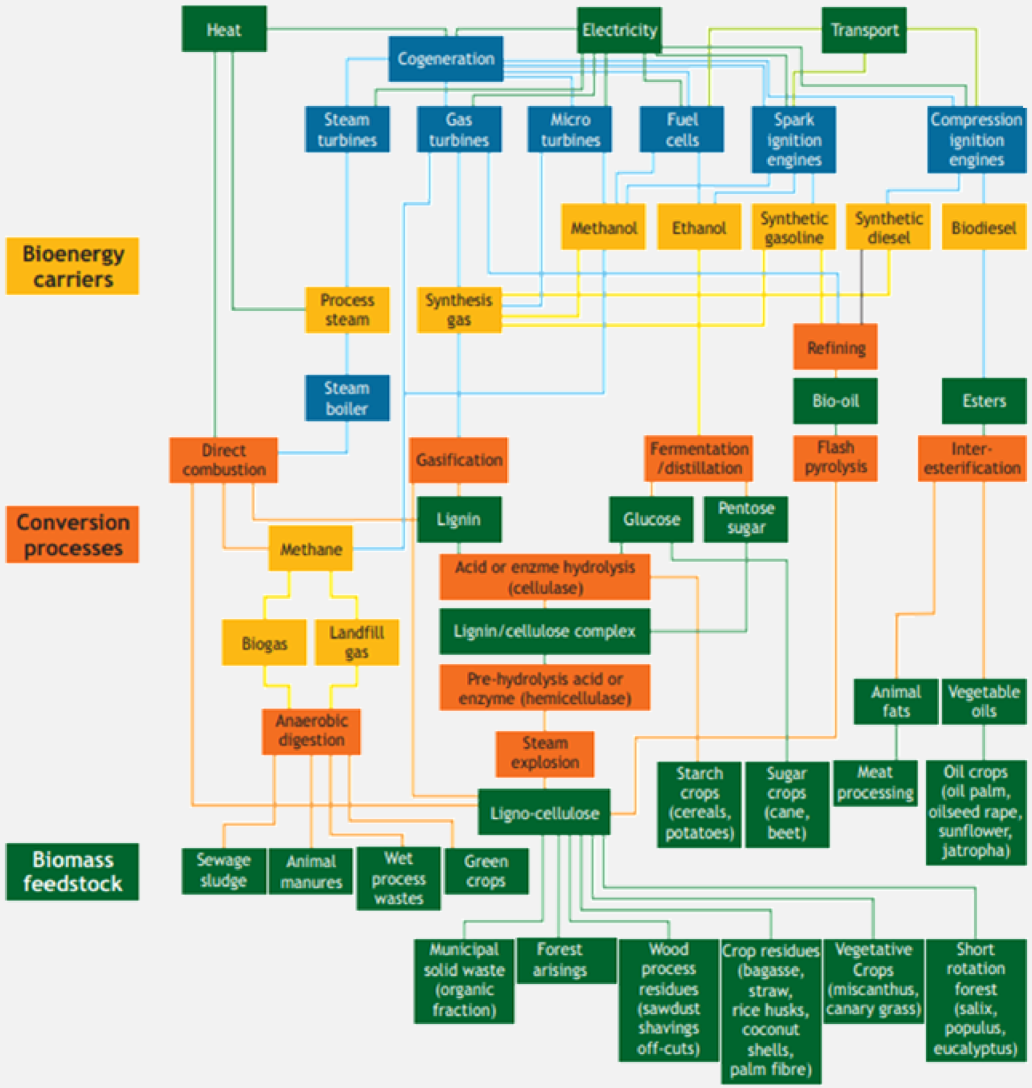


Figure 1 – The biomass pathways for energy purposes [1] [2]

Key definitions (1/2)

Term	Definition
Biomass category	Grouping of biomass feedstocks based on criteria including origin, main subsequent treatment processes and main sustainability risks that their production and utilization may lead to, such as “Solid Agricultural Waste” or “Solid wood and other products extracted from forests”.
Biomass feedstock	Referring to the initial source of biomass before its transformation into a biofuel.
Biomass Sustainability Risk Assessment Tool	Spreadsheet guiding the user to identify the biomass feedstock and category and screen the environmental and social risks from the evaluation indicators of the given biomass feedstock options.
Cascading use	Cascading use maximizes resource effectiveness by using biomass in products that create the most economic value over multiple lifetimes. This approach to production and consumption states that energy recovery should be the last option, and only after all higher-value products and services have been exhausted.
Energy efficiency and Clean energy solutions	Use of best practices and technologies in terms of energy savings and energy efficiency for biomass conversion equipment as well as the manufacturing of machines in order to limit the amount of energy and biomass input for one unit of the final product.
Evaluation indicator	Indicator to be evaluated through the Biomass Sustainability Risk Assessment used to assess the environmental and social risks of a given biomass source production and utilization.
Factory-level	Referring to the elements that are directly under factory’s operational control, including internal energy equipment, factory and internal energy utility workforce, ethics & compliance and risk management procedures, internal waste management equipment and protocols.
Key principles	Principles such as “Legality and Compliance” or “Responsible Consumption and Production” overarching the environmental and social risks assessment to be considered for reviewing the legality and relevance of using biomass over other technologies and ensuring that the biomass utilization serves purposes compatible with sustainability targets and development goals.
Legality & compliance	Key principle referring to the compliance with main local and national laws, applicable permits and licenses required and alignment on recognized standards and good practices.
Mitigation measure	Measure to be selected based on option list in order to reduce the risk level to acceptable level for a given evaluation indicator in the Biomass Sustainability Risk Assessment Tool used on specific biomass feedstock.

Key definitions (2/2)

Term	Definition
Responsible consumption & production	Key principle referring to “the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations” [10].
Risk assessment/Screening	Process handled through the Biomass Sustainability Risk Assessment Tool in order to screen the key risks based on the evaluation indicators.
Risk mitigation	Step following the Biomass Sustainability Risk Assessment aiming at identifying potential risk mitigation options, to increase acceptability of the biomass source.
Supply-chain level	Referring to the elements that are not under factory owner/operator operational control including the operations for biomass extraction/production, pre-treatment & treatment, transportation and storage.
Sustainability of biomass	Refers as “Biomass for energy must be produced, processed and used in a sustainable and efficient way in order to optimise greenhouse gas savings and maintain ecosystem services” while ensuring the respect of human rights, application of good labour practices and providing economic opportunities to local communities.
Sustainable Biomass Guidelines	Present document introducing the key concepts of sustainability for biomass as energy source in the fashion industry and explaining how to perform the biomass sustainability risk assessment.
Sustainability driver	Key topic that can be directly or indirectly affected by an unsustainable production, transportation and/or use of biomass as energy.

List of Abbreviations

Abbreviation	Meaning
CV	Calorific value (also referred as energy value) – LCV: lower calorific value; HCV: higher calorific value
E&S	Environmental and social
EFB	Empty fruit bunch
ESG	Environmental, social and governance
FAO	Food and Agriculture Organization
FSC	Forest Stewardship Council
GHG	Greenhouse gas
HIGG FEM	Higg Facility Environmental Module
ISO	International Organization for Standardization
LUC/ILUC	Land-use change / Indirect land-use change
MOC	Management of change
MSW	Municipal solid waste
OHS	Occupational health & safety
RAT	Risk Assessment Tool
RSB	Roundtable on Sustainable Biomaterials
RSPO	Roundtable on Sustainable Palm Oil
SDG	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

Objectives:

This section aims at presented the challenges related to sustainability in the fashion industry and for the use of biomass. Considering the diversity of biomass, a categorization of the different types of feedstock is proposed in this section.

1.1. Introduction – Energy use and GHG emissions of the fashion industry

Greenhouse gas emissions of the fashion industry

- The fashion industry represents an important contributor to the global energy use and greenhouse gas (GHG) emissions. Due to lengthy supply chains and energy-intensive production methods, the fashion industry (not including footwear) generated approximately 2% of global carbon emissions (based on data from 2019). [3]
- With processes like textile production and the manufacturing of clothes, high levels of energy are required to satisfy the fast-paced, dynamic system. Without mitigation solutions and if the fashion industry continues developing on the same trend, GHG emissions from production are set to rise **60% by 2030** compared to 2019 [3], up to an estimated 1.6 billion tons of CO_2. [4]
- Maximize material efficiency, energy efficiency, shift to 100% renewable electricity and eliminate coal from manufacturing are among the key interventions to achieve target of 45% reduction of GHG by 2030 as defined by the apparel industry. [5]
- For the latter, along with other clean energy technologies, the **utilization of biomass** can be considered as a transition fuel in phasing out the use of fossil fuels, notably to produce thermal energy (steam and/or hot water), and thus help reduce GHG emissions.

Energy use in the fashion industry

- The steps involved in the fashion industry and its supply-chain are commonly divided into different tiers (see figure 2) and differ based on the type of textile products and the fuel type used. As shown on the figure 3, material production and textile finishing which consist in a wide range of operations to convert input material into the final product are the steps requiring the biggest amount and therefore have the biggest contribution in terms of GHG emissions.

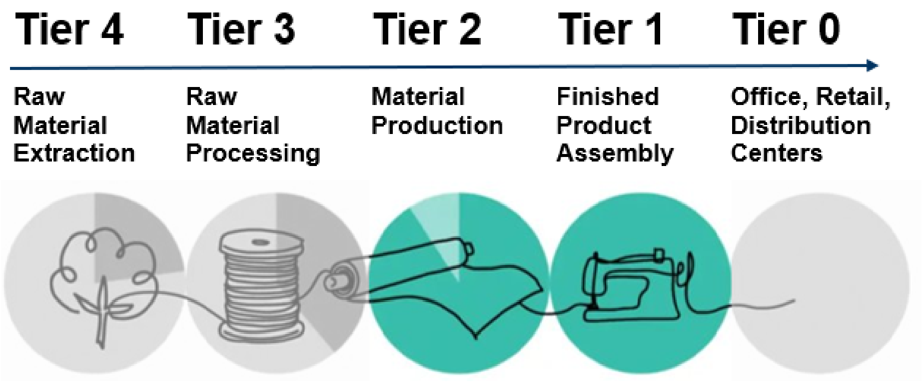


Figure 2 – Four Tier Supply Chain Model. Source: WRI and Aii (2021) [6]

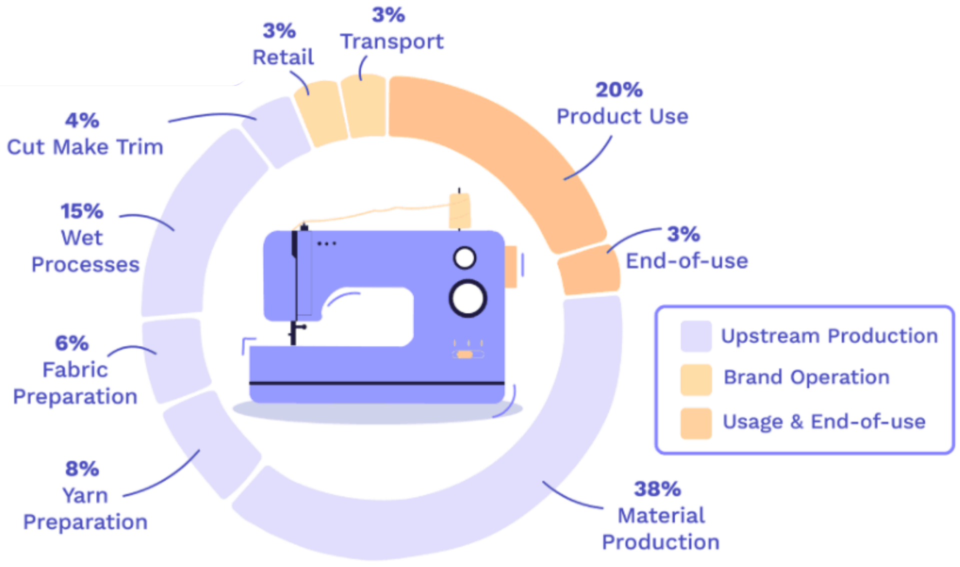


Figure 3 - Emissions contribution of fashion supply chain [7]

