BIOENERGY AND FOOD SECURITY RAPID APPRAISAL (BEFS RA)

User Manual

2G ETHANOL

2014

BEFS Rapid Appraisal

Energy End Use Options Module

Transport Sub-Module

2G Ethanol

User Manual

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1 Unless otherwise specified, all authors were affiliated to FAO at the time of their contribution.

2 The BEFS working Group in Malawi comprises the following members: Ministry of Energy, Ministry of Lands, Housing, and Urban Development, Ministry of Finance, Ministry of Agriculture and Food Security, Ministry of Environment and Climate Change and Department of Forestry, Ministry of Industry and Trade, Ministry of Economic Planning and Development, Ministry of Labour and Vocational Training, Ministry of Transport and Public Infrastructure, Ministry of Information and Civic Education, Ministry of Local Government and Rural Development.

3 The National Biofuels Board is chaired by the Secretary of Department of Energy and includes the following members: Department of Trade and Industry, Department of Science and Technology, Department of Agriculture, Department of Finance, Department of Labor and Employment, Philippine Coconut Authority, Sugar Regulatory Administration.

BEFS RA User Manual Volumes

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1 Overview of the Transport Sub-Module

Liquid biofuels are most commonly produced either as biodiesel or ethanol. Biodiesel can be produced from vegetable oil or animal fat and is used to replace fossil diesel. It can be used as a pure fuel or blended with petroleum diesel (commonly B5 or B20, which contains, respectively, 5 per cent or 20 per cent biodiesel mixed with fossil diesel). Ethanol is a clear alcohol that can be used as a fuel in a spark-ignition engine, either neat or blended with gasoline. Biodiesel has about 92% of the energy content of petroleum diesel. Ethanol has around two-thirds the energy content of gasoline (regardless of feedstock used), but it has a significantly higher octane rating.

The *Transport Sub-Module* assists the user in evaluating the potential to develop the production of liquid biofuels, namely ethanol and biodiesel in the country. The *Ethanol* section of the tool is used to assess the potential for developing the ethanol industry in the country. Likewise, the *Biodiesel* section assesses the potential for developing the biodiesel industry. The analysis builds on the results generated in the *Natural Resources* module in terms of feedstock availability. The tool is designed to assess the competitiveness of liquid biofuel production chains, which vary depending on the origin of the feedstock (outgrowers scheme, own production scheme, and mixed outgrowers-own production scheme); and the pre-defined technology configurations and sizes of biofuel production plants (5, 25, 50 and 100 million litres per year). The tool provides preliminary estimates on the cost of production of the biofuel value chain and analyses the financial and socio-economic aspects of the production chains.

After completing the analysis, the user will be able to assess:

1. the economic profitability of the liquid biofuel value chain, particularly when including outgrowers as feedstock suppliers;
2. the most viable feedstock that can be used for producing ethanol and biodiesel;
3. the potential plant sizes that can be considered in the country;
4. the employment generation potential in rural areas associated with each value chain; and
5. the amount of biofuel that can be produced for domestic markets, export markets, or both.

More specifically, the results will provide an indication on:

1. the amount of biomass required to supply each of the pre-defined capacities;
2. the cost of production and the investment cost associated with each production option;
3. the financial indicators on Net Present Value (NPV) and Internal Rate of Return (IRR);
4. the feasibility to integrate outgrowers in the production chain; and
5. the quantity of jobs that can be created.

The flow of information within the *Transport Sub-Module*, which includes sections on biodiesel and ethanol, together with the links to other components in the BEFS Rapid Appraisal is depicted in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

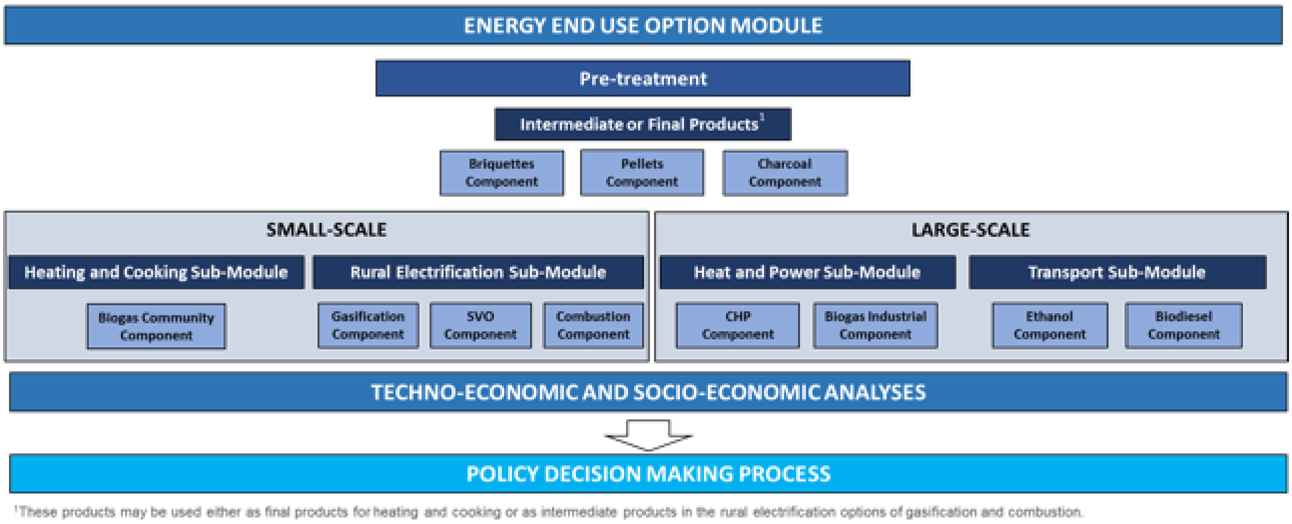

Figure 1: The Structure of the Energy End Use Option Module

2 The 2G Ethanol Component

The *2G Ethanol Component* is designed to assist the user in evaluating the potential to produce ethanol from lignocellulosic feedstock. The boundary of the analysis for the processing of ethanol from lignocellulosic feedstock is shown in Figure 2. The tool is based on extensive literature reviews. The detailed assumptions and calculations used to develop the tool are provided in the Annex.

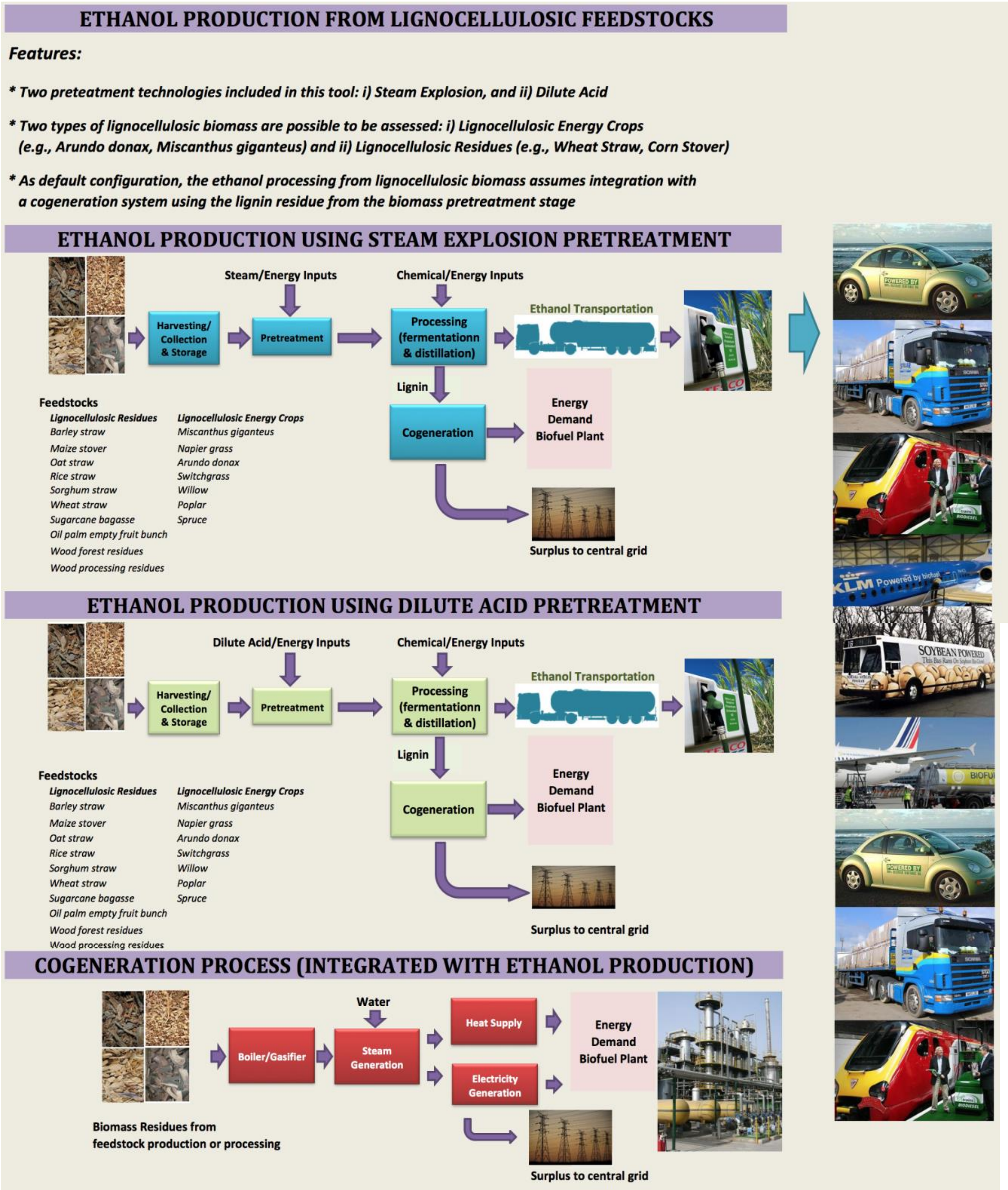

Figure 2: Processing of Ethanol from Lignocellulosic Feedstock

After completing the analysis, the user will have an indication on: 1) ethanol production costs and investment required to set up plants of various scales; 2) feedstock demand according to plant size; 3) Percentage of obtainable ethanol demand blend; 4) the number of jobs that could be potentially created; and 5) viability associated to each plant scale. The user will also be able to include in the analysis a cogeneration system.

3 Terms and Definitions Used in the 2G Ethanol Component

This section includes definitions of specific terms used in the *2G Ethanol Component.* It is important to anticipate these definitions and consider them throughout the analysis as to be able to interpret the results correctly.

3.1 Comparison between production cost of ethanol and fossil fuels/liquid biofuels

In the Data Entry sheet, users are asked to specify whether the country considered in the analysis is a net importer/exporter of ethanol; or a net importer/exporter interested in exporting ethanol. Depending on the answers to these questions, the users are confronted with different combinations of the scenarios described below, which entail different price comparisons and thus certain data requirements.

3.1.1 Comparison with fossil fuels

Scenario 1 – Net importing country

The sub-module compares the production cost of ethanol (in oil equivalent) with the Free on Board (FOB) price of gasoline.

If the main port used to import fossil fuels does not correspond with the main city (and thus consumption point) in the country, then the tool compares the production cost of ethanol (in oil equivalent) with the FOB price of gasoline to which the transport cost of these fuels from the port to the main city is added.

Scenario 2 – Net exporting country

The sub-module compares the production cost of ethanol (in oil equivalent) with the Refinery Gate Price (RGP) of gasoline.

3.1.2 Comparison with liquid biofuels

Scenario 1 – Net importing country

The sub-module compares the production cost of ethanol with the Free on Board (FOB) price of ethanol.

If the main port used to import fossil fuels does not correspond with the main city (and thus consumption point) in the country, then the tool compares the production cost of ethanol (in oil equivalent) with the FOB price of gasoline to which the transport cost of these fuels from the port to the main city is added.

Scenario 2 – Net exporting country

The sub-module compares the production cost of ethanol with the average factory gate price of ethanol in the country[4].

Scenario 3 – Interested in exporting

The sub-module compares the production cost of ethanol with the Free on Board (FOB) price of ethanol to which the transport cost of these fuels from the main city to the port has been subtracted.

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[4] This is useful, for instance, when assessing the competitiveness of alternative feedstock for the biodiesel/ethanol already produced in the country.

If the FOB price of biofuels is not available, the sub-module uses the FOB price of the closest port where biofuels are traded.

- **Break-even point:** The break-even point represents the amount of sales that are required to cover total costs (both fixed and variable). Profit at break-even is zero, as costs and revenues are equal.

3.2 Ethanol production

The sub-module considers the following indicator based on the total amount required to meet the mandatory blending as indicated in the Biofuel Demand sheet (see section 5.1):

- **Percentage of obtainable mix with ethanol produced:** The maximum attainable ethanol production with available molasses indicates to which extent the ethanol obtained is enough to meet the amount proposed under different mandatory blending mandates. The demand created with blending mandates is calculated from the current demand of gasoline in the country (see section on Step 1: Fuel demand in the Country).

3.3 Financial analysis

The financial analysis examines the profitability of investing in biofuel processing plants of different sizes. The sub-module computes the following indicators[5]:

- **Net Present Value (NPV)**: The difference between the present value of cash inflows and the present value of cash outflows. Cash flows are a sequence of values extending over several years. When using NPV, the selection criterion is to consider positively all investments with a NPV greater than zero, when discounted at a suitable discount rate, most often the opportunity cost of capital.

- **Internal Rate of Return (IRR)**: The discount rate that makes the NPV equal zero. If the IRR on the investment is greater than the minimum required rate of return – the cost of capital – then the investment is worth it. Conversely, if the IRR on the investment is lower than the cost of capital, then the best course of action may be to not proceed with the investment.

Other financial terms that the user should consider:

- **Discount rate:** The interest rate used to determine the present value of a future value through discounting.

- **Opportunity cost of capital:** The cost of using resources in the specific investment rather than in their next best alternative option. It is usually expressed in the interest rate form, i.e. the rate at which benefits and costs are discounted in calculating the Net Present Value.

4 Scope and Objective of the *2G Ethanol Component*

The aim of the *2G Ethanol Component* is to assess the feasibility of producing ethanol from lignocellulosic feedstocks.