1.2. Introduction – Biomass

- Already widely produced in most parts of the globe –particularly in Southeast Asia (see figure 4), biomass has played for a longtime an important role in terms of primary energy supply particularly in the developing and under development countries.
- As of 2022, traditional biomass accounted for about 7% of the global direct primary energy consumption providing a stable quantity of energy between 10,000 and 12,000 TWh/year since the years 1980's. In addition, modern biofuels (such as bioethanol, biodiesel or biogas) represented a smaller portion of the energy consumption with approximately 1,200 TWh in 2022 or 0.7% of the global direct primary energy consumption (see figure 5). For elements of comparison, coal, natural gas and oil represented a combined 136,000 TWh/year or approximately 85% of the global direct primary energy consumption.
- Due to the carbon captured during its lifecycle, biomass can be considered as a low carbon transition energy source to produce hot water and steam generation, in substitution of fossil fuels such as coal, oil or natural gas.
- Nevertheless, while representing an alternative transition solution for phasing out of fossil fuels, biomass production, transportation and utilization can also generate direct and indirect negative environmental and social impacts such as deforestation, air pollution from biomass combustion or competing use between food and energy purposes.
- Therefore, assessing and ensuring the sustainability of biomass sources needs to be done properly along the supply-chain until final utilization and waste disposal.

Figure 4 - Feedstock-wise biomass production potential in Southeast Asia [8]

Note: EFB refers to Empty Fruit Bunch Unit: Million liters

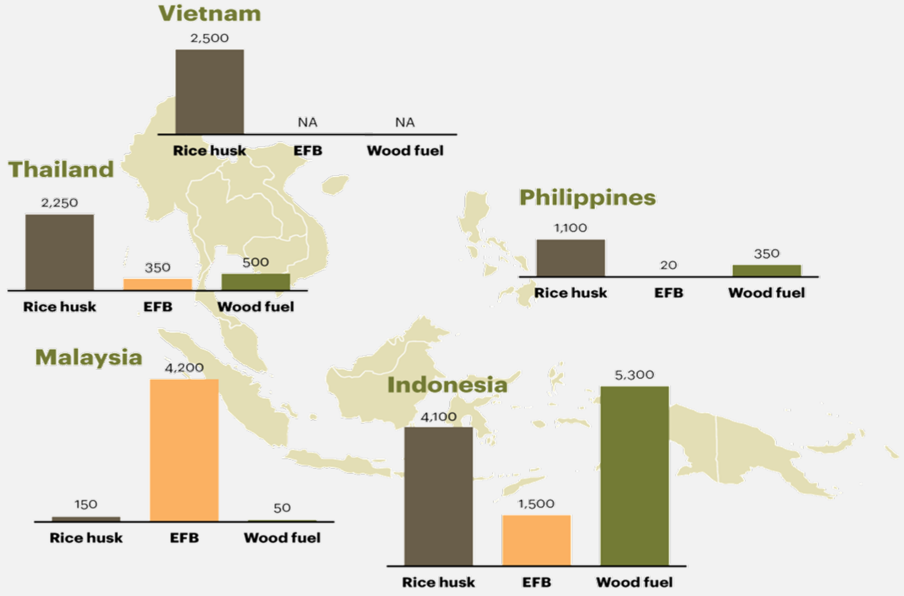


Figure 5 – Evolution from 2000 to 2022 of the global direct energy consumption from traditional biomass and modern biofuels [9]

1.3. Introduction – Categorization of biomass feedstocks

- Biomass, in the energy context, is an energy source derived from biological material, also called bioenergy. The biomass can originate from various feedstock types and may need to be transformed through various chemical, mechanical, and thermal processes to produce the final biomass product in a form of a solid (wood pellets, charcoal, etc.), liquid (bioethanol, biodiesel) or gas biofuel (biogas) to be used in boilers, turbines or engines at factories to fully or partially substitute fossil fuels.
- Given their diversity on a global scale and based on criteria such as origin, technical characteristics and sustainability risks, **five biomass feedstock categories** have been defined as follows:
  - **Category 1: Solid wood and other products extracted from forest**, such as wood from natural forests or wood production forests;
  - **Category 2: Primary products from crops used for food and/or energy**, such as sugar and cereal or oil crops used notably to produce bioethanol or biodiesel;
  - **Category 3: Solid agricultural waste**, such as risk husk, palm kernel, wheat straw, wood waste from fruit/rubber plantations;
  - **Category 4: Animal manure as residues from livestock processes** such as cows, sheep, pig or poultry manure used notably to produce biogas; and
  - **Category 5: Organic waste from industries and municipal solid waste (MSW)**, such as food waste from restaurants, or generally from the food industry and residue from industries using wood as main raw material.
- More details about the Biomass categories are provided in Annex 1.

Category 1: Solid wood and other products extracted from forests

Category 2: Primary products from crops used for food and/or energy

Category 3: Solid agricultural waste

Category 4: Animal manure as residues from livestock processes

Category 5: Organic waste from industries and municipal solid waste (MSW)

Figure 6 – Visualization of the proposed 5 biomass categories

2. Sustainable Biomass Guidelines

<u>Objectives:</u>

This section introduces the key principles and drivers to be assessed for evaluating the sustainability of biomass, introducing a hierarchy of biomass categories in terms of acceptability based on their potential impact on E&S criteria.

2.1. Key principles before using biomass (1/2)

Before proceeding to the selection and assessment of biomass resources for energy uses, the user at factory-level shall consider overarching principles without which the sustainability of the biomass and efficiency of implementation of decarbonization initiatives may not be guaranteed. The use of technologies shall seek to maximize production efficiency and social and environmental performance and minimize the risk of damages and impact to the environment and people.

Key principles include:

A. Legality and compliance
B. Responsible production and consumption
C. Cascading use
D. Energy efficiency and clean energy solutions
E. Waste management

Before proceeding to the assessment, a set of questions related to key principles for sustainable use of biomass and readiness of the company in terms of techno-economic aspects, to gain understanding about the rationale and maturity of the choice of using biomass at site for energy use before proceeding with the selected biomass source.

A. Legality and compliance

Compliance with main local and national laws and best practices for E&S, business activities, ethics, etc. shall be ensured at any stage of the project implementation and checked for the different steps of the biomass production and supply until utilization and waste management at factory level with the appropriate permits and licenses required and alignment on recognized standards and good practices. Sustainable operations and compliance shall be planned, implemented, and continuously improved through an open, transparent, and consultative impact assessment and management process and an economic viability analysis. It is therefore recommended for the factories to:

- To check the sufficiency of permit and license, including business license, water use and discharge permit (if applicable) from the biomass production factories, permits for equipment purchase and import, etc.
- To have a management system and staff responsible for the ethics and compliance checks at supply-chain and factory levels.

Note: it has to be mentioned that the involvements of local and/or national authorities' bodies into the value-chain of biomass does not guarantee the legality of these activities, as economic activities, as conducted by administration, police or army related organizations, may also represent a risk of ethics and lack of transparency, for which appropriate screening and due diligence shall also be performed.

2.1. Key principles before using biomass (2/2)

B. Responsible production and consumption (SDG 12)

This principle refers to the Sustainable Development Goal 12, “the use of services and related products, which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of future generations”. [10]

In order to ensure the proper application of the SDG 12, fashion industry stakeholders should also:

- Ensure quality and longevity to the highest standards of its products
- Provide the relevant information to consumers about environmental and social impact of its products.

C. Cascading use

Cascading use maximizes resource effectiveness by using biomass in products that create the most economic value over multiple lifetimes. This approach to production and consumption states that energy recovery should be the last option, and only after all higher-value products and services have been exhausted, including:

Wood-based product:

- Extending service life
- Re-use
- Recycle
- Bioenergy
- Disposal

Agricultural products:

- Human and/or livestock feeding or utilization as raw material
- Soil amendment
- Bioenergy
- Disposal

D. Energy efficiency and clean energy solutions

Use of best practices and technologies of the highest standards in terms of energy savings and energy efficiency for biomass conversion equipment as well as the manufacturing of machines in order to limit the amount of energy and biomass input for one unit of the final product shall be considered at the earliest stage of the project. Appropriate energy audits to identify the potential for energy savings and energy requirements can be conducted ahead of the technical feasibility.

Such energy audit should also consider other clean technologies options such as solar energy (photovoltaic, thermal solar), heat pumps, direct electrification and compare their potential with biomass use.

Proper Energy Management Systems could also be implemented to monitor the energy use and lead to energy savings (following recognized protocols and standards such as ISO 50001).

E. Waste management

Waste management should also be well-considered at all steps of the supply chain in order to recover most of the organic fractions that can be considered as secondary products, therefore increasing the efficiency of the whole system. For the remaining waste products (including combustion ash or smoke treatment residue), proper management should be ensured whether the waste are considered as non-hazardous or hazardous to limit environmental and social impacts as well as material and/or energy recovery before proceeding to landfill disposal.

2.2. Biomass sustainability drivers

In order to screen the sustainability (i.e., potential environmental and social risks) of the various biomass options, five main **sustainability drivers** have been identified covering environmental and social criteria, namely (i) climate change, (ii) conservation and natural resources, (iii) air quality, (iv) human rights and labor practices and (v) social development and local food security.

For each sustainability driver, **evaluation indicators** have been selected aiming at reflecting the main sustainability risks related to the production and use of biomass resources for energy. These evaluation indicators and sustainability drivers have been identified based on several references, including the United Nations' Sustainable Development Goals (SDGs) and the RSB's Standards and Principles and will be assessed through the **Biomass Sustainability Risk Assessment Tool**. The list of the five sustainability drivers can be seen on the right**.**

The evaluation indicators include (more details provided in Annex 2):

- Emissions of greenhouse gases (GHGs) during the production of the biomass products
- Loss of natural habitats causing loss of biodiversity (such as deforestation)
- Air contaminants emissions from biomass combustion
- Occupational health and safety
- Impact on food availability and price

Economic criteria (such as cost of biomass), or technical characteristics (such as calorific value) have not been considered as sustainability drivers.

Environment

CLIMATE CHANGE

CONSERVATION AND NATURAL RESOURCES

AIR QUALITY

Social

HUMAN RIGHTS AND LABOR PRACTICES

SOCIAL DEVELOPMENT AND
LOCAL FOOD SECURITY

Figure 7 – Presentation of the 5 drivers for biomass sustainability based on environmental and social criteria

2.3. Biomass categories' acceptability

- Based on the potential sustainability risks pre-identified for the different biomass categories through key principles and the sustainability drivers, a preliminary hierarchy of biomass acceptability is developed to help decision-makers select biomass types for conducting an E&S assessment from a potential wide panel of available options in a given geography and market.
- The most appropriate and acceptable type of biomass for use in a region will be highly dependent on local and regional circumstances. A deeper analysis and implementation of risk mitigation solutions, together with proper planning may reduce the risk and increase the sustainability (and acceptance level) of a biomass source. On this basis, the Biomass Sustainability Risk Assessment Tool (RAT) will help refine the sustainability assessment to consider local factors and biomass supply-chain characteristics.
- Factors influencing the biomass selection include aspects from market availability, local production, technology readiness and E&S risks. The operator should conduct a comprehensive feasibility assessment for the biomass selection, taking into account technical and economic parameters and as well as sustainability considerations.

<u>Acceptable categories:</u>
- Solid agricultural waste (Category 3), e.g., rice husk, rice straw, coconut shell, cashew nutshell, wheat straw, corn stover, and palm kernel shell (certified by the Roundtable on Sustainable Palm Oil (RSPO)).

<u>Acceptable categories with mitigation plans:</u>
- Wood waste from plantations and wood industry (Category 3), e.g., saw dusk from furniture mill, wood waste from cashew, rubber, and mango plantations.
- Animal manure as residues from livestock processes (Category 4), e.g., as used for biogas production
- Organic waste from Industries and MSW (Category 5).

<u>Unacceptable categories:</u>
- Solid wood and other products extracted from forests (Category 1), e.g., including wood from the forests and plantation for fuel (grow to burn), e.g., bamboo (except those with 100% traceability Forest Stewardship Council (FSC) - certified wood).
- Primary products from crops used for food and/or energy (Category 2), e.g., direct combustion or biodiesel/bioethanol directly produced from 1st generation biomass such as corn, sugarcane, wheat, cassava, oil crops, switchgrass, jatropha, etc.

Note: this biomass acceptability categorization is provided as a basis for initial screening. Local considerations, as well as individual initiatives from apparel brands, shall be further checked to assess whether stricter rules apply regarding the acceptability of specific biomass type.

3. Biomass Sustainability Risk Assessment

Objectives:

This section explains the sustainable biomass evaluation approach using complementary Biomass Sustainability Risk Assessment Tool

3.1. Introduction of the Biomass Sustainability Risk Assessment

What is the objective of the risk assessment?

- To gain understanding of environmental and social (economics and human rights) risks aspects that occur per type of specific sourced biomass and in the biomass processing supply chain.
- To support key decision-makers in selecting biomass for energy purpose and screening biomass suppliers.

When and who should conduct the risk assessment?

- Fashion brand/Factory decision-makers, technical officers and procurement officers transitioning from fossil fuels and considering biomass as alternative for energy supply in their activities.
- Fashion brand/Factory decision-makers, technical officers and procurement officers willing to screen the E&S risks of potential biomass supply in the stage of supplier selection or that is already used for energy supply of their activities.

Which issues should be covered in the risk assessment?

- The evaluation indicators consolidated into sustainability drivers as described in Annex 2 are used for the evaluation of the sustainability of biomass production and utilization as well as suppliers' practices. In case of complex supply-chain with the intervention of various intermediaries, assessment should be conducted at minimum on the supplier contracted by the factory which should be "take the ownership" of traceability and information provision to the assessor.

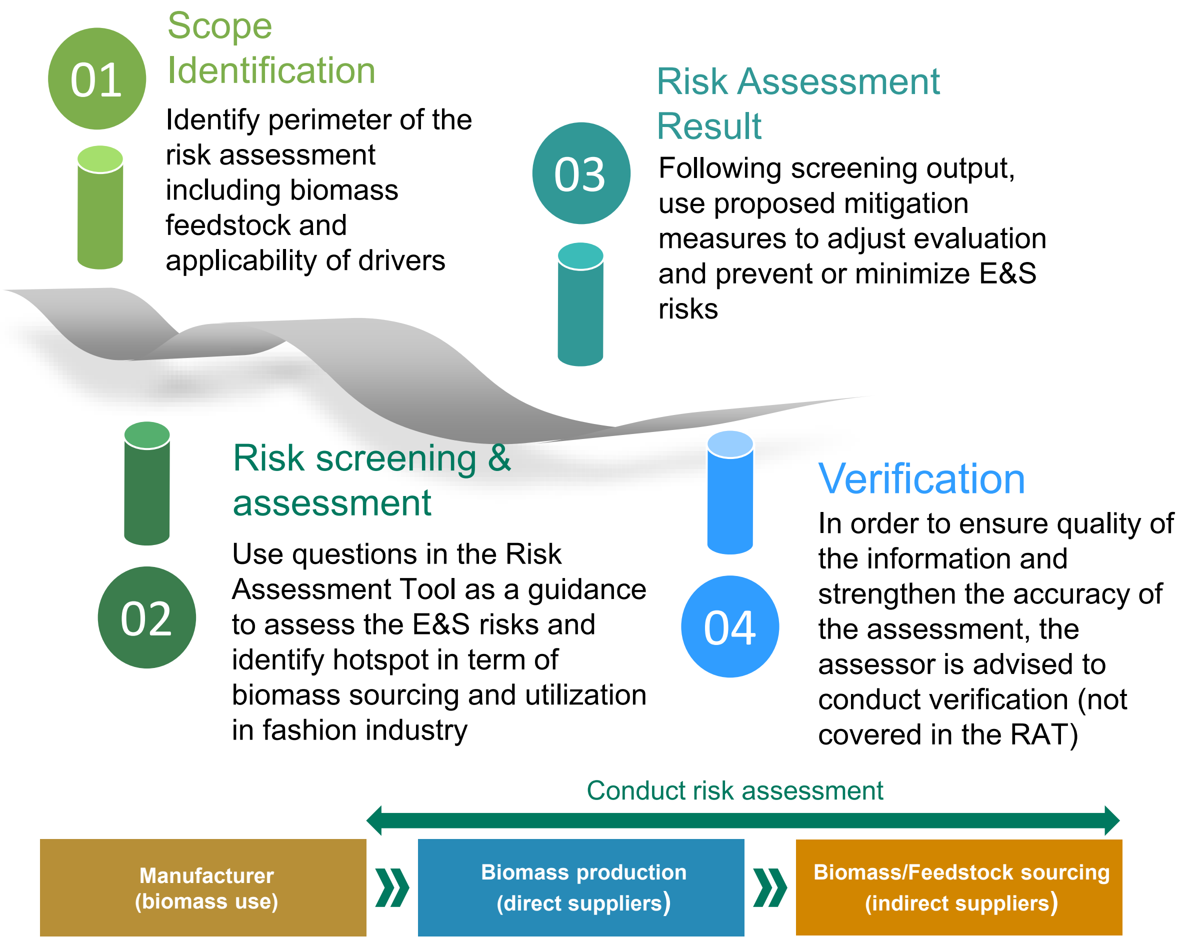


Figure 8 – Scope of risk assessment

3.2. Guidelines for Adopting Sustainable Biomass

At the stage of exploring, analyzing and implementing projects and operations related to biomass, as for any new project, sustainable operations shall be planned, implemented, and continuously improved through an open, transparent, and consultative impact assessment and management process and an economic viability analysis.

The following approach should be considered to ensure appropriate, efficient implementation of the project when shifting from fossil fuels to biomass.

1. Scoping and review of biomass acceptability

- Identify the available biomass types/category in the local geography
- Filter the biomass categories based on their acceptability referring to the "Biomass categories' acceptability" section 2.3.
- Check the good application of overarching considerations including legality and compliance, responsible production and consumption, cascading use, energy efficiency and clean energy solutions, and appropriate waste management

2. Biomass Sustainability Risk Assessment

- If the biomass origin is unknown and no biomass supplier is identified at this stage, use the **Biomass Sustainability Risk Assessment – Level 1 (Biomass Pre-screening**)

  OR
- In the case a biomass type (on which to conduct the assessment) is identified as well as the probable geographies of its production are known, conduct a **Biomass Sustainability Risk Assessment – Level 2 (Basic Assessment)** on the biomass option that should be aligned with "Biomass categories' acceptability" section 2.3.

  OR
- In the case the assessor has selected a biomass option or is already using biomass in its production and has access to information related to biomass supply-chain and more particularly about the practices of the current or identified biomass supplier, conduct **Biomass Sustainability Risk Assessment – Level 3 (Detailed Assessment)** on the biomass option that should be aligned with "Biomass categories' acceptability" section 2.3.

3. Technical assessment and management decision

- Based on the assessment conducted in the previous step, a biomass type which has a lower overall sustainability risk should be selected. If the selected biomass type for a given indicator presents a "high" risk, mitigation actions shall be identified and selected before pursuing with this biomass type, while it is recommended to bring mitigation measures for indicators presenting a "medium" risk level. If mitigation actions are not possible or are not sufficient to reduce risk level to "low" or "medium", do not source the relevant biomass type.
- From the Biomass Sustainability Risk Assessment, if the selected biomass type presents indicators evaluated "low" or at most "medium" risks for all drivers (after mitigation measures identification), it can be further pursued with the biomass types and/or the selected biomass supplier.

4. Implement biomass options

- Source biomass from the selected vendor/supplier.
- If actual conditions/parameters differ than those expected, implement corrective measures.

3.3. Indicative roadmap and actions for biomass assessment and adoption

The figure below shows an indicative recommendation of when to apply the Sustainable Biomass Guidelines and the Biomass Sustainability Risk Assessment Tool during the project development cycle, in the case of the operator considering to use biomass instead of fossil fuels (Case 1) or in the case whereby it is already using biomass and wants to assess its sustainability (Case 2).

Case 1: Operations running on fossil fuels

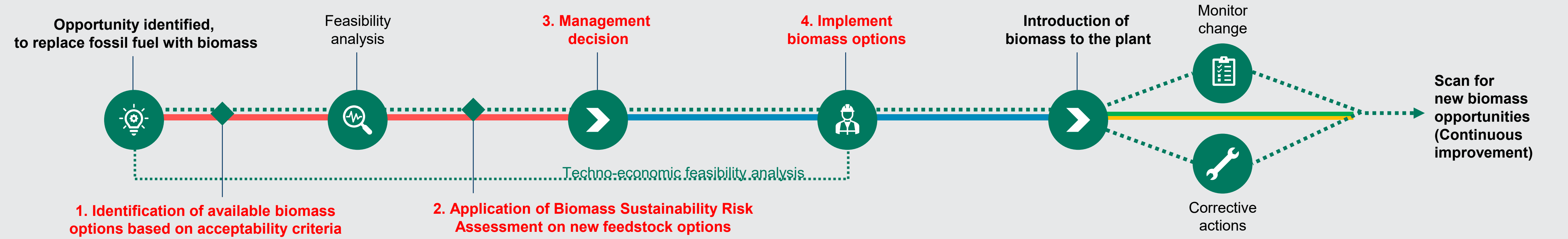


Figure 9 – Indicative roadmap and actions for biomass assessment adoption in case of operations running on fossil fuels

Case 2: Operations already running on biomass fuels (including partially)

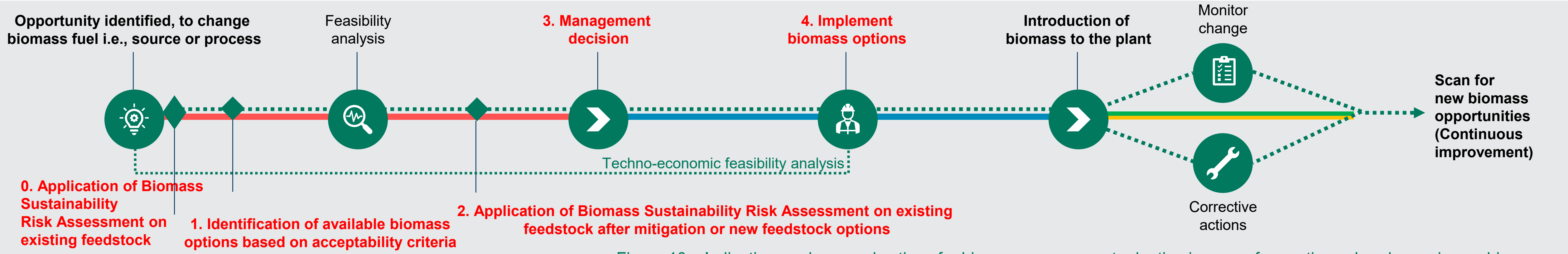


Figure 10 – Indicative roadmap and actions for biomass assessment adoption in case of operations already running on biomass

3.4. Introduction of the Biomass Sustainability Risk Assessment Tool

Acknowledging that the level of information available for providing comprehensive review of E&S risks may differ depending on the type of biomass or local practices and awareness in terms of traceability and compliance, the Biomass Sustainability Risk Assessment has been developed with 3 levels of assessment aiming to provide preliminary risks screening at depending on the level of knowledge of the biomass characteristics.