The results of the analysis can be used to identify the viability of ethanol production from lignocellulosic feedstock in terms of feedstock availability, the financial viability of the different processing scales, maximum attainable ethanol production according to available feedstock, and the socio and economic benefits that can

[5] For further information on the indicators see De Benedictis, 1976; Gittinger, 1982; Squire van der Take, 1975.

be attained. The information generated by the analysis can also be used as an initial basis to discuss potential strategies to promote the production of ethanol at the industrial level.

The *2G Ethanol Component* can also analyse the inclusion of a cogeneration system for the generation of electricity and/or heat at the industrial level.

The following section describes the flow of the analysis and options within this component. The background methodology for the financial analysis, biomass collection and biomass storage is described in detail in the Annex.

Figure 3: Rapid Appraisal Abridged Tool for the Production of 2G Ethanol

5 Running the *2G Ethanol Component*[6]

During the analysis, the user is navigated step by step through each of the options and is asked to enter the data needed in order to obtain the final results. When the required data are limited or unavailable, then the default values provided by the tool can be used. The navigation buttons are placed on the top and bottom of

[6] A complete and detailed description of the processing budget structure both for the calculation of the production costs of 2G ethanol and for the estimation of land and labour requirements is presented in the Annex. Description on GHG emissions calculation is presented in Annex.

each sheet, indicating the next step with the button “NEXT>>” and allowing the user to return to the previous section with the “<<BACK” button.

The following sub-chapters describe each step of the analysis, using Colombia as the example.

The user should follow a sequence of steps in order to obtain final results. Nevertheless, an experienced user can run the sub-module following a different order or even omitting some steps or options (e.g. biofuel demand).

The user should enter the required data in the white cells, while calculations are shown in the grey cells. If the information is not readily available, the user will be guided through web links in order to find the corresponding country-specific information.

5.1 Step 1: Biofuel demand at country level

This step aims at estimating the amount of 2G ethanol needed to reach a given national biofuel blending mandate, computed based on gasoline consumed in the country. The share of ethanol is obtained by applying the coefficients of mandatory blending for gasoline.

The user must enter:

1. Data on gasoline domestic consumption in ML/year. Information provided in the *Country Status* module can be used here (Figure 4, label 1).
2. Data indicating the level of ethanol blending planned at the domestic level. Information provided in the *Country Status* module can be used here (Figure 4, label 2).

The amount of ethanol the country should produce is generated by the tool based on the information provided (Figure 4, label 3).

Under Biofuel Production and Trade, the user can determine the amount of liquid biofuels consumed in the country. This value is obtained by adding the imported quantity to domestic production and subtracting the quantity exported (Figure 4, label 4). If the given country only imports, then the value will simply be the import value.

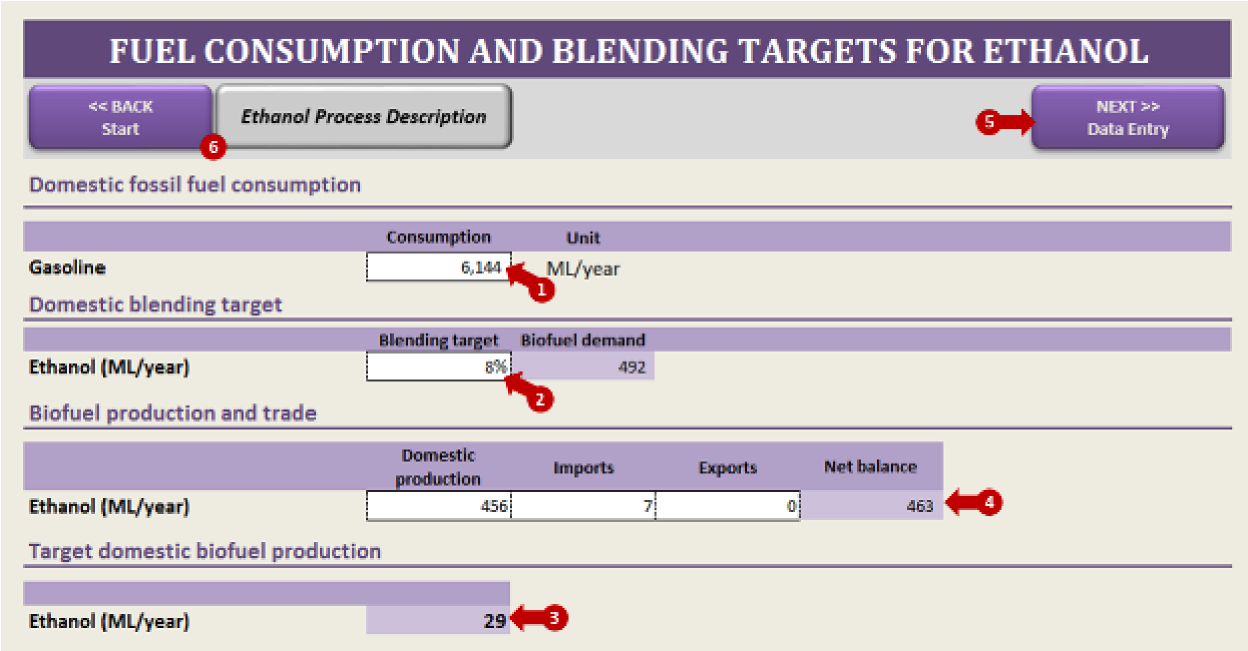


Figure 4: Biofuel Demand (Fuel Consumption and Blending Targets)

5.2 Step 2: Data entry sheet

Information provided in the Data Entry sheet is useful in assessing the possibility of producing 2G ethanol from selected crops/residues based on specific technical production coefficients. The Data Entry sheet is composed of the following sections:

- Feedstock Availability and Cost – The user enters feedstock data.
- Biofuel Production Cost and Financial Parameters - The user enters data on inputs used in the production processes (e.g. chemical inputs, utilities, labour, transportation and storage) as well as financial parameters (i.e. discount rate, loan interest rate, loan term and loan ratio).
- Labour and Land Parameters – The user enters data related to labour and land requirements (i.e. yields, manual and machinery labour).

Before proceeding with the analysis, the user can choose to load the default values for running this component by clicking on the "Load Default Values" button as shown in Figure 4, label A.

5.2.1 Defining the feedstock

In this section, the first step that the user needs to define is the operating mode (

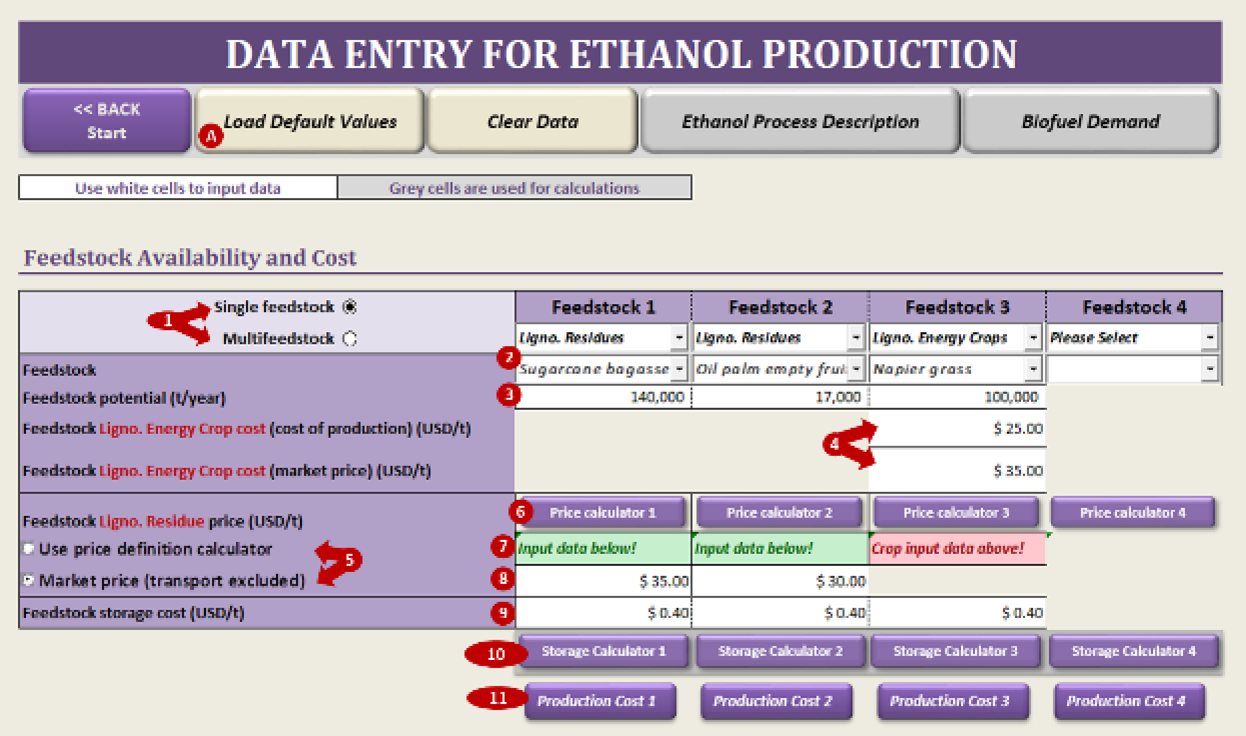


Figure **5**, label 1). The 2G ethanol tool allows the user to run the analysis using two operations mode: single feedstock mode and multi-feedstock mode. The single feedstock mode assumes that only one feedstock can feed the 2G ethanol plant at the different capacities. This allows the user to test different feedstocks and compare the results between them. Up to four feedstocks (residues or crops) can be analysed at the time. The multi-feedstock mode assumes that the ethanol plant can be supplied by different feedstocks at different seasons of the year. This allows the user to assess whether multiple feedstocks can be used instead of single feedstocks for 2G ethanol production. To define the feedstocks, the user is asked to select the feedstock crops (e.g. energy crops such as grasses with non-food applications) or residues (e.g. agricultural residues and forestry residues of common crops) used for 2G ethanol production from a long list of options[7]. Up to four feedstocks (residues or crops) can be selected from a dropdown list. The list includes 17 key feedstocks for 2G ethanol production, among which 10 are agricultural/forestry residues: barley straw, maize stover, oat straw, rice straw, sorghum straw, wheat straw, sugarcane bagasse, oil palm empty fruit bunch, wood forest residues and wood processing residues; and 7 lignocellulosic energy crops: miscanthus *giganteus*, napier grass, arundo *donax*, switchgrass, willow, poplar and spruce.

[7] The information available from the *Country Status* module can help in the selection of the bioenergy feedstocks.

In order to select the crops/residues, the user has to first decide what type of feedstock(s) (residues or lignocellulosic crops) will be considered (

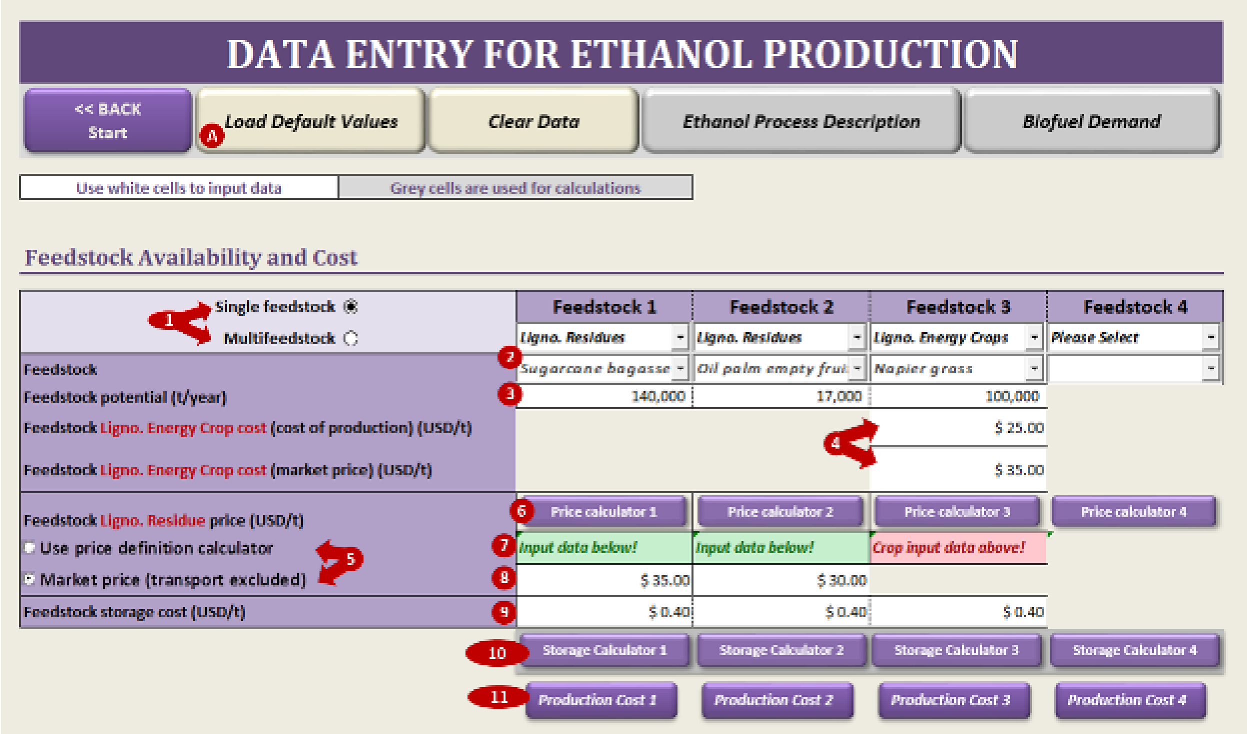
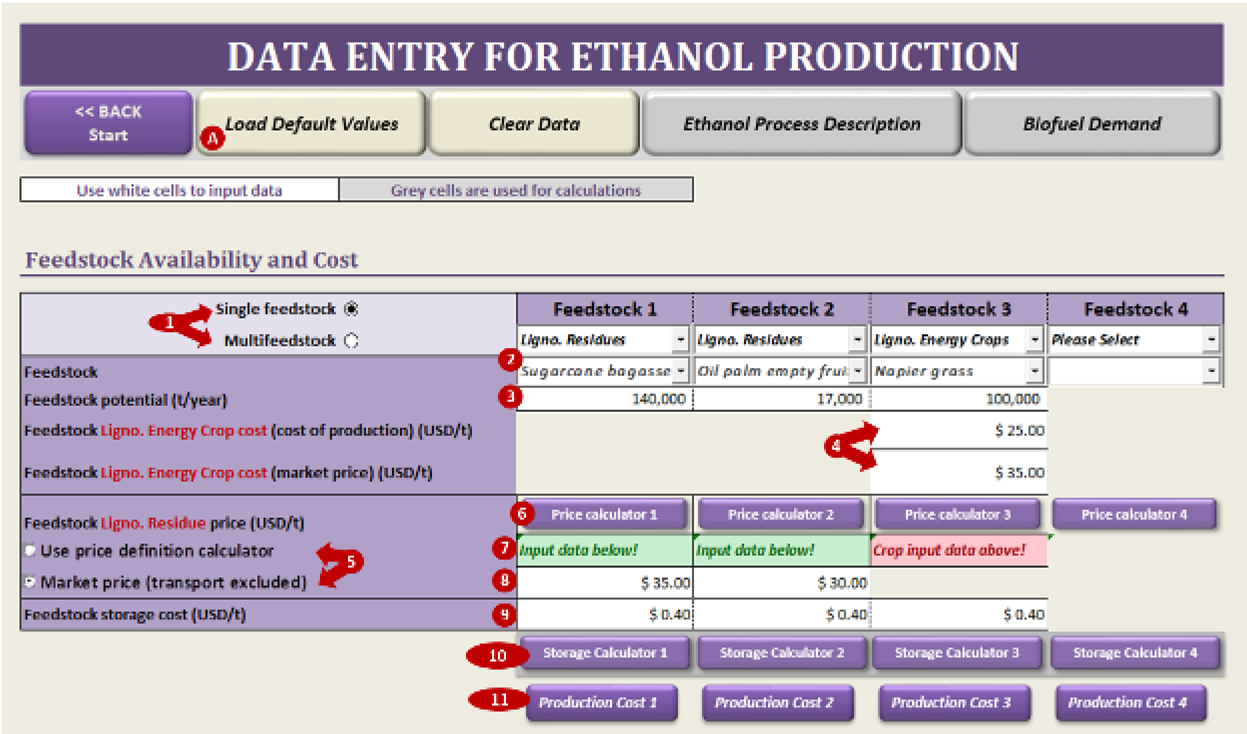


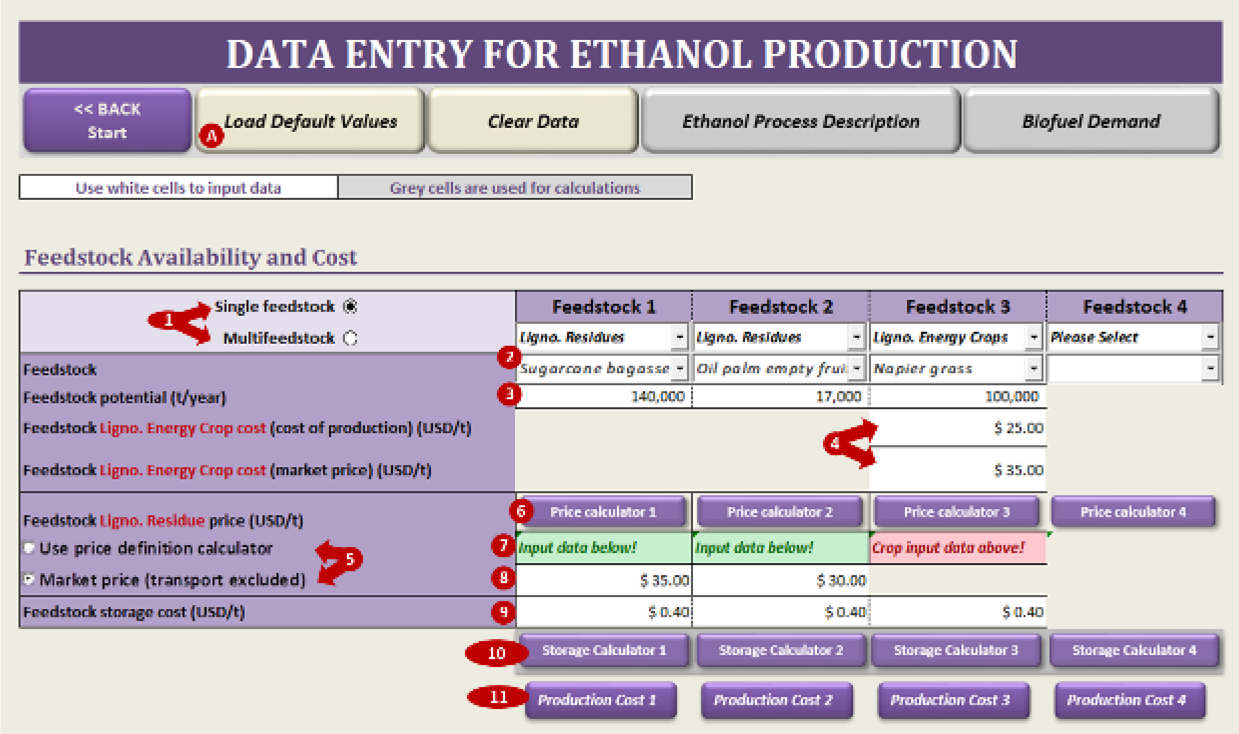
Figure **5**, label 2; Figure showing details for single feedstock mode) (In the case of Colombia, only 3 feedstocks are considered here). For each selected crop/residue, the user should enter[8]:

1. Total feedstock availability (computed in the *Crop Production Tool* and the *Woodfuel Tool* for agricultural/forest residues) (



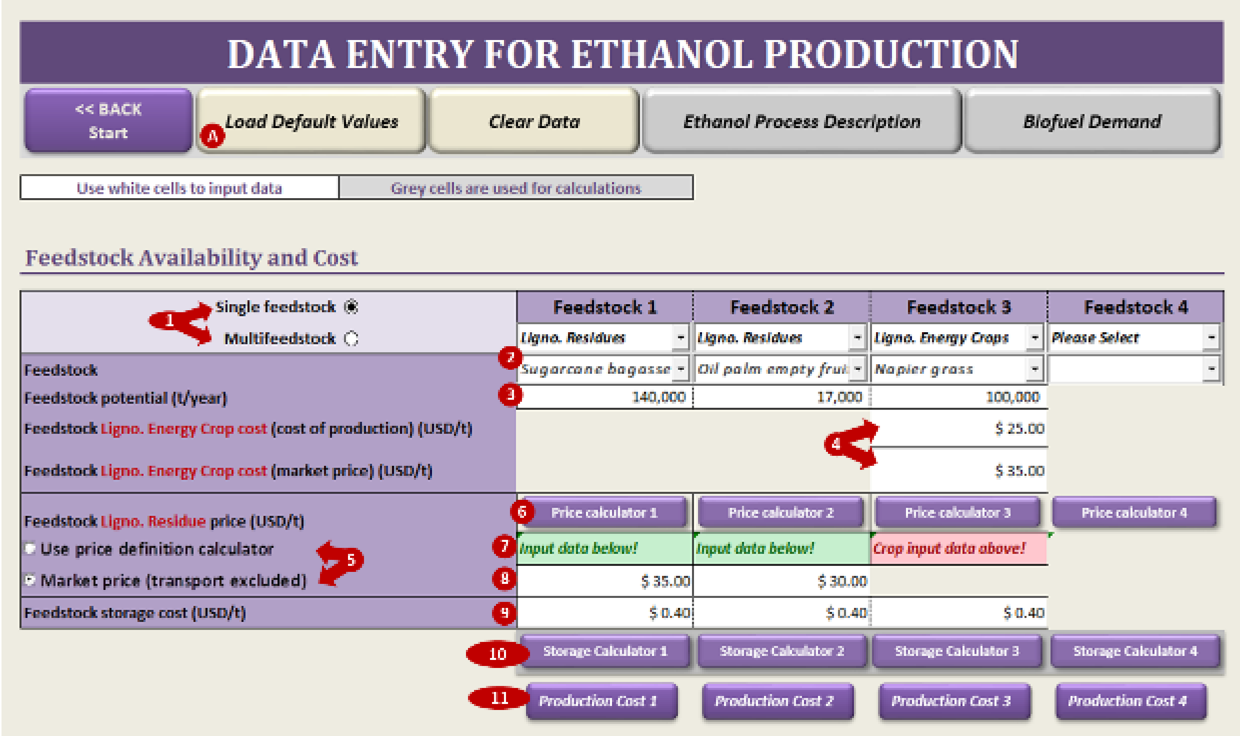
[8] The user can refer to Table 2 in the Appendix (section 8.2) where data needed to run the *Transport Sub-Module* are summarized. An indication of what data can be found in other modules, sub-modules or components are also provided.

2. Figure **5**, label 3; see section 8.2.1).
3. Feedstock prices (expressed in USD per t), which differs depending on the different production schemes (outgrowers, own production or mixed outgrowers-own production).
   A. In the case of energy crops, it should be noted that the own production price stems out of the *introduced manually by the user*, while the price of feedstock produced by outgrowers is assumed to be the market price based on the current average national prices (



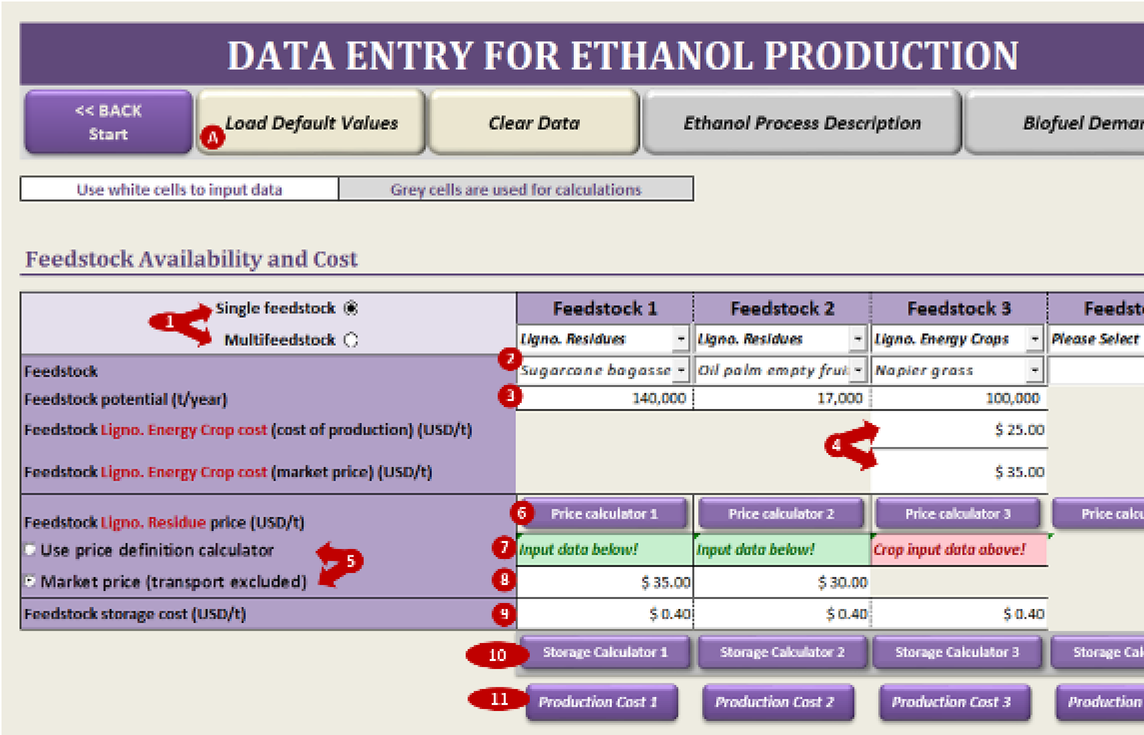
   B. Figure **5**, label 4; see section 8.2.1).
   C. In the case of agricultural/forestry residues, it should be noted that the own production price is assumed to be 0 USD/t based on the reasoning that all crop costs are allocated to the crop itself and not to the residues. The price of feedstock produced by outgrowers is assumed to be the market price. The user can choose between two options for determining