The three levels of assessment, namely “Pre-Screening – Level 1”, “Basic Assessment – Level 2” and “Detailed Assessment – Level 3” have been developed and complement each other in terms of due diligence process. They are proposed based on the level of knowledge and information from the assessor aiming to source biomass for energy use. The process of assessment and selection of the most suitable assessment level can be declined through 2 scenarios:

1. <u>In the case of new adoption of biomass or shift:</u>
    a. In the case the assessor wants to perform a pre-selection of several biomass types, the **Biomass Pre-Screening – Level 1** can be used referencing the level of risk per biomass categories.
    b. After selecting biomass types, the assessor, with the information about the expected origin of the pre-selected biomass production and transformation can conduct the **Basic Assessment – Level 2** evaluating risks based on geographical considerations
    c. When one or several biomass types are selected and the assessor has identified potential biomass suppliers, the **Detailed Assessment – Level 3** can be conducted with the objective of assessing and comparing suppliers’ practice on the basis of information either provided directly by the supplier or on performing a high-level due diligence.
2. <u>In the case factory already uses biomass and wants to check its sustainability:</u>
    a. Perform the **Detailed Assessment** using information and documentation provided by supplier or from due diligence conducted on the supplier.
    b. In case the supplier is not able to provide further information about its practices, perform the **Basic Assessment**, using information related to the origin of the biomass production and transformation
    c. In case the assessor does not have information about the country of production and transformation of the biomass, use the **Biomass Pre-Screening Assessment**

The three levels of assessment differ in terms of accuracy of the risk assessment outputs. While no specific skills and/or expertise and limited amount of time is required to perform any of the risk assessment levels, it is highly recommended to prefer conducting the highest level of assessment when applicable, even in case of partial availability of information from biomass origin and/or final biomass suppliers' practices.

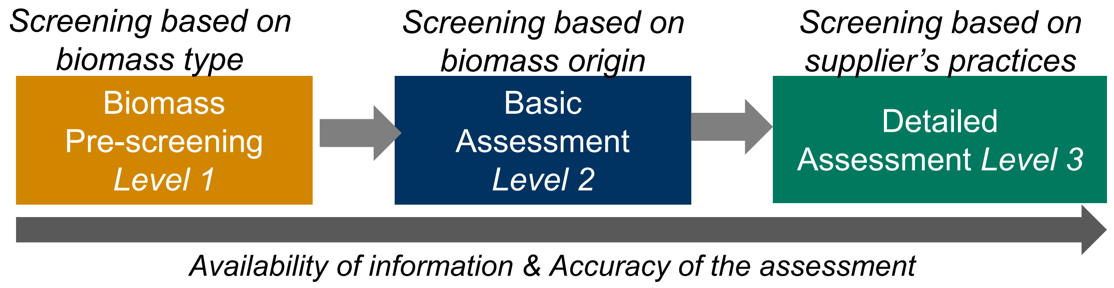


Figure 11 – Assessment flow based on the level of available information

4. How to use Risk Assessment Tool

Objectives:

This section provides the main steps on how to use the Biomass Sustainability Risk Assessment Tool.

4.1. Guidelines to conduct Biomass Sustainability Risk Assessment (1/5)

The Biomass Sustainability Risk Assessment Tool (RAT) is developed in a spreadsheet format and aimed to assist in the biomass sustainability risk assessment process as described in the previous section. The methodology as per below:

Step 0: User information

- This step is used to register the RAT user (assessor) information (company, name of user in charge of assessment, date of assessment, location) for documentation control purposes.

Step 1: Scope identification

- From the drop-down lists provided in the tool, the user will select the main details about the biomass option to be screened including type of biomass fuel, type of treatment processes and biomass feedstocks.
- A biomass fuel may be produced from several biomass feedstocks. In such case, it is advised to assess all the main feedstocks accounting for minimum 90% of the volume of the total biomass fuel supply. Based on the feedstock identified by the RAT user, a biomass category will automatically be recognized in the RAT, guiding the next risk screening step. The assessor is also asked to answer on whether a supplier has already been identified which will guide the level of assessment that is needed.
- Further, scoping, but non-binding questions related to the Key Principles (such as legality and compliance) as defined in the section 2.1. will require considerations and comments from the assessor.

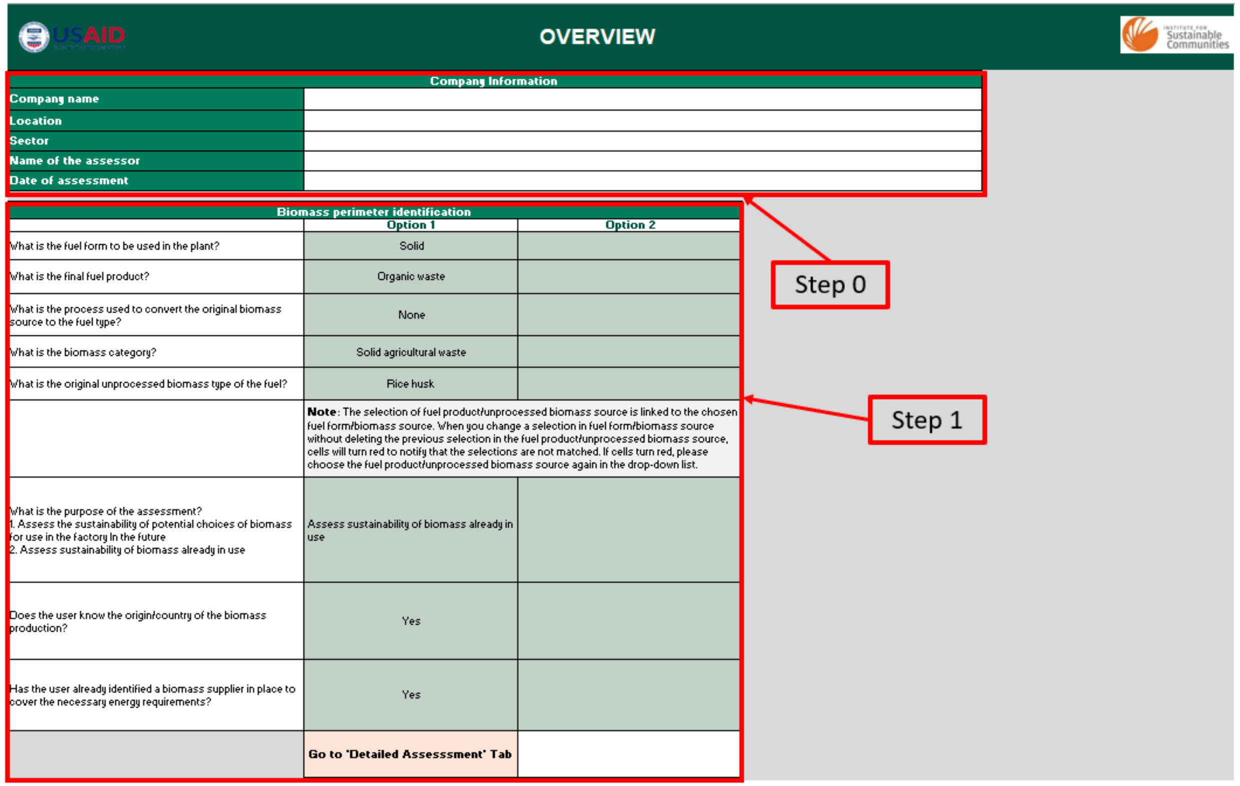


Figure 12: Presentation of the Steps 0 and 1 of the Biomass Sustainability Risk Assessment Tool

4.1. Guidelines to conduct Biomass Sustainability Risk Assessment (2/5)

Step 2: Risk Screening

Based on the previous answers, the assessor is guided to different levels of assessment in Tab "**2 – Basic Assessment**" and "**3 – Detailed Assessment**" :

Biomass Pre-screening – Level 1 (if biomass origin is not defined and no supplier is identified):

- Based on the biomass type selected, the RAT provides a pre-defined maximum risk level for each evaluation indicator. The risk level corresponds to the maximum level that can be observed for the related biomass category as presented in Annex 2. It is advised to further refine the assessment by conducting a Basic and/or Detailed Assessment.

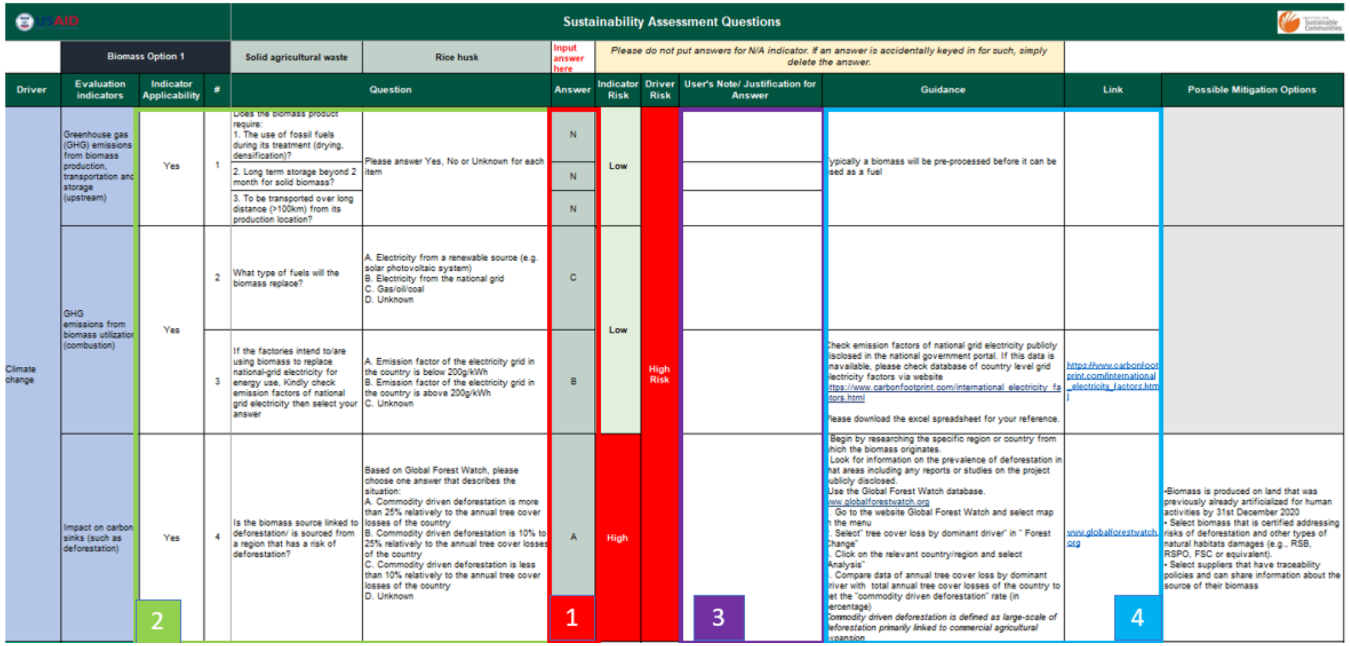


Figure 13: Presentation of the Step 2 of the Biomass Sustainability Risk Assessment Tool

Basic Assessment – Level 2 (if no specific supplier is identified yet or if there are only limited information and data available):

- The assessor answers (see item 1 of Figure 13) a limited set of questions (see item 2 of Figure 13) to assess the biomass against a maximum of 18 evaluation indicators under the five sustainability drivers. The answer options are predefined based on the information available about the biomass characteristics, local and/or national context and factory facilities. Questions should be answered based on the level of information available prioritizing direct suppliers' details. In addition, guidance (see item 3 of Figure 13) for answer options is provided to users with the attached references to support determining the risk level. In case no supplier is identified, questions can still be answered using publicly available information on the local context and national and/or regional trends to estimate the level of risk. While answers are already pre-registered in RAT, it is highly recommended that users provide justifications and/or additional comments in the designated space in the tool (see item 4 of Figure 13).