this data (

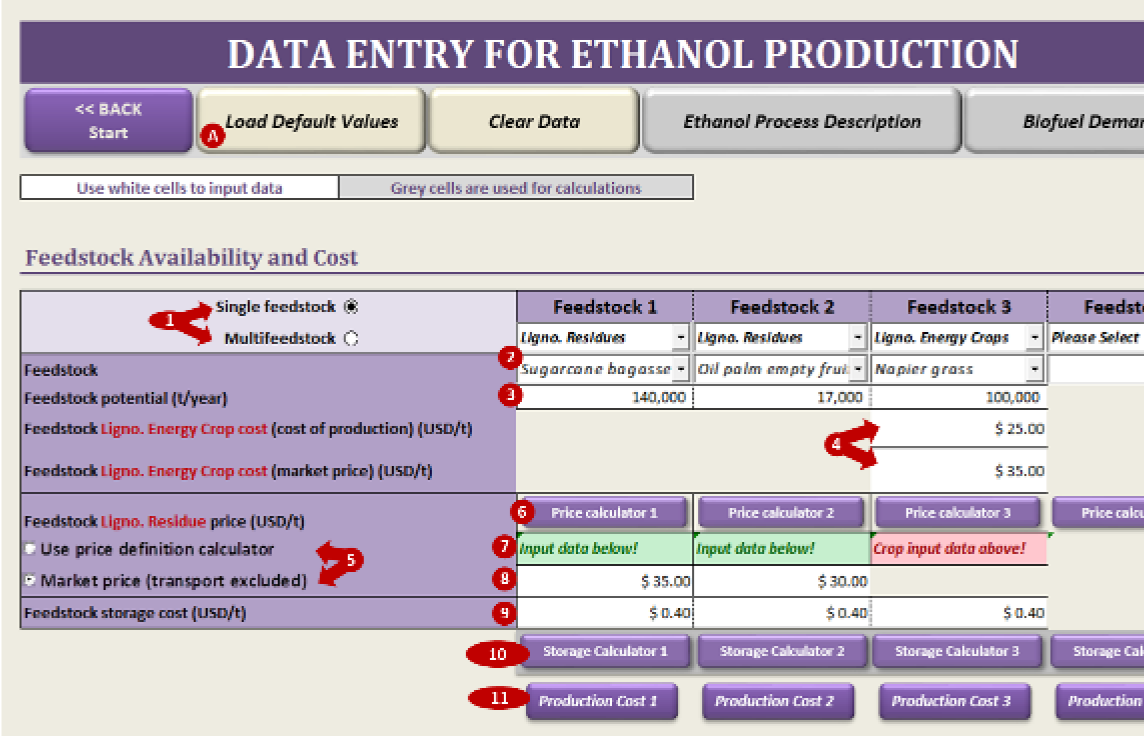


D. Figure **5**, label 5).

a. Use the *price definition calculator* (

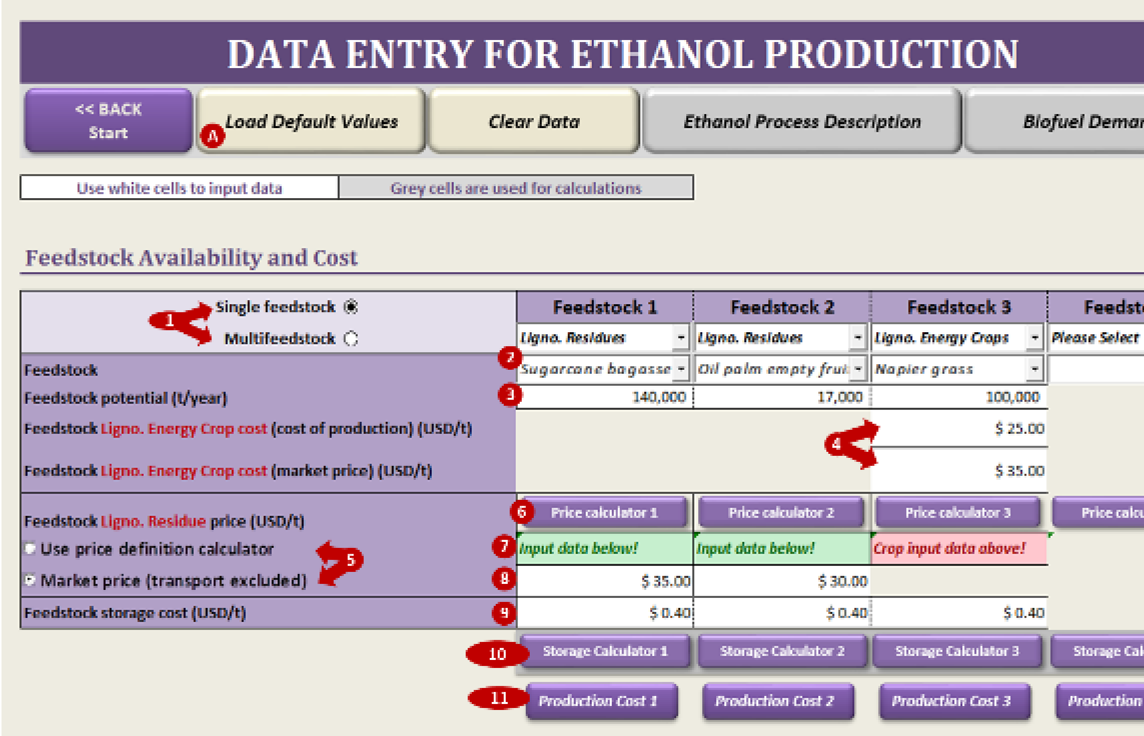


b. Figure **5**, label 5 upper option). The user will need to click on the "Price calculator" button (



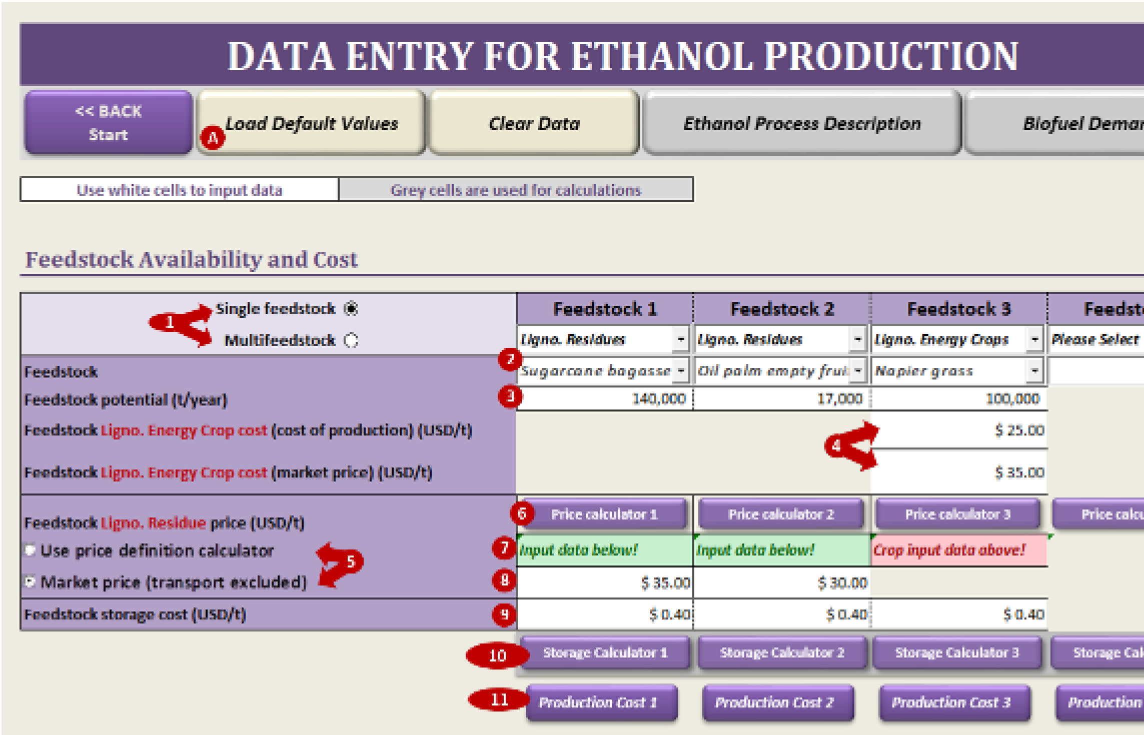
c. Figure **5**, label 6), which will direct the user to a different sheet (see Figure 6). Additional data is required to calculate the collection price of the residue such as, number of skilled/unskilled workforce (Figure 6, label 1), skilled/unskilled labour wage which is included in the data entry (Figure 6, label 2; see section 8.2.1), fuel economy (Figure 6, label 3), and fuel price which is also included in the data entry (Figure 6, label 4; see section 8.2.1). The user can choose whether the collection is manual, semi-mechanized, and mechanized (Figure 6, label 5). Once all data, and collection method is defined, a collection price can be retrieved (Figure 6, label 6).

This value is returned to the data entry sheet cells related to each feedstock (

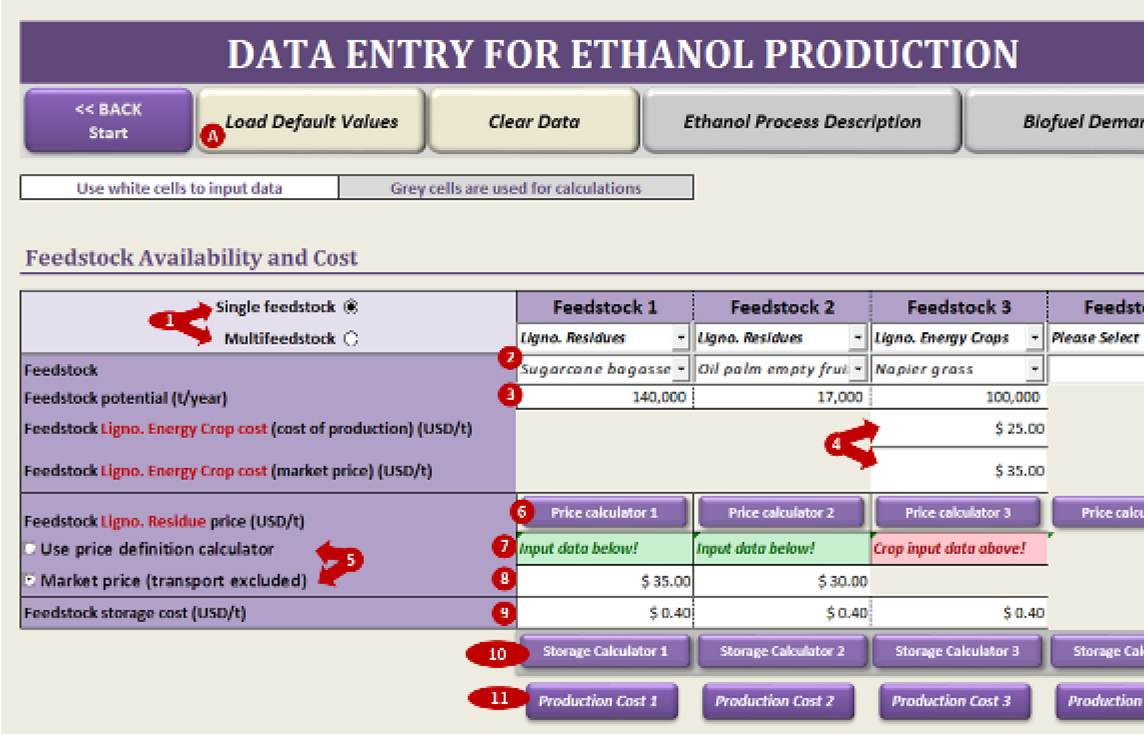


d. Figure **5**, label 7). If the user has chosen other agricultural/forestry residue as feedstocks, needs to repeat this procedure accordingly.

e. The user can enter *the existing market price* of the residue as a proxy (

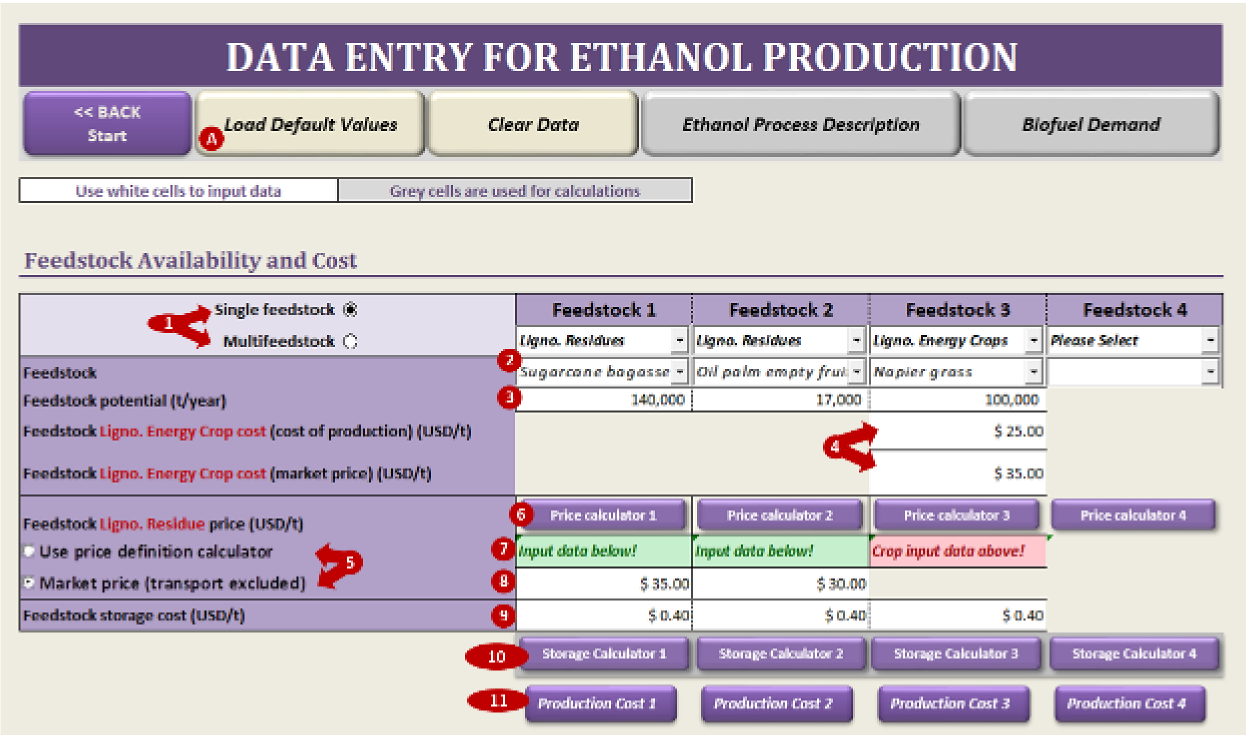


f. Figure **5**, label 5 lower option). The price should be entered in the respective cell for each residue feedstock (USD/t) (



g. Figure **5**, label 8).

4. Storage cost (expressed in USD per t) (



5. Figure **5**, label 9) – the user has two options to determine this data:
   A. The user can enter *the existing prices* of storage of agricultural/forest residues and energy crops in the country as a proxy. The price should be entered in the respective cell for each feedstock (USD/t). If this information is not available, then the user should go to the next step.

B. The user can determine *a proxy* for this value. The user will need to do the following:
   - Identify a type of feedstock storage likely associated with conditions in their country from the options presented in Table 1. Table 2 is the estimated cost of storage for feedstock that can be used for ethanol production.
   - For the selected storage option, look up the global building cost provided in Table 1.
   - Enter the proxy value (USD/tonne) in the respective cell for each feedstock.

Table 1: Estimated Cost of Storage for Ethanol Feedstock

Estimated Cost of Storage	Unit	Min	Average	Max
Enclosed structure with crushed rock floor	USD/t	10	12.5	15
Open structure with crushed rock floor	USD/t	6	7	8
Reusable tarp on crushed rock	USD/t	n/a	3	n/a
Outside unprotected on crushed rock	USD/t	n/a	1	n/a
Outside unprotected on ground	USD/t	n/a	0	n/a

Source: (EPA, 2007)

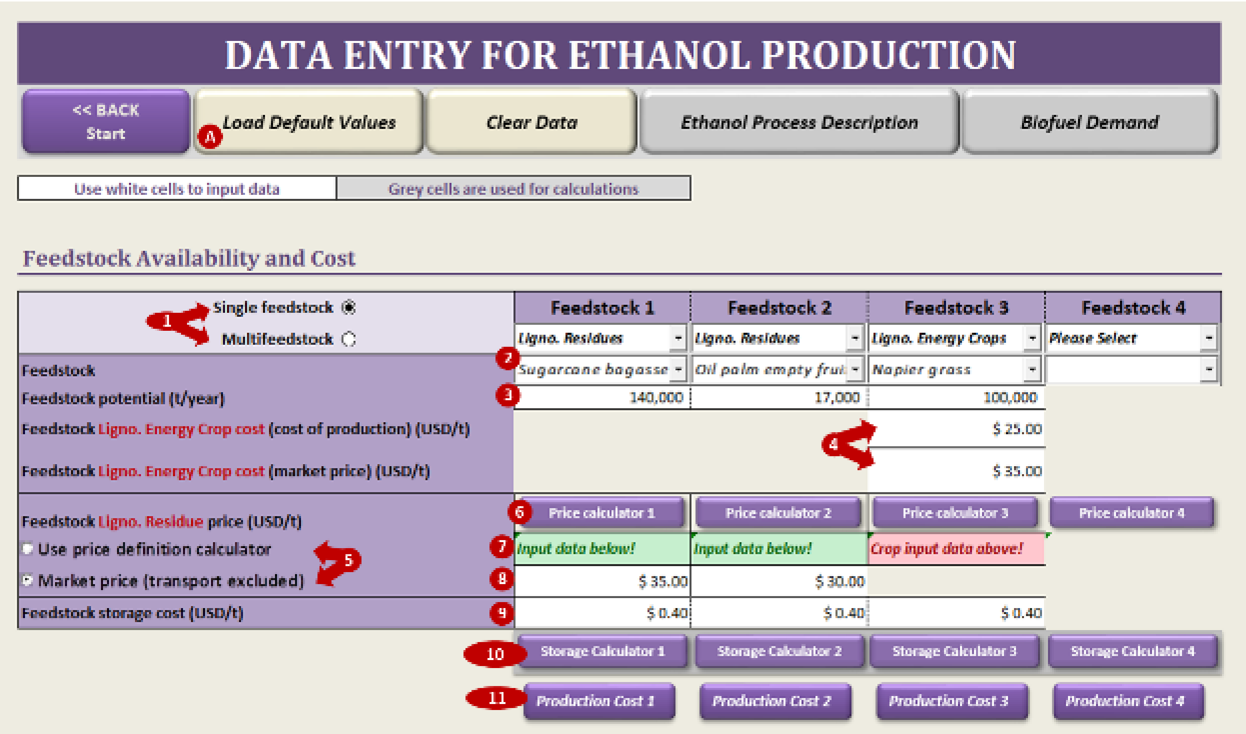


Figure 5: Data Entry for Liquid Biofuels: Feedstock Availability and Cost, Single Feedstock Operation Mode

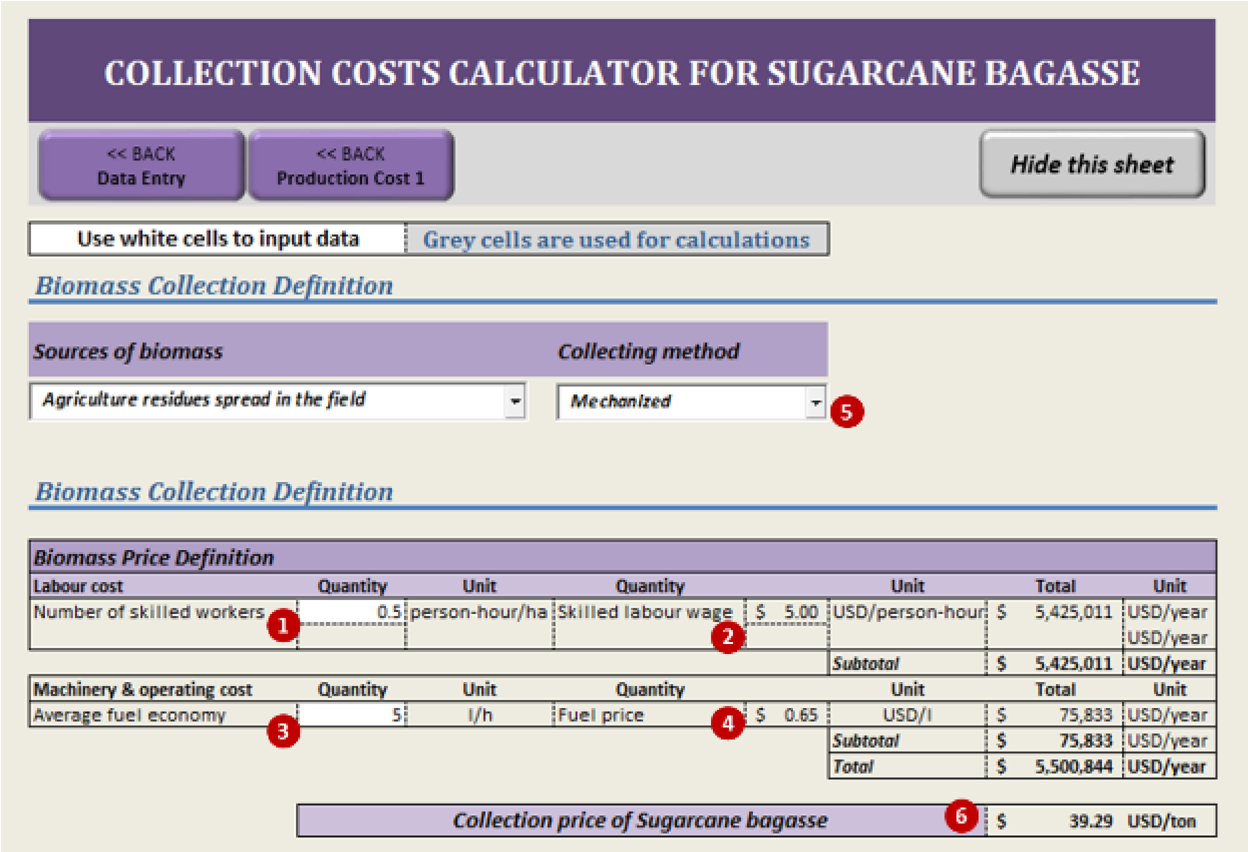


Figure 6: Collection Price Calculation for Agricultural Residues

In order to calculate the storage capacity needs, the user needs to click on the "Storage Calculator" button (

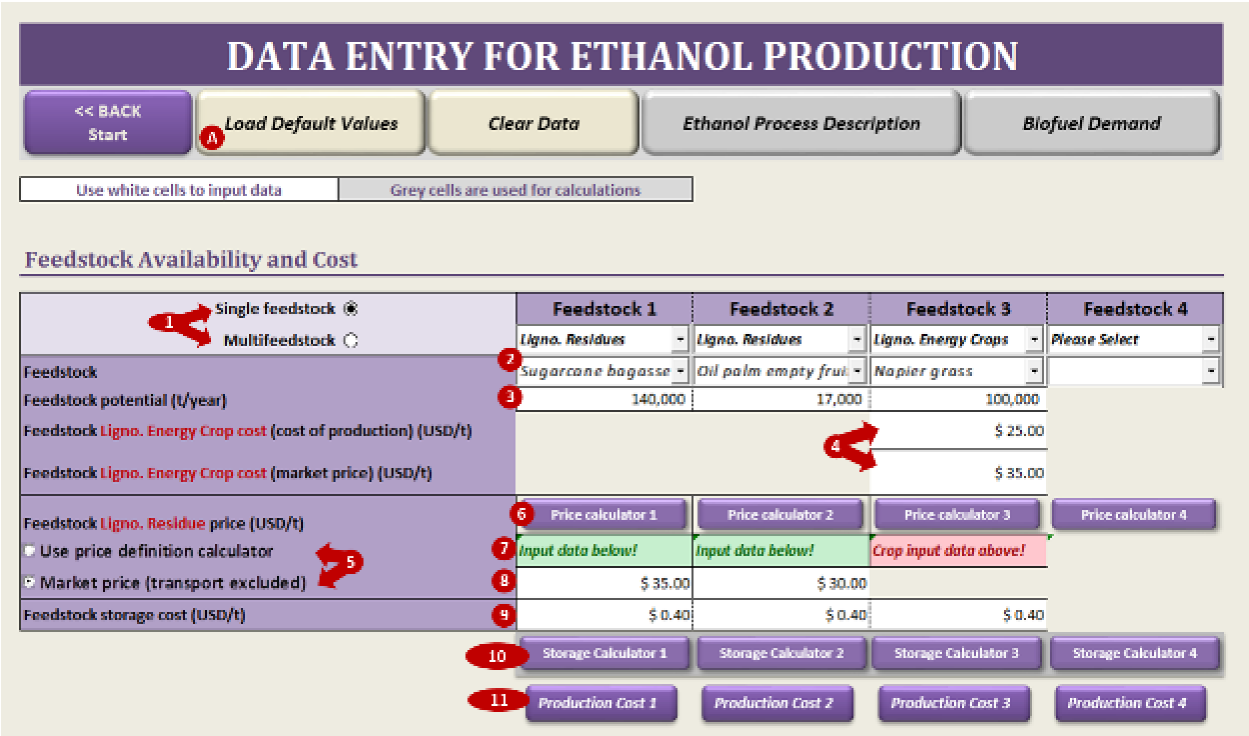


Figure **5**, label 10). This will take the user to the Biomass Storage Calculator (Figure 7). In this worksheet, the user will need to:

1. Select the harvesting month(s) of the crop (Figure 7, label 1).
2. Enter the biomass safety stock rate (%). This is the percentage of biomass needed to secure continuous supply of feedstock to deal with uncertainty in production due to seasonal availability, flood, drought, and other factors. This stock rate % is used to estimate the storage capacity (Figure 7, label 2).
3. Click on "Calculate" (Figure 7, label 3) to automatically compute the amount of maximum storage capacity required (tonnes) and the minimum safety storage (tonnes per month) for each of the pre-defined capacities (Figure 7, label 4).
4. Clicks "OK" to return to the Data Entry Needs sheet (Figure 7, label 5).
5. Repeat the same steps for all feedstock.

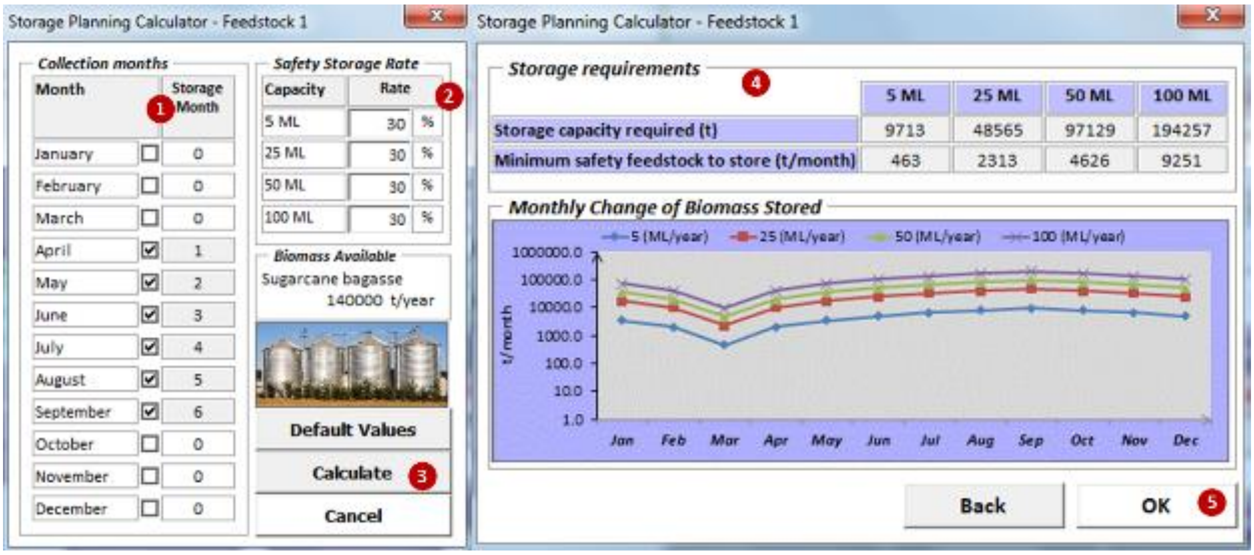


Figure 7: Storage Calculator of Feedstock (Single Feedstock Mode)

At this stage, the user may choose either to look at how production costs are structured (

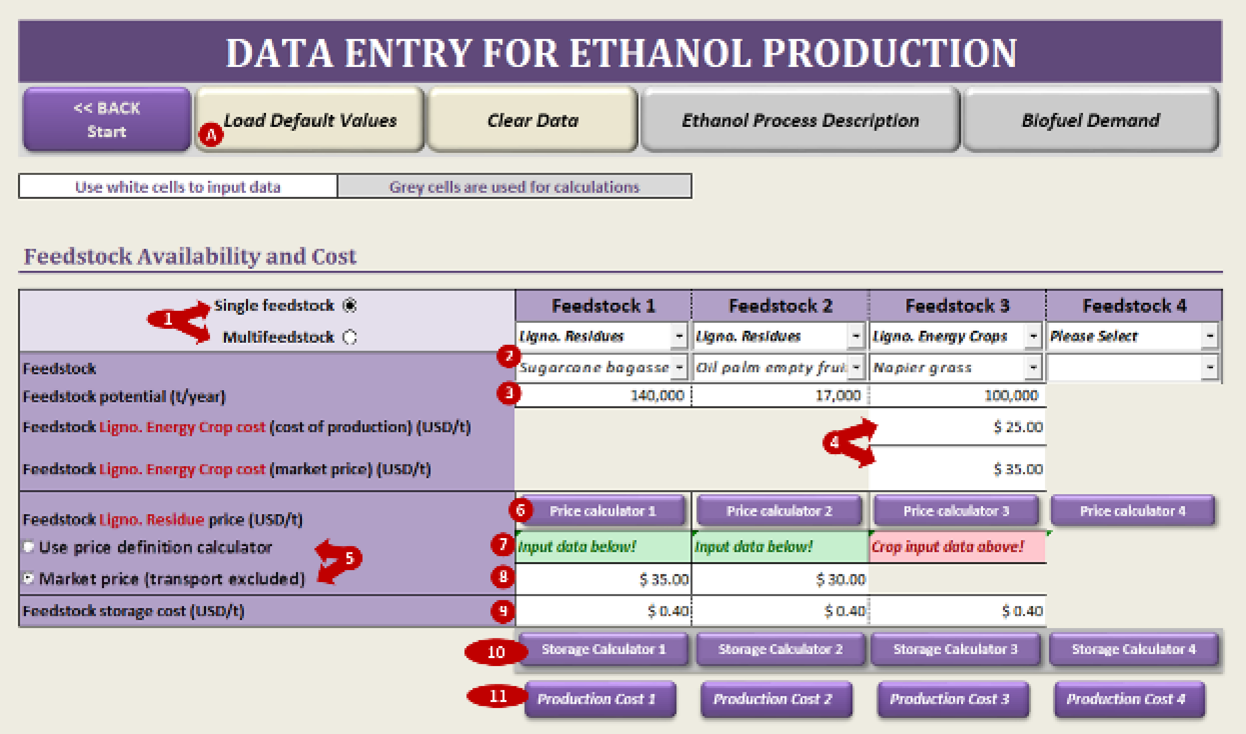


Figure **5**, label 11) or continue to insert data into the Data Entry sheet. The user can find a detailed explanation of the structure of the Processing Budget in the Annex.