Detailed Assessment – Level 3 (if one or several suppliers have already been identified and/or a more detailed assessment is required):

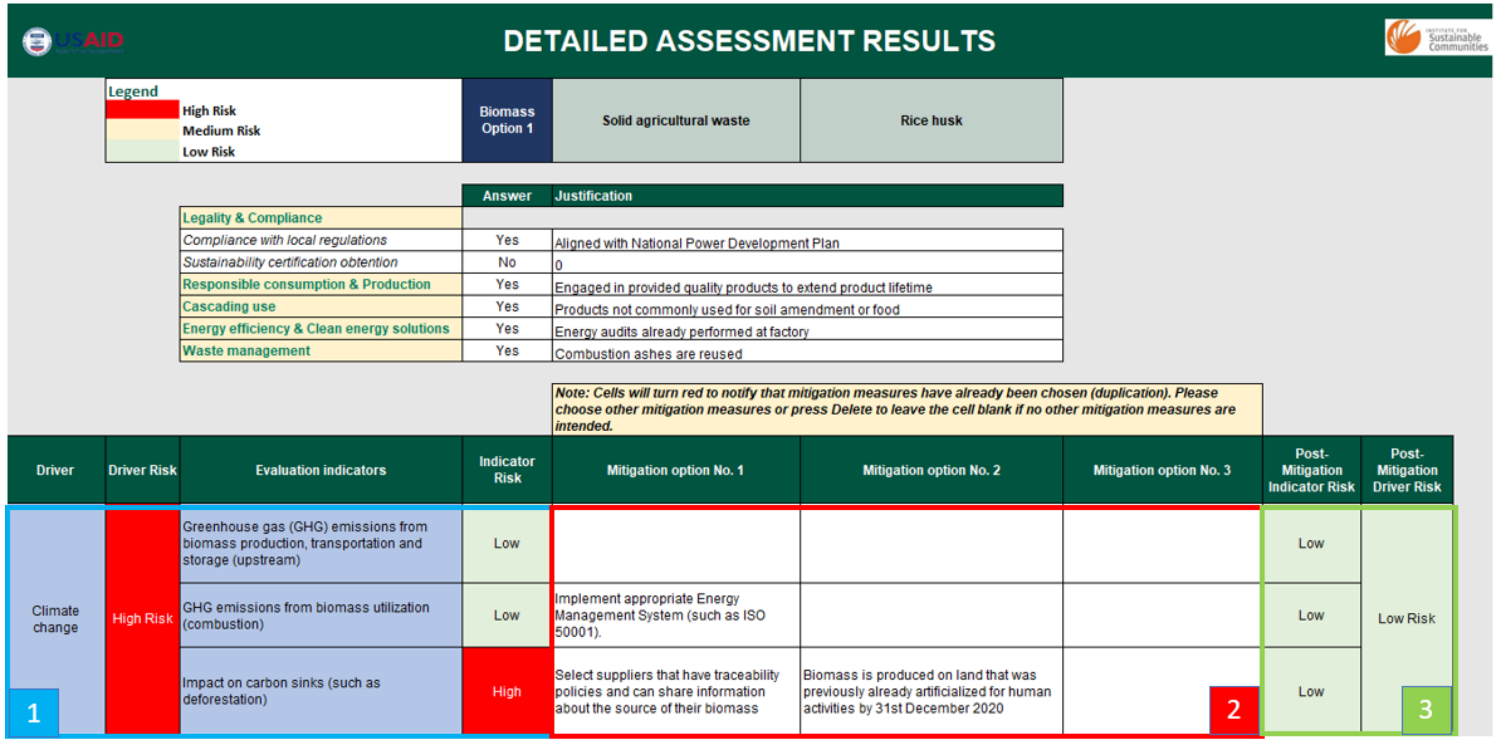
- Similar to Level 2, the assessor will need to answer a more comprehensive list of questions to assess potential risks against each evaluation indicator with, in addition, questions related to the supplier's practices (such information may be requested directly to the supplier).

4.1. Guidelines to conduct Biomass Sustainability Risk Assessment (3/5)

Step 3: Risk Analysis and Result

The sustainability risk heat map is generated based on the answer provided in step 2, displaying indicators and the level of risk (high, medium and low – see definition below) determined from the assessment (see item 1 of Figure 10) and can be seen in the Tab "**1 – Pre-screening Assessment**" or "**2 – Basic Assessment Results**" or "**3 – Detailed Assessment Results**".

Based on the level of risk (highly recommended for indicators with high risk and recommended for indicators with medium risk), opportunity is given to select risk mitigation measures from a predefined list provided in the tool (see item 2 of the picture below). While selecting applicable mitigation measures (list provided in Annex 2) with the objective of lowering the risk, the heat map is automatically updated (see item 3 of Figure 13) allowing comparison between various biomass feedstock options (with or without selecting mitigation measures).



	Answer	Justification
Legality & Compliance		
Compliance with local regulations	Yes	Aligned with National Power Development Plan
Sustainability certification obtention	No	0
Responsible consumption & Production	Yes	Engaged in provided quality products to extend product lifetime
Cascading use	Yes	Products not commonly used for soil amendment or food
Energy efficiency & Clean energy solutions	Yes	Energy audits already performed at factory
Waste management	Yes	Combustion ashes are reused

Note: Cells will turn red to notify that mitigation measures have already been chosen (duplication). Please choose other mitigation measures or press Delete to leave the cell blank if no other mitigation measures are intended.

Driver	Driver Risk	Evaluation indicators	Indicator Risk	Mitigation option No. 1	Mitigation option No. 2	Mitigation option No. 3	Post-Mitigation Indicator Risk	Post-Mitigation Driver Risk
Climate change	High Risk	Greenhouse gas (GHG) emissions from biomass production, transportation and storage (upstream)	Low				Low	Low Risk
		GHG emissions from biomass utilization (combustion)	Low	Implement appropriate Energy Management System (such as ISO 50001).			Low	
		Impact on carbon sinks (such as deforestation)	High	Select suppliers that have traceability policies and can share information about the source of their biomass	Biomass is produced on land that was previously already artificialized for human activities by 31st December 2020		Low	

Figure 14: Presentation of the Step 3 of the Biomass Sustainability Risk Assessment Tool

Low: Given biomass option utilization is considered acceptable regarding a given evaluation indicator or sustainability driver.

Medium: Given biomass option utilization is considered acceptable regarding a given evaluation indicator or sustainability driver in case of identification and application of mitigation measures.

High: Given biomass option utilization is considered unacceptable regarding a given evaluation indicator or sustainability driver. In other case, a more detailed examination biomass supplier should be conducted and provided. Mitigation measures should be implemented before considering use of the biomass.

4.1. Guidelines to conduct Biomass Sustainability Risk Assessment (4/5)

Step 3: Risk Analysis and Result (continued)

As per the Basic & Detailed Assessment Results sheets, the tool determines the level of acceptability of the biomass option based on the answers provided in the previous steps and the risk level estimation. The following evaluation will appear based on the risk level assessment:

Before mitigation:

- "Unacceptable without mitigation measures" – in the case where at least sustainability driver is assessed as "high" risk (see top right image – item No. 1)
- "May be acceptable but should implement Mitigation measures" in the case where at least one evaluation indicator is assessed as "high" risk, but the risk level of the related sustainability drivers is "medium" or "low". (see bottom right image – item No. 3)
- "Acceptable with mitigation measures" in the case where at least one evaluation indicator is assessed as "medium" risk, but none as "high" risk.
- "Acceptable" in the case where all evaluation indicators are evaluated as "low" risk.

After mitigation:

- "Unacceptable" in the case where (i) at least one sustainability driver is assessed as "high" risk or (ii) the biomass category is *Solid wood and other products extracted from forest* and the Mitigation measures related to FSC certification or equivalent (see in Annex 2 for examples of certification) is not selected or (iii) the biomass category is *Primary products from crops used for food and/or energy* and the evaluation indicator for Food availability and price is shown as "high" risk after mitigation. (see top right image – item No. 2).
- "May be acceptable upon implementation of the selected mitigation measures and additional ones to cover remaining "high" & "medium" risk indicators" when at least one evaluation indicator is still evaluated as "high" or "medium" risk after mitigation.
- "Acceptable upon implementation of the selected mitigation measures" when all evaluation indicators previously evaluated as "high" or "medium" risk levels have been lowered to "low" risk. (see bottom right image – item No. 4).
- "Acceptable" with or without mitigation if the previous result was already "Acceptable" before mitigation selection.

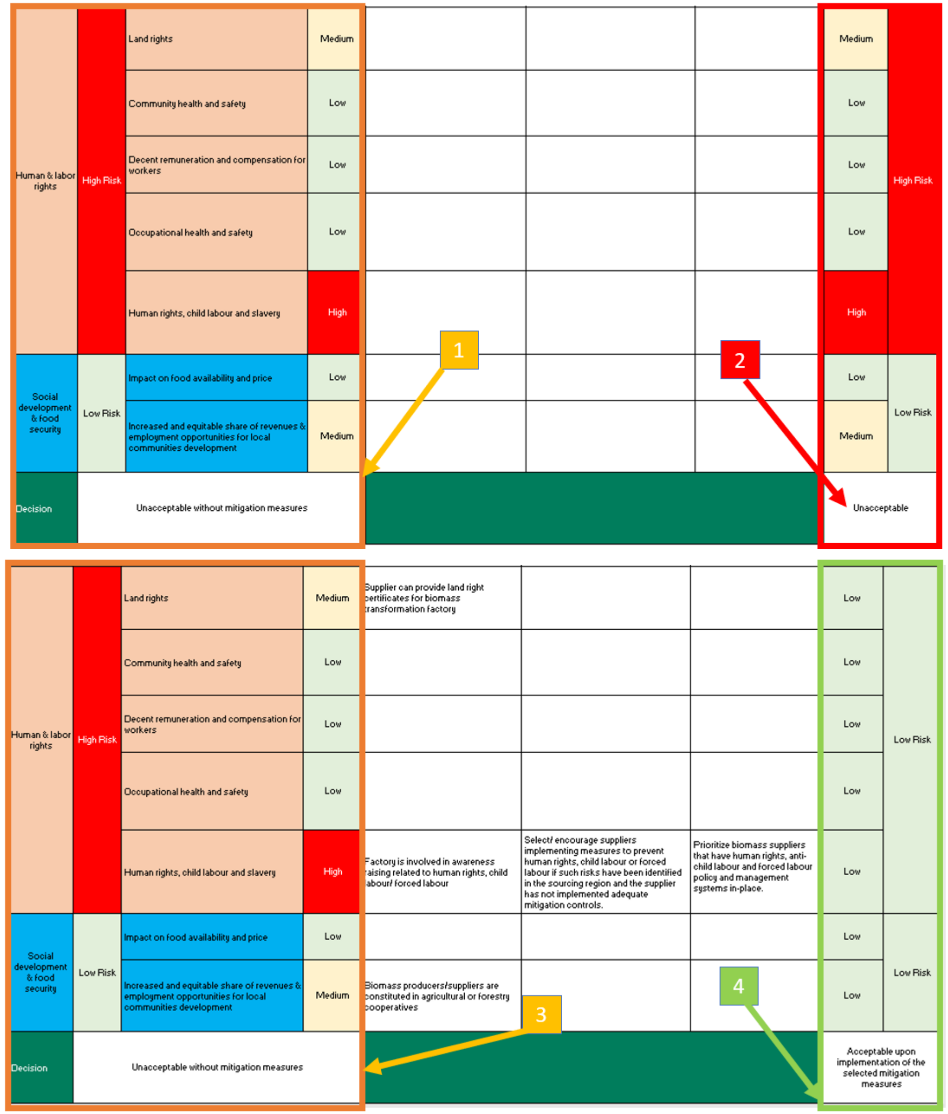


Figure 15: Acceptability assessment from the Biomass Sustainability Risk Assessment Tool

4.1. Guidelines to conduct Biomass Sustainability Risk Assessment (5/5)

Step 4: Verification

In order to ensure quality of the information and strengthen the accuracy of the assessment, verification of the results from the Biomass Sustainability Risk Assessment should be applied using one of the approaces below:

- For Biomass Pre-Screening – Level 1 and Basic Assessment - Level 2 (if no specific supplier is identified yet or if there are only limited information and data available) - minimum requirement: factory self-verification following internal quality check protocols, biomass purchase receipt (for those procured already), and/or verified by HIGG Facility Environmental Module (FEM) as part of the energy consumption.
- For Detailed Assessment – Level 2 (if one or several suppliers have already been identified and/or a more detailed assessment is required) – advanced approach: factory self-verification following internal quality check protocols, biomass purchase receipt (for those procured already), and verified by HIGG FEM as part of the energy consumption, local staff via desktop and site-visit, and/or 2nd or 3rd party verifiers.

To allow the verification step to be adequately implemented, the factory should keep a copy of and archive the results of the Biomass Sustainability Risk Assessment realized on each biomass options according to the relevant internal document archiving policies ensuring accessibility for consultation, action and periodic review from the relevant internal staff (management, operations & sustainability teams) as well as from the factory brands willing to review the assessment prepared by their suppliers.

5. References and bibliography

References

[1] Biomass Conversion Pathways

[2] Lignocellulosic Biomass to Ethanol Process Design

[3] Fashion Industry, UN Pursue Climate Action for Sustainable Development

[4] Pulse of the Fashion Industry 2017

[5] Global Carbon Emissions of Apparel Industry

[6] Four Tier Supply Chain Model

[7] Emissions contribution of fashion supply chain

[8] Feedstock-wise biomass production potential in Southeast Asia

[9] Global direct primary energy consumption (ourworldindata.org)

[10] Sustainable Development Goals (SDGs) – Responsible Consumption and production (un.org)

[11] Caloric value of wood species

[12] Biomass characteristics and energy contents of dedicated lignocellulosic crops

[13] Calorific-value-biomass.pdf (cfnielsen.com)

[14] Combustion characteristics of animal manures

[15] Average biogas production yield by tons of feedstock type

[16] Caloric value of raw organic waste

[17] Heat values of various fuels

[18] 2006 IPCC Guidelines for stationary combustion – air emissions

[19] Comparison of life cycle CO2 emissions

Other references used for the preparation of the Sustainable Biomass Guidelines

[1] Energy Profile for Cambodia, IRENA, 2022

[2] Energy Profile for Thailand, IRENA, 2022

[3] Energy Profile for Vietnam, IRENA, 2022

[4] "Scaling up biomass for the energy transition , untapped opportunities in southeast asia", IRENA, 2022

[5] "Guidelines for greening the textile sector in Vietnam", WWF, 2020

[6] "A decision support tool for sustainable bioenergy", FAO & UNEP

[7] CDP Technical Note: Biofuels", CDP, 2022

[8] Bioresources within a Net-Zero emissions economy, Energy transitions Commission, 2021

[9] RSB Principles & Criteria, Rountable on Sustainable Biomaterials, 2016

[10] Biofuels, Sustainability Accounting Standard, 2018

[11] Fashion industry Charter for Climate Action, UNFCCC, 2021

[12] H&M Group Responsible Raw Material Sourcing Policy – 2022

[13] H&M Group Sustainable energy sources guidance version 1.0 2021-08-26

[14] Wood Sourcing Requirements - DRAFT (1), H&M, 2022

[15] VF Corporation Forest Derived Materials Policy, VF, Not dated

[16] BECIS' 1st Biomass Plant Project developed for Heineken in Cambodia | BECIS (be-cis.com)

[17] Thailand taps rice, sugar biomass to wean itself from fossil fuels - Nikkei Asia

[18] Cambodia's Bioenergy Situation, by Khorn Saret

[19] Community Capacity-Building Mobilization towards Energy Transitions in the Era of Thailand 4.0: A Case Study on Biomass Power Plants, by Yuttana Homket, Pongthep Sutheravut and Sawpheeyah Nima, 2021

[20] EU biomass-incentives madness reaches Vietnam, 18 November 2022

[21] Major clothing brands contribute to deforestation in Cambodia, report finds (mongabay.com)), 3 December 2021

[22] Biomass Opportunities in Vietnam, NL Agency, Ministry of Foreign Affairs, 2012

[23] FSC blocks An Viet Phat Energy for making false claims on large volumes of wood pellets, 18 October 2022

[24] RE100 (there100.org)

[25] BECIS' 1st Biomass Plant Project Developed for Heineken in Cambodia, 9th May 2022,

[26] https://www.eria.org/uploads/media/Research-Project-Report/RPR-2022-08/Cambodia-Energy-Statistics-2019-2020.pdf; Cambodia Energy Statistics 2000–2019 (eria.org)

[27] Biofuels Annual, Thailand, United States Department of Agriculture, Foreign Agricultural Service, 14 June 2022

[28] Climate Protection through Sustainable Bioenergy Markets in Viet Nam (BEM), GIZ Vietnam, 2021

[29] Governing the risks and opportunities of bioenergy, IRGC, IUCN, August 2007

Annex 1

Biomass description and categorization

Objectives:

This section describes the different biomass options and aims to categorize these options based on their common characteristics and sources.

Category 1: Solid wood and other products extracted from forests

Definition

Wood products includes wood directly extracted from natural forests or harvested from cultivated forests.

Solid wood or Forest residues refers to a residue from forest harvesting such as any component of trees after timber logging or clearing land for construction.

Main source

- Direct cutting trees from natural forests
- Wood from harvested forests (Sylviculture plantations)
- Dead wood collected in forests

Main Technical characteristics

Calorific value of wood species ranges between 18.5 to 21.0MJ/kg [11]

Moisture content between 9 to 13 % (on a basis after being oven dried at 105°C)

Main biomass treatment processes

Key processes

- Direct combustion
- Pyrolysis → Charcoal
- Gasification → Syngas

Final usage

- Wood or charcoal in boilers
- Syngas in gas turbines or gas boilers directly or mixed with natural gas

Main sustainability risk

Supply-chain level

- Impact on carbon sinks (e.g., deforestation)
- Loss of natural habitats causing loss of biodiversity (e.g., deforestation) from Land-Use Change (LUC) and Indirect Land-Use Change (ILUC)
- Non-respect of land rights affecting local communities due to extraction of natural resources and land-use change
- Poor compensation schemes and non-respect of legal labor rights for workers

Factory level

- Air quality control from combustion in biomass boiler/turbines
- Public & Occupational Health & Safety at site

Category 2: Primary products from crops used for food and/or energy

Definition

This category refers to crops that are grown for particular purpose such as for food and/or biomass feedstocks in biorefineries for energy. For this category, the main output of the crops is directly used as biomass products. Nevertheless, some of the crops can also be considered for human alimentation or animal feeding.

Main source

- Edible crops: corn, cassava, wheat, sugar crops, sorghum, starch crops, and oil crops (including palm oil)
- Non-edible crops: Switchgrass, Jatropha, miscanthus, and dedicated biomass sorghum

Main Technical characteristics

Calorific value of dedicated crop species ranges between 17.0 to 19.5 MJ/kg [12]

Moisture content of the harvested product normally ranges from 40% to 50%[12]

Main biomass treatment processes

Key processes

- Inter-esterification → Biodiesel
- Fermentation/Distillation → Bioethanol
- Anaerobic digestion (limited, in complement of other biomass sources) → Biogas
- Pyrolysis, Gasification (limited) → Charcoal, Syngas
- Direct combustion (limited)

Final usage

- Biodiesel and bioethanol in engines or oil boilers (in replacement of oil, gasoline, gasoil)

Main sustainability risk

Supply-chain level

- Impact on carbon sinks (e.g., deforestation)
- Loss of natural habitats causing loss of biodiversity (e.g., deforestation) from Land-Use Change (LUC) and Indirect Land-Use Change (ILUC)
- Increased water consumption and competing use
- Loss of biodiversity, soil and water contamination and increased emissions of GHG due to use of chemicals (fertilizers, herbicides/pesticides)
- Non-respect of land rights affecting local communities due to expansion of agricultural lands
- Impact on air quality due to agricultural waste field burning
- Competing use of biomass between energy and food impacting food availability and safety
- Poor compensation schemes and non-respect of legal labor rights for workers

Factory level

- Occupational Health & Safety at site

Category 3: Solid agricultural waste

Definition

Solid agricultural waste and residues are byproducts from crops destinated to human alimentation, animal feeding or biomass (see Category 2) and that do not directly compete with food production.

Main source

- Palm kernel, coconut shell rice straw, wheat straw, rice husk and corn stover
- Wood waste resulting from tree plantations (such as fruits, palm oil, rubber, cashew nuts, etc.)

Main Technical characteristics

Calorific values of crop residues ranges between 13.5 to 18.5 MJ/kg (considering LCV and HCV).

Crop Residues	MJ/Kg	
	Lower Calorific Value	Higher Calorific Value
Rice straw	13.50	14.80
Wheat straw	15.00	18.90
Rice husk	14.20	15.40
Corn stalks/ stover	16.80	18.50

Converted and retrieved from [Calorific-value-biomass.pdf (cfnielsen.com)](Calorific-value-biomass.pdf) [13]

Main biomass treatment processes

Key processes

- Direct combustion
- Pyrolysis, Gasification → Charcoal, Syngas
- Anaerobic digestion (limited and in complement of other biomass sources) → Biogas

Final usage

- Solid biomass (in replacement of oil, gasoline, gasoil)
- Charcoal
- Added to animal manure for biogas production

Main sustainability risk

Supply-chain level

- Impact on carbon sinks (e.g., deforestation) (indirect*)
- Loss of natural habitats for biodiversity (indirect*)
- Affected land rights to local communities (indirect*)
- Soil and water contamination and increased emissions of GHG due to use of chemicals (indirect[1])
- Competing use of biomass between energy and food and other practices
- Poor compensation schemes and non-respect of legal labor rights for workers

Factory level

- Air contaminants emissions during combustion
- Occupational Health & Safety at site

** – Solid agricultural waste may not directly lead to environmental and social risks as they would be accounted primary products from food and energy crops, however, increased utilization and value generated from agricultural waste in addition to the primary products may lead to consider them as by-products and therefore be accountable for E&S risks and impacts.*

Category 4: Animal manure as residues from livestock processes

Definition

This category refers to livestock manure derived from animal feces and urine, that can be used in the production of biogas.