When multi-feedstock operation mode is selected, the steps for defining the feedstocks, feedstock availability and feedstock pricing remain identical to the previously provided explanations. In this mode, two new buttons are activated: "Feedstock planner" (Figure 8, label 2) and "Production cost MFS" (Figure 8, label 3). Clicking on "Feedstock planner" will direct the user to a new sheet (*Planner _MFS*) where the biomass potential capacity of each feedstock (feedstock potential in Data Entry) needs to be allocated on a monthly basis in order to calculate the storage capacity needs. In this worksheet, the user will need to distribute each biomass in each month, according to the country context on seasoning (Figure 9, label 1). The user may leave months unfilled but allocating all biomass inputs in the selected operating months. In case the monthly distribution of feedstock is unknown, the user can click on *"spread"* (Figure 9, label 2) to distribute the feedstock in even fractions across the twelve months. Depending on the distribution selected by the user, the storage capacities rates are calculated on a monthly basis and extrapolated to the predefined ethanol capacities (5, 25, 25 and 100 million litres per year) (Figure 9, label 3). Next, the maximum required capacity is computed and used as input in the storage costs calculations at the different pre-defined capacities (Figure 9, label 4).

Similar to the case of single feedstock mode, at this stage, the user may choose either to look at how production costs are structured (Figure 8, label 3) or continue to insert data into the Data Entry sheet.

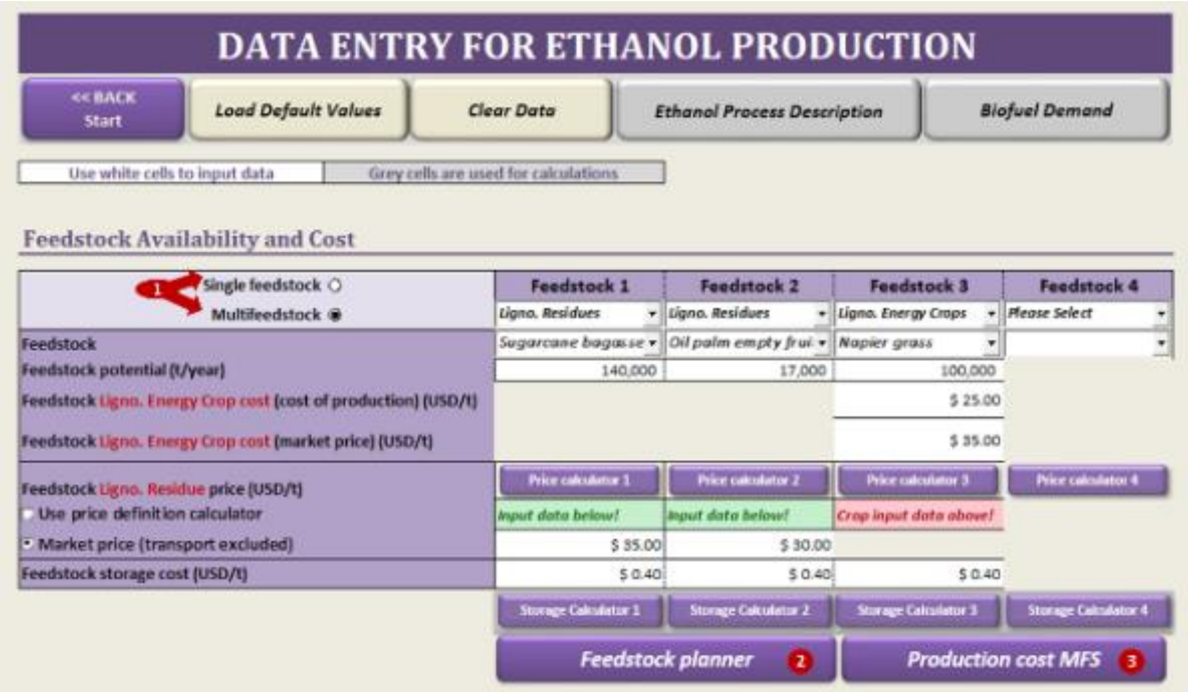


Figure 8: Data Entry for Liquid Biofuels: Feedstock Availability and Cost, Multi-feedstock Operation Mode

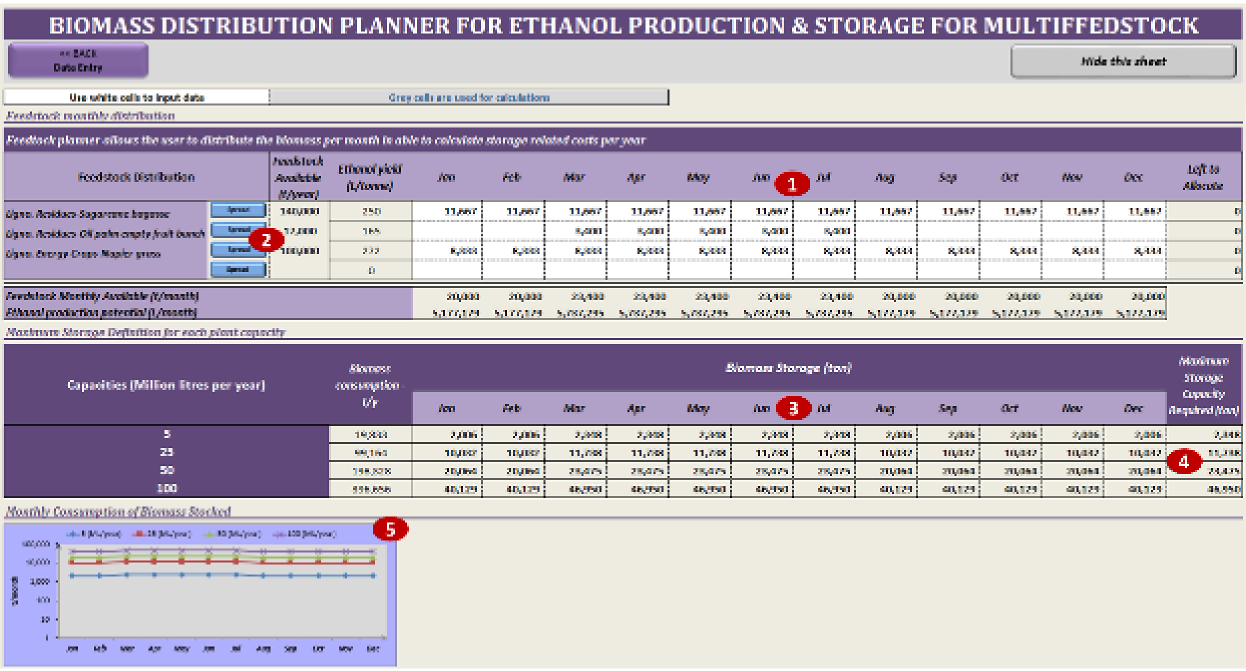


Figure 9: Feedstock Planner and Storage Calculator for Multi-feedstock Operation Mode

5.2.2 Biofuel production cost and financial parameters

In this section, the user is asked to select the technologies for 2G ethanol production, and enter data related to inputs used in feedstock processing, specifically: chemical inputs, heat carrier, electricity and water, and labour. Additional data related to transport, feedstock collection and storage costs as well as other costs and the price of co-products are also required here.

1. Selection of technologies

In this section, the user has the option to choose between two pre-treatment technologies for 2G ethanol production: dilute acid and steam explosion (Figure 10, labels 1). In the processing of the feedstocks, there is always an unconverted solid fraction (*i.e.,* lignin) which can be considered as a co-product of 2G ethanol production, or which can be used as fuel for energy production (in the form of electricity and/or heat). The user has the option to choose between different cogeneration technologies (Figure 10, labels 2). Four are included: no cogeneration, simple technology (electricity production only), semi-advanced (combined heat and power using back-pressure steam turbine technology) and advanced (combined heat and power biomass gasification combined cycle). In the case in which no cogeneration is selected, lignin is automatically considered as co-product and thus its pricing need to be included (**Figure 16**, label 2, price of co-products). In the case of selecting any cogeneration technology, the analysis first estimates whether the produced electricity and steam can cover the energy demand of the 2G ethanol plant. If electricity surplus is achieved after covering the energy demand, this is considered as co-product of the 2G ethanol system and thus its price needs to be included (**Figure 16**, price of co-products). In the case of Colombia, the combination of dilute acid technology and advanced cogeneration technology was selected.

2. Chemical inputs and utilities (heat carrier, water and electricity)

Chemical inputs used in feedstock processing are: ammonia, yeast, sulfuric acid and enzyme (Figure 10, labels 3) for 2G ethanol production. The user must enter input prices in USD/t and can research online for current prices[9]. The user also has to insert the prices of heat carrier (USD per t), water (USD per m^3) and electricity (USD per kWh) employed in the transformation process (Figure 10, label 4).

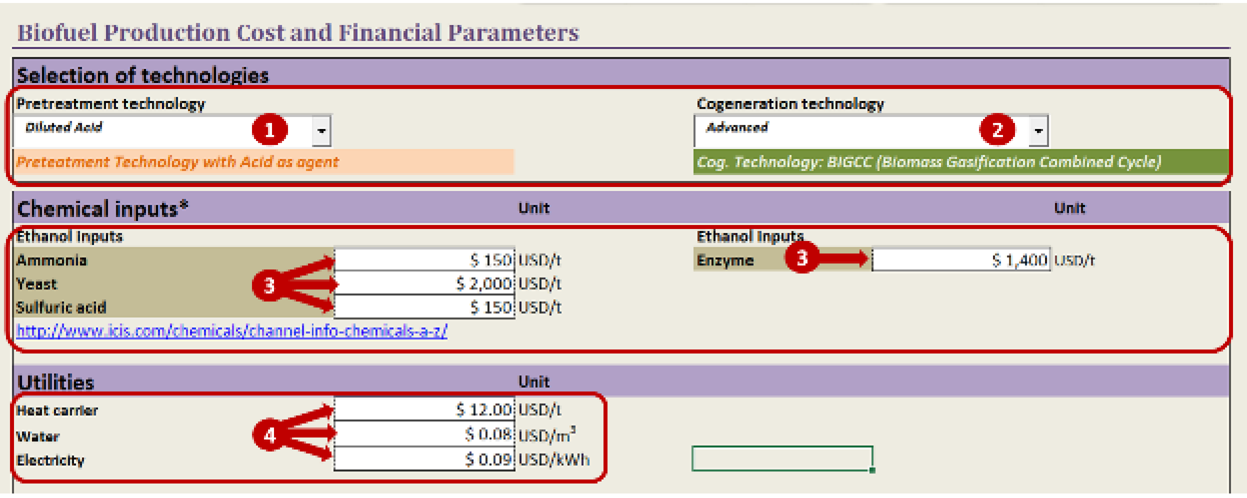


Figure 10: Data Entry for Liquid Biofuels: Selection of Technologies, Chemical Inputs and Utilities

3. Labour cost, working days per year and miscellaneous costs

The user should enter (unskilled and skilled) labour cost rates for the feedstock processing step (industry), in accordance with the national average wages (expressed in USD per person per hour) (Figure 11, label 1). The user should also enter (unskilled and skilled) labour cost rates for the feedstock collection step (Agriculture – Collection, expressed in USD per person per hour) (Figure 11, label 2). The number of 333 working days per year was assumed for the case of Colombia (Figure 11, label 3). However, given the significant differences

[9] For example, see http://www.icis.com/chemicals/channel-info chemicals-a-z/.

among countries regarding this parameter, the user may insert the number of working days per year which better reflects the country's reality. The user should also indicate the share of miscellaneous costs expressed as percentage of total labour cost (Figure 11, label 4). Miscellaneous costs comprise the cost of operating supplies and laboratory charges required for the daily processing activity. A default value of 25% was established as default.

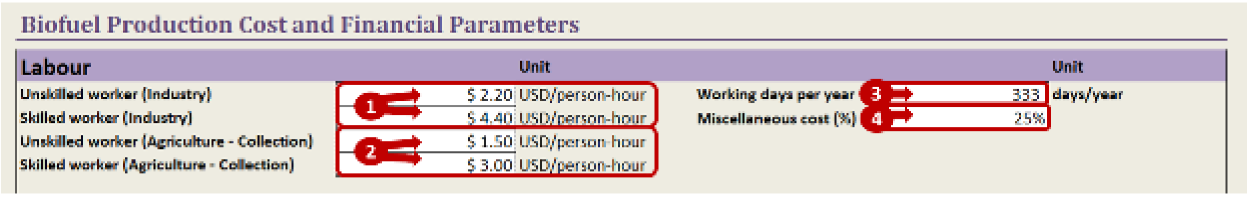


Figure 11: Data Entry for Liquid Biofuels: Labour Cost, Working Days per Year and Miscellaneous Costs

4. Feedstock collection

In this section, the user has to insert the working hours per day of manual biomass collection (Figure 12, label 1), the working hours per day of mechanized biomass collection (Figure 12, label 2), and diesel price to run the machinery for collection (Figure 12, label 3). This data is used as input for feedstock price calculator (Figure 6).