The biogas is produced from anaerobic digestion (methanization) and shall not be confused with biomethane that is obtained from purification of biogas or from thermal gasification and methanation from biomass (syngas).

Main source

- Main livestock manures (cows, goats, sheep, poultry and pigs) that are used in the methanization process to produce biogas
- Producing biogas generally requires mixing manures with lignocellulose biomass (ensuring proper carbon/nitrogen content). Sludge can also be used for producing biogas.

Main Technical characteristics

Animal manure	CV (MJ/kg) [14]	Biogas potential (toe/ton) [15]
Cattle, Bull	14.9-16.3	0.008
Goat & Sheep	12.4-13.2	
Hen & Duck	22.7-23.3	0.039
Pig		
Agricultural crops		0.16-0.25
Biogas (before purification) about 60-65% CH4	~30	
Biogas (after purification) – 90% CH4	~45	

Main biomass treatment processes

Key processes

- Methanization (complementing solid agricultural residues)

Final usage

- Biogas (in gas turbines or gas boilers) complement or replacement of natural gas

Main sustainability risk

Supply-chain level

- Impact on carbon sinks (e.g., deforestation) (indirect*)
- Loss of natural habitats of biodiversity (indirect*)
- Affected land rights to local communities (indirect*)
- Leakage of methane and condensate in biogas production and distribution infrastructures
- Competing use of biomass between energy, food and other practices (such as soil amendment for agriculture)
- Poor compensation schemes and non-respect of legal labor rights for workers

Factory level

- Occupational Health & Safety at site

** – Solid agricultural waste may not directly lead to environmental and social risks as they would be accounted primary products from food and energy crops, however, increased utilization and value generated from agricultural waste in addition to the primary products may lead to consider them as by-products and therefore be accountable for E&S risks and impacts.*

Category 5: Organic waste from industries and municipal solid waste (MSW)

Definition

Biodegradable garbage, usually referred to as organic waste, is mainly the organic fraction (in opposition to mineral). It can originate from municipal waste or industrial waste.

Main source

- Food waste from restaurants, markets, organic fraction of MSW
- Non-contaminated sludges (organic fraction)
- Organic Waste from food industry including slaughterhouse waste.
- Residues from industry using wood as main feedstock (furniture, construction etc.) including wood chips, bark, sawdust, etc.

Main Technical characteristics

Calorific value of organic waste ranges are very wide-ranging depend on the waste types and the moisture component requiring drying before processing. After drying, calorific value is comprised between 16 and 20 MJ/kg [16].

Calorific value of fully dried sludge ranges between 10.9 to 13.0 MJ/kg

No	Non Recycled MSW Components	Moisture (%)		Calorific Value (MJ/kg)		
		inherent moisture	total moisture	dry-based	air-dried	as received
1	Leaf litter	12.32	40.67	19.62	17.20	11.64
2	Food waste	8.51	65.00	18.00	16.47	6.30
3	Vegetable waste	11.46	88.25	18.25	16.16	2.14
4	Fruit waste	9.92	83.53	18.38	16.56	3.03
5	Mixed organic MSW	10.79	61.32	18.77	16.74	7.26

Main biomass treatment processes

Key processes

- Anaerobic digestion in landfills or methanization units
- Direct Combustion in Waste-to-Energy units or coprocessing
- Thermal processes such as pyrolysis or gasification
- Pelleting

Final usage

- Biogas or syngas (in gas turbines or gas boilers) as a complement or replacement of natural gas
- Solid biomass, pellets or charcoal to be used in boilers

Main sustainability risk

Supply-chain level

- Improper waste management leading to soil and water contamination or air pollutants emissions.
- Biomass biodegradation due to improper storage/disposal increasing GHG emissions
- Poor compensation schemes and non-respect of legal labor rights for workers

Factory level

- Air contaminants emissions during combustion
- Occupational Health & Safety at site

Summary of biomass categories technical characteristics

	Category 1 – Solid wood and other products extracted from forests	Category 2 – Primary products from crops used for food and/or energy	Category 3 – Solid agricultural waste	Category 4 – Animal manure as residues from livestock processes	Category 5 – Organic waste from industries and municipal solid waste (MSW)	Coal	Diesel	Natural gas
Calorific value [17]	16 (firewood) to 21.0MJ/kg	17.0 to 19.5 MJ/kg	13.5 to 18.5 MJ/kg	Direct Waste: 14.9 to 23.3 MJ/kg Biogas (before/after purification): 30/45 MJ/kg	Solid biomass waste: 16 and 20 MJ/kg Dried sludge: 10.9 to 13.0 MJ/kg	Lignite/brown coal (IEA definition): <17.4 MJ/kg Sub-bituminous coal: 17.4-23.9 MJ/kg Hard black coal: >23.9 MJ/kg	Petrol/gasoline: 44-46 MJ/kg Diesel fuel: 42-46 MJ/kg	Natural Gas: 42-55 MJ/kg Purified Methane (CH_4): 50-55 MJ/kg
Air emissions (GHG) – from stationary combustion (2006 IPCC guidelines) [18] (not considering carbon removed during biomass lifecycle)	Wood: 112 g CO_2/MJ; 0.03 g of CH_4/MJ, 0.004 g of N2O/MJ Charcoal 112 g CO_2/MJ; 0.2 g of CH_4/MJ, 0.004 g of N_2O/MJ	Bioethanol: 71 g CO_2/MJ; 0.003 g of CH_4/MJ, 0.0006g of N2O/MJ Biodiesel: 71 g CO_2/MJ; 0.003 g of CH_4/MJ, 0.0006g of N_2O/MJ	Primary solid biomass 100 g CO_2/MJ; 0.03 g of CH_4/MJ, 0.004 g of N_2O/MJ	Biogas: 55 g CO_2/MJ; 0.001 g of CH_4/MJ, 0.0001g of N_2O/MJ	Municipal waste: 100 g CO_2/MJ; 0.03 g of CH_4/MJ, 0.004 g of N_2O/MJ Sludge and landfill gas: 55 g CO_2/MJ; 0.001 g of CH_4/MJ, 0.0001g of N_2O/MJ	Lignite: 101 g CO_2/MJ; 0.001 g of CH_4/MJ, 0.002 g of N_2O/MJ Anthracite: 98 g CO_2/TJ; 0.001 g of CH_4/MJ, 0.002 g of N_2O/MJ	Gas/Diesel Oil: 74 g CO_2/MJ 0.003 g of CH_4/MJ, 0.0006g of N_2O/MJ	Natural gas: 56 g CO_2/MJ; 0.0003 g of CH_4/MJ, 0.0001 g of N_2O/MJ
	1 ton of biomass emits 444 g of CH_4; 58g of NO_2 (GHG Emission Factor Hub – US EPA) – not accounting in Scope 1 the CO_2 emissions (to be accounted separately)							
Comparison of life cycle CO_2 emissions [19]	10-23 $kgCO_2$/MWh					750-1,200 $kgCO_2$/MWh	338-369 $kgCO_2$/MWh	263-302 $kgCO_2$/MWh
Air emissions [19]	Wood pellets: NOx: 0.15 g/MJ SO_2 – 0.03g/MJ PM2.5 & PM10 – 0.11 g/MJ					NOx: 0.2 g/MJ SO_2 – 0.9 g/MJ PM2.5 & PM10 – 0.17-0.26 g/MJ	NOx: 0.07-0.1g/MJ SO_2 – 0.14 g/MJ PM2.5 & PM10 – 0.003 g/MJ	NOx: 0.07 g/MJ SO_2 – 0.000 5g/MJ PM2.5 & PM10 – 0.0005 g/MJ

Annex 2:

Drivers for Sustainable Biomass

Objectives:

This section identifies and describes the key drivers to assess the sustainability of biomass sources on the basis of ESG criteria.

Key drivers for Sustainable Biomass
Environment

#	Sustainability Driver	Potential Risks	Link with SDGs	Evaluation Indicators
1	Climate Change	• Although CO2 emissions are reported separately outside of Scope 1 emission (cf. GHG Protocol) due to the carbon absorbed during the biomass lifetime before its combustion, combustion of biomass directly emits GHG for which its consumption should be minimized when possible (for example, through energy efficiency measures) and compared with other clean technologies for energy production. • Production, transportation & storage and utilization of biomass may generate GHG (C02, CH4, N2O) that are not fully compensated by the amount of carbon stored during the life-cycle of the biomass. These emissions shall be quantified and minimized. • Moreover, the production of biomass, due to its impacts on natural ecosystem may impact the capacities of carbon sinks to absorb carbon (e.g., reduction of forest cover for expansion of agricultural lands).	SDG 11 - Sustainable Cities and Communities SDG 13 - Climate action	1. GHG emissions from biomass production, transportation and storage (upstream) 2. GHG emissions from utilization (combustion) 3. Impact on carbon sinks (such as deforestation)
2	Conservation & Natural Resources	• The extraction and/or production may pose a threat on ecosystems and biodiversity habitats due to land type change from natural ecosystem (forest, savanna, wetland) to agricultural, production forests or already artificialized lands particularly in hot-spot biodiversity areas. • Biomass production may require the use agricultural and or harvesting practices including the use of fertilizer, chemicals that may contaminate the soil and the water resources and affect biodiversity due to extensive use of chemicals including pesticides. • Biomass production may require important quantity of water (for example through irrigation) and land that may impact the availability of the resources and lead to conflicts of usages particularly in water-stress areas. • Finally, important use of chemical or production of highly concentrated effluents during the biomass production and/or transformation processes may cause water resources and soil contamination if improperly managed	SDG 3 - Good health and well-being SDG 6 - Clean water and sanitation SDG 12 - Responsible Consumption and Production SDG 14 - Life below water SDG 15 - Life on Land	1. Loss of natural habitats causing loss of biodiversity (such as deforestation) from Land-Use change (LUC) and Indirect Land-Use Change (ILUC) 2. Loss of biodiversity due to increased use of chemicals (pesticides, herbicides, etc.) 3. Water consumption for biomass production 4. Water & Soil contamination
3	Air quality	During its production phase, agricultural practices such as agricultural waste burning or improper management of chemicals as well as industrial processes for biomass treatment and final combustion processes without appropriate air contaminant control may affect the quality of air and pose public health issues for workers and communities at local and up to regional level.	SDG 3 - Good health and well-being SDG 11 - Sustainable Cities and Communities	1. Open field burning of agricultural waste and wildfires 2. Air contaminants emissions during production processes 3. Air contaminants emissions from biomass boiler/turbines

Key drivers for Sustainable Biomass
Social

#	Sustainability Driver	Potential Risks	Link with SDGs	Evaluation Indicators
4	Human and labor rights	• Production and utilization of biomass may affect the rights of communities including land rights or rights to benefit from ecosystem services (particularly for minorities and indigenous people), while all stakeholders may not be granted to rights for information and participation to decision-making as stakeholders in the development of the biomass supply-chain. • Production, transformation and utilization of biomass may use industrial processes and/or lead to environmental contamination affecting both workers and communities and therefore pose risk to occupational and public health & safety. • Production, logistics, utilization and waste management of biomass products may lead to labor practices which do not provide fair right for workers (remuneration, decent contracts), non-discrimination and safe place to work (OHS) posing additional risk for vulnerable populations such as women, senior workers, minorities, migrants, disabled population. Attention shall also be given to the risk of child labor and modern slavery in the different stages of the supply-chain.	SDG 5 - Gender equality SDG 8 - Decent work and economic growth SDG 10 - Reduce inequality within and among countries	1. Land rights 2. Community (Public) health and safety 3. Occupational Health & Safety 4. Decent remuneration and compensation for workers 5. Human rights, Child Labor & Slavery
5	Social development & Local food security	• Biomass use for energy purposes in the industry may also compete with existing use in local communities primarily in case of edible crops for food, but also in the case of agricultural residues when traditionally used as local and inexpensive source of energy for cooking or also as soil amendment or livestock feeding in local farming. At a more macro-scale, production of biomass from crops that can be used for alimentation or on land that used to or could be used for food crops may impact the food safety with the risk of lower availability of food products necessary for ensuring good nutrition and/or increased price due to competition between food and energy usages • Production, logistics, utilization of biomass products may generate additional revenues and employment opportunities, though the distribution may face challenges with main portion being monopolized by a limited number of stakeholders (insider or outsider of the local communities) with the risk that the community only partially or negligibly benefits from the potential opportunities of biomass.	SDG 2 - Zero hunger SDG 5 - Gender equality SDG 8 - Decent work and economic growth SDG 10 - Reduce inequality within and among countries SDG 11 - Sustainable Cities and Communities SDG 12 - Responsible Consumption and Production	1. Impact on food availability and price 2. Increased and equitable share of revenues & employment opportunities for local communities' development

Risk pre-screening for evaluation indicators for biomass

As developed and used for the Pre-Screening Assessment – Level 1, a risk matrix is provided and used as the base for the evaluation indicators on a given biomass option. The risk level corresponds to the maximum level that can be observed for the related biomass category.

Evaluation Indicators			Biomass categories					Remarks
			1 – Solid wood & other products extracted from forests	2 – Primary products from crops used for food and/or energy	3 – Solid Agricultural waste	4 – Animal manure as residues from livestock	5 – Organic waste from industries and MSW	
Environment	Climate Change	GHG emissions from biomass production, transportation and storage (upstream)	Low	Medium	Medium	Medium	Medium	Medium risk is assigned when more risk of biodegradation during storage, leakages in biogas infrastructures as well during multiplication of intermediary processes mainly for biodiesel/bioethanol production
		GHG emissions from utilization (combustion)	Low	Low	Low	Low	Low	For combustion, as per frameworks, all types of biomass are considered similar in terms of GHG emissions from combustion and expected to support decarbonization effort due to carbon stored during biomass lifetime.
		Impact on carbon sinks (e.g., deforestation)	High	High	Medium	Medium	Low	High right for production or extraction of main biomass products to be used for energy (direct deforestation for wood or land-use change for agricultural products), Medium risk for by-products (agricultural waste) and low risk for tertiary waste (waste from industries and MSW)
	Conservation & Natural Resources	Loss of natural habitats causing loss of biodiversity (e.g., deforestation) from Land-Use Change (LUC) and Indirect Land-Use Change (ILUC)	High	High	Medium	Medium	Low	High right for production or extraction of main biomass products to be used for energy (direct deforestation for wood or land-use change for agricultural products), Medium risk for by-products (agricultural waste) and low risk for tertiary waste (waste from industries and MSW)
		Loss of biodiversity due to increased use of chemicals (pesticides, herbicides, etc.)	Low	High	Medium	Low	Low	High risk for Primary products from agricultural processes, Medium for categories originating from agricultural processes as by-products
		Water consumption for biomass production	Low	High	Medium	Low	Low	High risk for Primary products from agricultural processes, Medium for categories originating from agricultural processes as by-products
		Water & Soil contamination	Low	High	Medium	Medium	Medium	High risk for Primary products from agricultural processes, Medium for categories originating from agricultural processes as by-products. Medium risk for biogas production animal manures due to risk of digestate leakages from biogas plant and leachate from MSW storage
	Air quality	Open field burning of agricultural waste and wildfires	High	High	Low	Low	Low	High risk for Primary products from agricultural processes. For other categories, using biomass waste basically prevent the open field burning of that waste. High risk for production forest due to impacts of wildfires.
		Air contaminants emissions during production processes	Medium	Medium	Medium	Medium	Low	For biomass requiring intermediary processes like production of bioethanol, biodiesel, biogas and considering other processes such as pyrolysis from wood for charcoal production.
		Air contaminants emissions from biomass combustion	High	Medium	High	Low	High	Assuming animal manures leads to biogas, and food & energy crops lead to biodiesel and bioethanol, these biofuels are generally less air pollutants than solid biofuels.
Social	Human & Labor Rights	Land rights	High	Medium	Low	Low	Low	Land-Use change from natural areas with extraction of natural resources or from land grabbing for intensive agricultural production are the most likely to affect existing land rights from local communities (including indigenous peoples)
		Community health & safety	High	High	High	High	High	As the combination of the main risk from the indicators "Water & Soil contamination", "Air quality" drivers, and considering the needs of environmental protection/assessment from biofuels industrial plants (biorefinery, large-scale biogas plant) as per local regulations
		Decent remuneration & compensation for workers	High	High	High	High	High	Each value-chain is at risk in terms of non-respect of local labor regulations, including illegal labor.
		Occupational Health & Safety	High	Medium	Medium	Medium	High	Extraction of natural resources (such as wood from forests), is considering at the highest risk with MSW management from workers. Other biomass categories requiring work outdoors are kept as Medium risk.
		Human rights, Child Labor & Slavery	High	High	High	High	High	Each value-chain is at risk in terms of non-respect of local labor and human rights regulations including migrants, child
	Social development & Local food security	Impact on food availability & price	Low	High	Medium	Medium	Low	High risk for crops that can be used directly for food or agricultural land diverted for energy purposes. Risk is considered as Medium for agricultural byproducts that can be used as soil amendment instead of chemical fertilizer.
		Increased and equitable share of revenues & employment opportunities for local communities' development	Medium	Medium	Medium	Medium	Medium	Medium risk based on the increased opportunities for communities on specific use of biomass (natural resources, agricultural products and byproducts) that can result in risk of main revenues share being monopolized by limited number of stakeholder

Indicative list of mitigation options (1/2)
Environment

Following the first assessment, several drivers may be evaluated as “low”, “medium” or “high” risk. “High” and “medium” risks should be mitigated while “low” risk mitigation may be considered.

The table on the right is provided for information purposes and aims at listing general mitigation solutions for each driver that may be applicable to the biomass source.

	Driver	Possible mitigation options (non-exhaustive list)
Environmental	Climate change	• Biomass is produced locally and/or within 100km from utilization • No drying is required, or it occurs before medium/long term storage • Energy efficiency or clean energies (renewable, electrification of needs) measures are applied during production process • Implement appropriate Energy Management System (such as ISO 50001). • Apply Energy efficiency best practices in energy systems of the factory to reduce the energy demand • Biomass is produced on land that was previously already artificialized for human activities by 31st December 2020 • Select biomass that is certified addressing risks of deforestation and other types of natural habitat's damages (e.g., RSB, RSPO, FSC or equivalent). • Select suppliers that have traceability policies and can share information about the source of their biomass
	Conservation & Natural resources (Soil& Water)	• Exclude areas that are protected and/or considered of significant value for biodiversity from conversion. • Select biomass that is certified addressing risks of Land-Use change and of natural habitats damages (e.g., RSB, RSPO, FSC or equivalent). • Biomass is produced from agroecology practices that provides conditions for biodiversity development and does not require pesticides and herbicides • Biomass is produced in areas with objectives of reduction of chemicals used in agriculture • Select biomass sources with reduced water consumption, especially in region with a risk of usages conflicts (no irrigation or processed industrial water) • Select biomass producer that has taken measure to reduce water usage or that is incorporated into a watershed management plan for a balanced share of water usage • Region of production has implemented measures or policies to reduce the use of chemicals in agriculture • Biomass production and factory have clear plans for hazardous water, sludges and waste management (i.e., digestate from biogas plant)
	Air Quality	• Biomass production follows measures/recommendations as per Clean Air act policies related to agricultural waste burning • Select suppliers for which biomass production is engaged into phasing out from organic waste open-air burning • Biomass production takes measure to reduce the impact or occurrence from wildfires • Biomass production follows measures/recommendations as per Clean Air act policies related to industrial air emissions • Biomass producers applies smoke and gas effluents monitoring control and treatment measures from biomass conversion processes (e.g., combustion, pyrolysis) • Factory has implemented measures and technologies to reduce air pollutants (NOx, SOx, PM and other pollutants)

Indicative list of mitigation options (2/2)
Social

	Driver	Possible mitigation options (non-exhaustive list)
Social	Human and Labor rights	• Audits on suppliers and biomass sources are performed to ensure that communities have not been affected or been compensated by the development of the biomass supply chain • Select biomass sources from a region that indigenous peoples have not been affected by the development of the biomass supply chain in term of land rights. • Supplier can provide land right certificates for biomass transformation factory • Supplier can provide land right certificates for agricultural lands • An Environmental and Social Impact screening and/or assessment (such as ESIA) related to the production of biomass has been performed and approved by authorities • The biomass producer can justify providing more advantageous conditions than the minimum wages to its workers • Audits on suppliers are performed to ensure biomass supplier aligns with national regulations related legal minimum worker's wage and working conditions • Factory is involved in awareness raising related to human rights, child labor/ forced labor • Select/ encourage suppliers implementing measures to prevent human rights, child labor or forced labor if such risks have been identified in the sourcing region and the supplier has not implemented adequate mitigation controls. • Prioritize biomass suppliers that have human rights, anti-child labor and forced labor policy and management systems in-place.
Social	Social Development & Food security	• Biomass is produced from non-edible crops • Select biomass that is produced on land that cannot be used for agriculture • Factory is directly supplied by the biomass supplier (limiting the number of brokers and intermediates) • Biomass producers/suppliers are constituted in agricultural or forestry cooperatives • Select biomass supplier/biomass producers that contribute to the social and economic development of local population, indigenous peoples and community.

International Management Standards – Certifications

In order to promote sustainable use of biomass, and more particularly aiming at reducing the risk of harming environment and communities from the extraction of natural resources, various certifications have been developed to guide industries and consumers in their supply choices.
Nevertheless, it has to be noted, despite being a tool aiming to improve the traceability and encourage good practices within the supply-chain, the certification, alone, may not fully guarantee that no risk or harm to environment or communities has occurred during the biomass production.
Below are provided several examples, internationally or locally recognized. In case, biomass user or supplier can justify existence of specific or local certifications for its biomass, a review of the eligibility criteria and alignment on internationally recognized certifications below should be performed.

Forest Stewardship Council (FSC)

- 3 categories: economic, environmental, social
- 10 Principles and Criteria (P&C) for sustainable forestry management to meet the social, economic, environmental needs for worldwide forests.
- Thematic areas:
  - Compliance with all laws and regulations
  - Indigenous Peoples' Rights
  - Improve long-term economic, social and environmental benefits for local communities
  - Maintain high conservation values
  - Avoid and/or mitigate negative environmental impacts.

Roundtable on Sustainable Palm Oil (RSPO)

- Promotes sustainable production of palm oil to combat deforestation, worker exploitation, and improve smallholder livelihoods
- Consists of RSPO Principles and Criteria, RSPO Supply Chain Certification Standard, and RSPO Independent Smallholder Standard
- Thematic areas:
  - Compliance with laws and business ethics
  - Optimize productivity, efficiency, positive impacts and resilience
  - Respect workers' rights and local communities
  - Protect, conserve and enhance ecosystems and the environment.

Programme for the Endorsement of Forest Certification (PEFC)

- Promotes sustainable forestry management to ensure forest-based products reaching the marketplace have been sourced sustainably.

Sustainable Forest Initiative (SFI)

- Promotes sustainable forestry practices based on 13 Principles, 17 Objectives, 41 Performance measures and 141 Indicators
- Includes sustainable fiber sourcing, Chain-of-Custody, and certified sourcing standards
- Applies to U.S. and Canada.

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