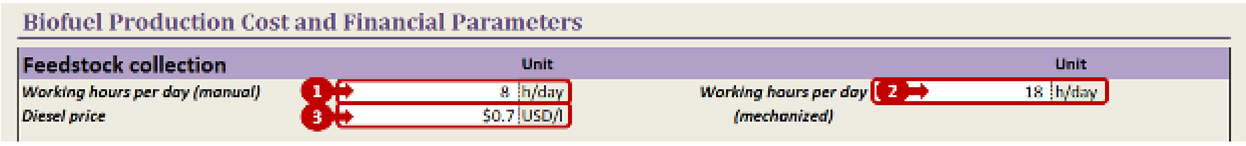


Figure 12: Data Entry for Liquid Biofuels: Feedstock Collection

5. Transportation cost

In this section, the user has to insert the feedstock transportation cost from farm gate to the processing plant (Figure 13, label 1), expressed in USD per t per kilometre.

The analysis does not consider the transportation cost of the final product from the plant to the distribution point.

Figure 13: Data Entry for Liquid Biofuels: Transportation Cost

6. Storage parameters

The user has to enter the storage cost for liquid biofuels (USD per litre per year) in the country (Figure 14, label 1). The storage rate of ethanol (%) is also defined by the user (Figure 14, label 2). In an industrial operation, a portion of the total product is stored before transportation and/or as a safety storage rate in case of stops or failures in production. The standard value for this is 20-30%.

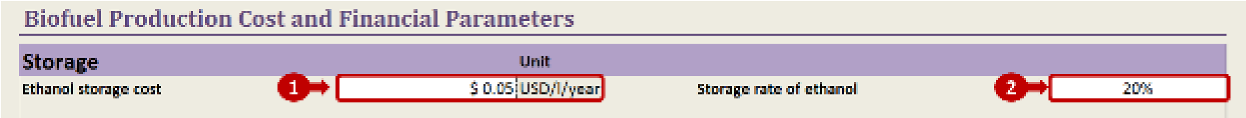


Figure 14: Data Entry for Liquid Biofuels: Storage Parameters

7. Other costs

Additional costs which cannot be easily calculated are estimated. These include:

- Maintenance costs (maintenance of equipment and devices), calculated as a percentage of the total cost of depreciation (default value is 20%) (Figure 15, label 1);
- Plant overhead (general expenditures), expressed as a percentage of the sum of labour costs and maintenance costs (default value is 20%) (Figure 15, label 2); and
- General and administrative costs (rent, insurance, managerial and administrative staff salaries), expressed as a percentage of the sum of plant overheads, maintenance, total labour costs and the other costs except the expenditure for feedstock purchase (default value is 8%) (Figure 15, label 3).

The user can choose different percentages in order to define a more realistic country context.

Figure 15: Data Entry for Liquid Biofuels: Other Costs

8. Price of co-products

The co-products resulting from processing activity are considered in the general inputs section. However, since earnings from co-products are revenues (expressed in USD per t), their total amount is subtracted from total production costs. The following co-products are considered: *carbon dioxide (CO_2)* from fermentation stage[10] (Figure 16, label 1), *lignin* (if cogeneration is not considered; Figure 16, label 2), and *electricity* (if surplus from cogeneration is available; Figure 16, label 3).

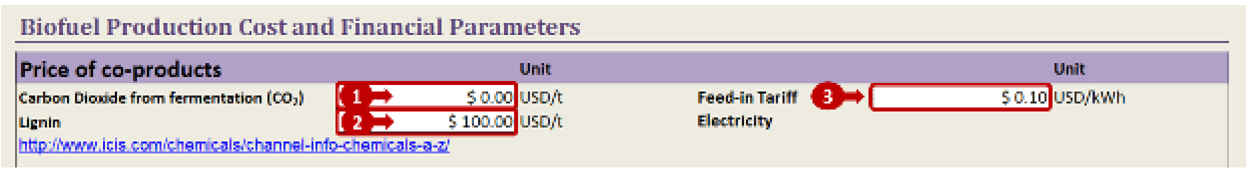


Figure 16: Data Entry for Liquid Biofuels: Price of Co-products

9. Price of transport fuels and net trade balance

Fossil fuels and liquid biofuels prices are taken into consideration in order to compare the production cost of liquid biofuel with the prices of alternative energy sources (international price of liquid biofuels and fossil fuel equivalent prices).

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[10] Please be aware that carbon dioxide produced during the fermentation step, do not represent the entire CO_2 emissions of the process. In some countries, this CO_2 stream is sold to surrounding industries. The most conservative approach assumes a selling price of 0 USD/t for the Colombian case.

The user is asked to specify whether the country considered in the analysis is: a net importer or exporter of fossil fuels (Figure 17, label 1); a net importer, net exporter, or interested in exporting liquid biofuels (Figure 17, label 2). The user has also to indicate whether the main port is located next to the main city in the country (Figure 17, label 3). Depending on the selections made, the user is confronted with different scenarios, which entail different price comparisons and data requirements (see section 3.1.2).

For fossil fuels, the FOB price of gasoline will be used if the country is a net importer (Figure 17, label 4). Otherwise, if the country is a net exporter, the Factory Gate Price (FGP) of gasoline price will be considered. If the main entry port of fossil fuels does not correspond with the main city (and thus consumption point) in the country, the user is asked to consider the transport cost from the port to the main city (Figure 17, label 6).

As for liquid biofuels, if the country is a net importer, the FOB price of ethanol will be considered. Otherwise, the average factory gate price of ethanol will be used[11]. Furthermore, if the main entry port for liquid biofuels does not correspond with the main city (and thus consumption point) in the country, the user is asked to consider the transport cost from the port to the main city (Figure 17, label 6). Finally, in the case of a country interested in exporting, the FOB price of ethanol to which the transport cost from the main city to the exit port is subtracted, should be considered (Figure 17, label 5).

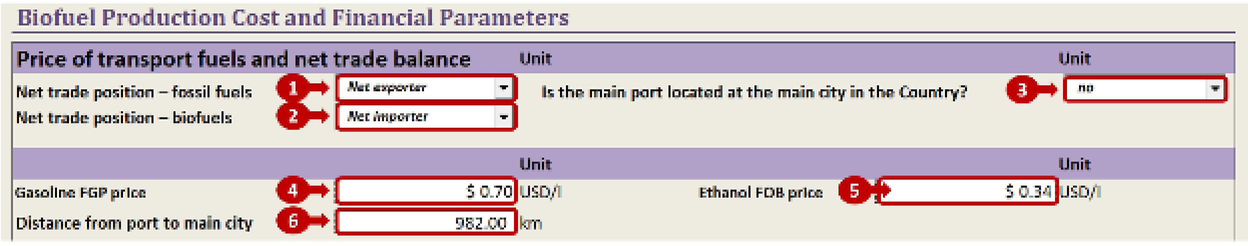


Figure 17: Data Entry for Liquid Biofuels: Price of Transport Fuels and Net Trade Balance

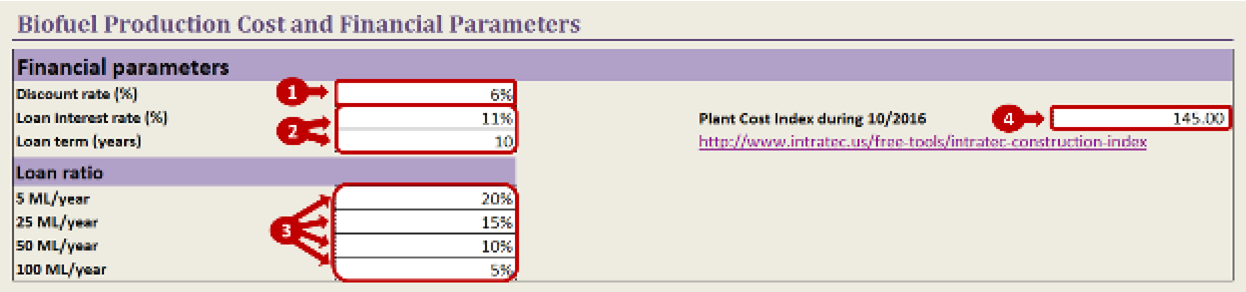
10. Financial parameters

A set of financial parameters should be entered in order to estimate the NPV and IRR indicators.

First, the user must enter the discount rate percentage. The default value is the interest rate charged by the country's central bank on government securities (Figure 18, label 1).

Second, since the tool takes into consideration the option of receiving a loan for realizing the investment, the loan interest rate (in percentage) and the number of years planned for repayment (loan term) are taken into account (Figure 18, label 2). The tool allows the user to set the loan amount through a specific coefficient that can be inserted for each plant size (Figure 18, label 3). The loan amount is computed as a percentage (the so called 'loan ratio') of the investment costs. The costs of the investment can be updated using the 'Plant Cost index' (Figure 18, label 4). Please note that if the plant cost index is not introduced by the user, the calculations will be referred to a default 'Plant Cost index' of 142.

[11] This is useful, for instance, when assessing the competitiveness of alternative feedstock for the biodiesel/ethanol already produced in the country.



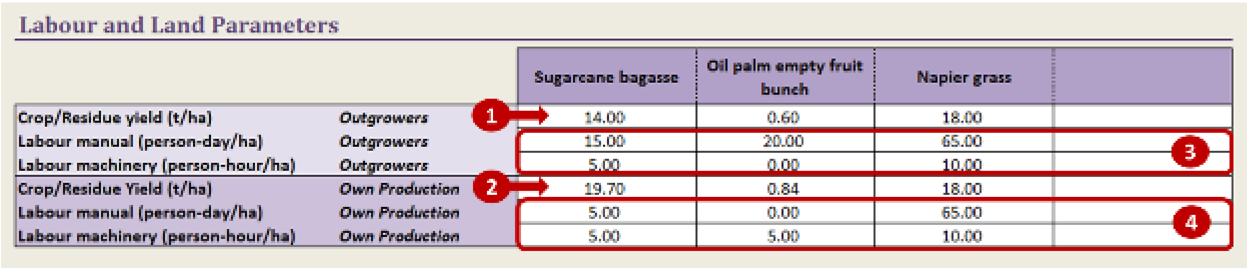
Biofuel Production Cost and Financial Parameters

Financial parameters			
Discount rate (%)	6%	Plant Cost Index during 10/2016	145.00
Loan interest rate (%)	11%	http://www.intratec.us/free-tools/intratec-construction-index	
Loan term (years)	10		
Loan ratio			
5 ML/year	20%		
25 ML/year	15%		
50 ML/year	10%		
100 ML/year	5%		

Figure 18: Data Entry for Liquid Biofuels: Financial Parameters

5.2.3 Labour and land parameters

In order to estimate labour requirements under different biofuel production schemes, the tool makes use of crop residue yields (Figure 19, labels 1 and 2), labour manual and labour machinery parameters (Figure 19, labels 3 and 4). The data need to be retrieved by the user before running the tool. The users may insert data which better reflects the country reality.



Labour and Land Parameters

		Sugarcane bagasse	Oil palm empty fruit bunch	Napier grass	
Crop/Residue yield (t/ha)	*Outgrowers*	14.00	0.60	18.00	
Labour manual (person-day/ha)	*Outgrowers*	15.00	20.00	65.00	
Labour machinery (person-hour/ha)	*Outgrowers*	5.00	0.00	10.00	
Crop/Residue Yield (t/ha)	*Own Production*	19.70	0.84	18.00	
Labour manual (person-day/ha)	*Own Production*	5.00	0.00	65.00	
Labour machinery (person-hour/ha)	*Own Production*	5.00	5.00	10.00	

Figure 19: Data Entry for Liquid Biofuels: Labour and Land Parameters

5.2.4 Additional Calculations/Analyses

In this section, the user can activate/deactivate (Figure 20, label 1) the GHG emission analysis for each feedstock (By clicking on the buttons the user will be directed to the GHG analysis for each feedstock, Figure 20, label 2). The GHG emission analysis is further explained in section 5.4. The user can also activate/deactivate the mass and energy balances details, for each technology and each feedstock at the different plant capacities (Figure 20, label 3; New sheets will be displayed in the sheet menu as seen in Figure 20, label 5)

At this stage, the user may choose either to look at the Summary of Results-Comparative, Summary of Results-By Feedstock or Summary of Results-Labour (Figure 20, label 4). Figure 20 shows the display for single feedstock operation. In the case, multi-feedstock operation other button will be available to direct the user to multi-feedstock Summary of Results.

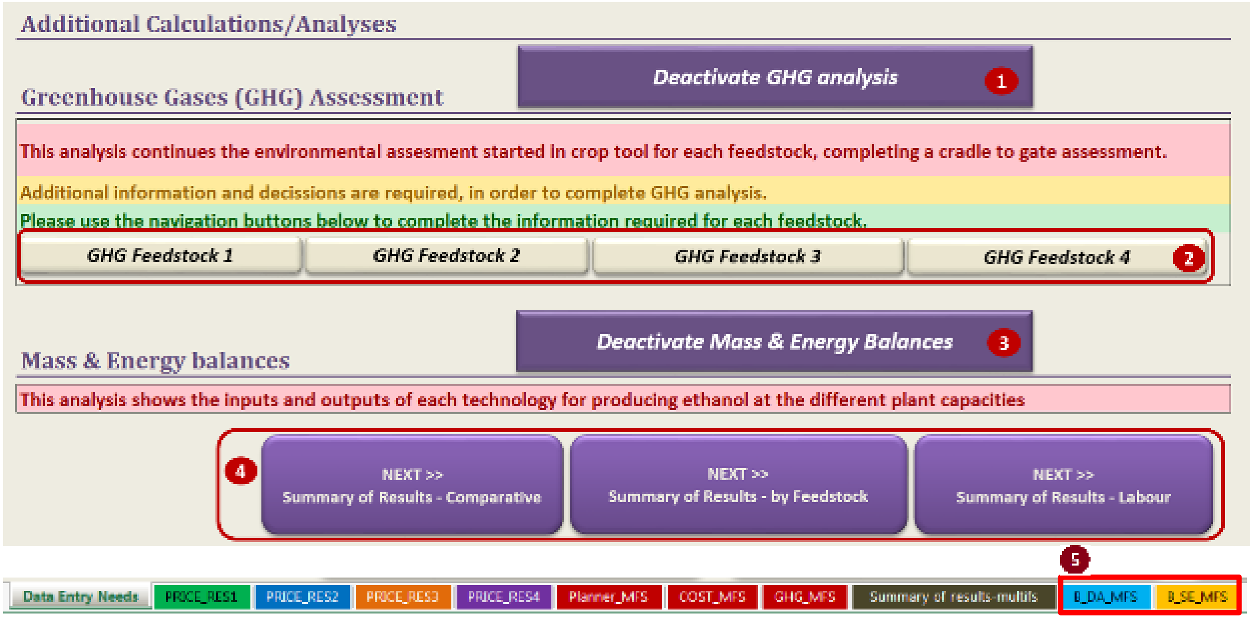


Figure 20: Data Entry for Liquid Biofuels: Additional Calculations/Analyses

5.3 Step 3: Processing costs

Overall, liquid biofuel production costs for any production scheme are included in the *Cost_Fs* sheets (there is one sheet for each selected feedstock, and *Cost_MFs* for multi-feedstock). This section reports summary information in reference to feedstock and storage and financial parameters (Figure 21, labels 1 and 2).

The transport distance section considers the average distance from the farm to the processing plant (Figure 21, label 3) and the amount of feedstock (Figure 21, label 4) for each plant size.

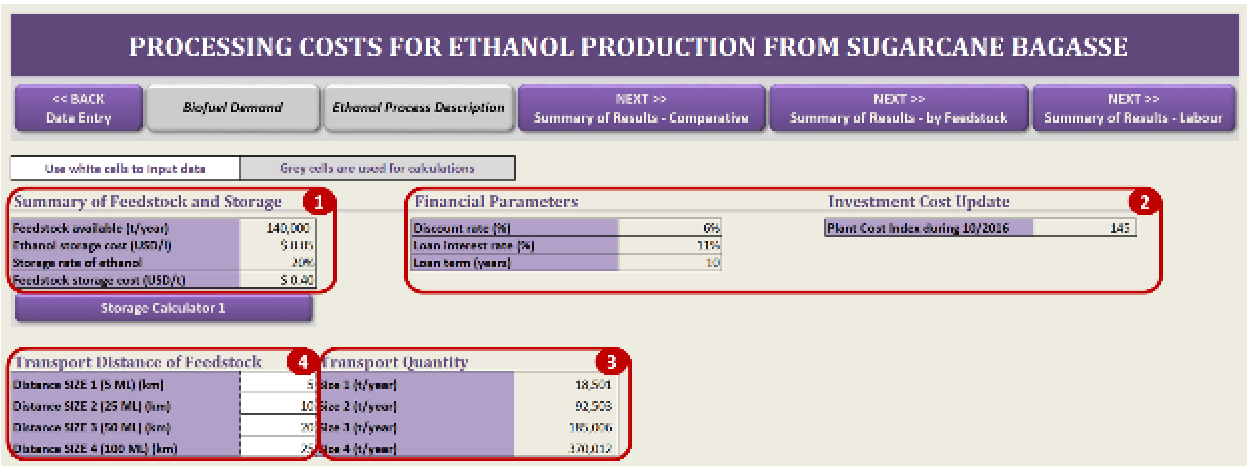


Figure 21: Processing Costs for Liquid Biofuel Production

The production schemes considered (outgrowers, own production and mixed outgrowers-own production) (see section 3.2) reflect the analytical scenarios which can be built using the tool. This is shown in Figure 22. As mentioned previously, in Scenario 2 (mixed scheme) the share of different farmer types involved in feedstock production could change depending on the country context (the user can use the "*Modify Ratios*" buttons to make any adjustments) (Figure 22, label 1).

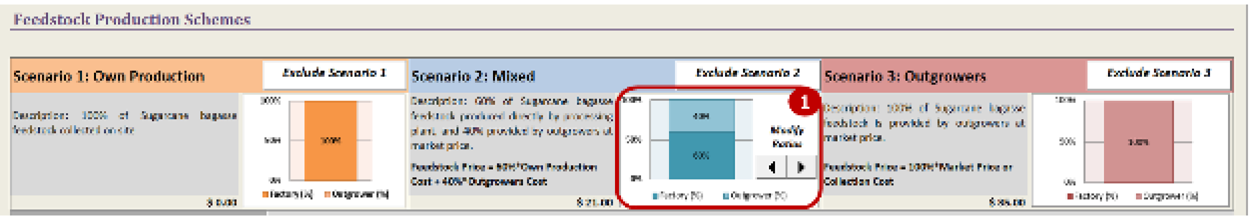


Figure 22: Feedstock Source Scenarios

The liquid biofuel processing budget allows computing production cost for ethanol production for plants of different capacities. The processing budget includes the costs of: inputs (raw materials), labour (skilled and unskilled), transport cost from farm to processing plant, investments, maintenance activities, and storage. Additional costs, such as plant overhead, general and administrative costs, are also computed. Credits by co-products are also included in this section (The processing budget is identical for multi-feedstock operation). These values are used to estimate the production cost per litre for each plant size. The results calculated with this tool are indicative under a global context and are applicable to different developing countries[12].

	Capacities (Million litres per year)			
	5 Operating hours per year 7,992	25 Operating hours per year 7,992	50 Operating hours per year 7,992	100 Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)	Financial Assessment Sc 1 (50 ML/year)	Financial Assessment Sc 1 (100 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)	Financial Assessment Sc 2 (50 ML/year)	Financial Assessment Sc 2 (100 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)	Financial Assessment Sc 3 (50 ML/year)	Financial Assessment Sc 3 (100 ML/year)

Total Production Costs (USD/year)

	Total (USD/year)	Total (USD/l)	Total (USD/year)	Total (USD/l)	Total (USD/year)	Total (USD/l)	Total (USD/year)	Total (USD/l)
Scenario 1								
Total operating costs	$ 1,470,147	$ 0.29	$ 4,998,988	$ 0.20	$ 10,116,982	$ 0.20	$ 20,418,970	$ 0.20
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22	$ 8,559,540	$ 0.17	$ 13,222,827	$ 0.13
Total other costs	$ 569,065	$ 0.11	$ 1,186,326	$ 0.05	$ 1,895,611	$ 0.04	$ 3,110,831	$ 0.03
Co-Products Credits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total production costs scenario 1 (USD/year)	$ 4,111,543		$ 11,750,987		$ 20,575,132		$ 36,752,628	
Total production costs scenario 1 (USD/l)		$ 0.82		$ 0.47		$ 0.41		$ 0.37
Scenario 2								
Total operating costs	$ 1,858,680	$ 0.37	$ 6,941,552	$ 0.28	$ 14,002,110	$ 0.28	$ 28,189,226	$ 0.28
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22	$ 8,559,540	$ 0.17	$ 13,222,827	$ 0.13
Total other costs	$ 569,065	$ 0.11	$ 1,186,326	$ 0.05	$ 1,895,611	$ 0.04	$ 3,110,831	$ 0.03
Co-Products Credits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total production costs scenario 2 (USD/year)	$ 4,500,056		$ 13,693,550		$ 24,460,260		$ 44,522,884	
Total production costs scenario 2 (USD/l)		$ 0.90		$ 0.55		$ 0.49		$ 0.45
Scenario 3								
Total operating costs	$ 2,117,669	$ 0.42	$ 8,236,594	$ 0.33	$ 16,592,195	$ 0.33	$ 33,369,396	$ 0.33
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22	$ 8,559,540	$ 0.17	$ 13,222,827	$ 0.13
Total other costs	$ 569,065	$ 0.11	$ 1,186,326	$ 0.05	$ 1,895,611	$ 0.04	$ 3,110,831	$ 0.03
Co-Products Credits	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total production costs scenario 3 (USD/year)	$ 4,759,064		$ 14,988,593		$ 27,050,345		$ 49,703,054	
Total production costs scenario 3 (USD/l)		$ 0.95		$ 0.60		$ 0.54		$ 0.50

Figure 23: Budget Structure: Processing Costs

5.4 Step 4: GHG Calculation Option

This optional feature allows the user to measure the potential environmental impacts during the production of biodiesel and ethanol, in terms of potential GHG emissions. To utilise this option, the user must activate the GHG analysis option in the Data Entry for Ethanol Production sheet. The GHG emissions are split in three main steps: Crop/Residue production (Figure 24, label 1), feedstock and residue transportation (Figure 24,

12 ASPEN Plus™ V7.1 (http://www.aspentech.com/products/aspen-plus.aspx) process simulation software was employed in the development of the technical processing model for the production of 5, 25, 50, 100 million litres per year.

label 2), biofuel processing emissions (Figure 24, label 3). Clicking on the results button (Figure 24, label 4), the user will be directed to the aggregated emissions of the three steps, expressed in kg CO_2-eq per litre ethanol, for each scenario based on production schemes (outgrowers, own production and mixed outgrowers-own production) and each plant capacity.

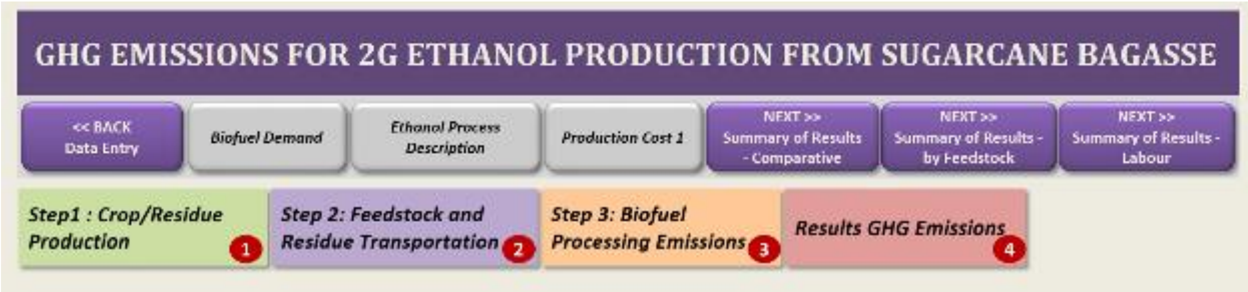


Figure 24: GHG emissions: Life cycle steps

The Crop/Residue production step reports the emissions related to the feedstock collection/production (Figure 25, labels 2 and 3). The user has to enter the emission factor for each residue/crop differentiated in own production and outgrowers (Figure 25, label 1).

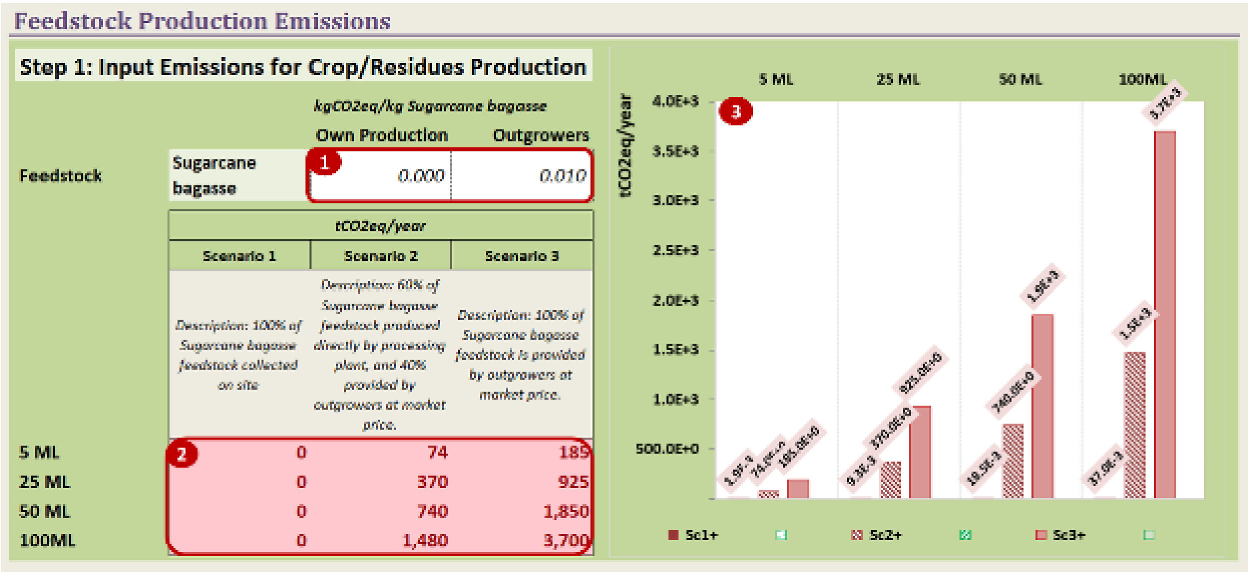


Figure 25: GHG emissions: Feedstock production

The *Feedstock and Residues Transportation* step reports the emissions related to feedstock transportation (Figure 26, label 1), and waste streams generated in the process (Sludge for 2G ethanol; Figure 26, label 2). The user should enter data related to the transport distance for the residues (Figure 26, label 3).

Feedstock and Residues Transportation

Step 2: Input transportation distances for residues

Feedstock Transported	*Sugarcane bagasse*	Residues Transported	*Sludge*
Mean of Transport	*Truck for dry product (Diesel)*	Mean of Transport	*Tanker truck MB2318 (Diesel)*

Plants	Quantity (t/year)	Distance (km)	tCO2eq/year	Plants	Quantity (t/year)	Distance (km)	tCO2eq/year
5 ML	18,501	5	14	5 ML	5,211	20	17
25 ML	92,503	10	140	25 ML	26,053	20	85
50 ML	185,006	20	562	50 ML	52,105	20	170
100 ML	370,012	25	1,404	100 ML	104,210	20	339

Figure 26: GHG emissions: Feedstock and Residues Transportation

The biofuel processing step reports the annual energy consumption of the 2G ethanol processing plant at the different default capacities (prior integration with cogeneration; Figure 27, label 1). Based on this information, the analysis accounts for two options for supply this energy: all energy consumption of the plant is supplied using external sources (Method 1) or all energy consumption of the plant is supplied using a cogeneration system using either biomass or fossil fuels (Method 2). The user can choose between the two methods for calculating the emissions related to the processing step by clicking on the button *"Switch to method"* (Figure 27, label 2). The user should consider that although a cogeneration technology was selected in the data entry (Section 5.2.2), the user is still able to choose whether to include cogeneration in the calculations of GHG emissions. This is useful information in order to assess the effect of possible GHG saving by including the cogeneration system. Figure 27 shows the display structure of GHG emissions of the processing step when no generation is considered (Method 1). In this configuration, the user has the option to choose whether both heat and electricity are covered by standalone technologies (not cogeneration) using fossil fuels, or if heat is covered by fossil fuels and electricity by the central grid (Figure 27, label 3). To calculate the emissions related to electricity from the central grid, the user needs to select the emission factor from a dropdown list (Figure 27, label 4). The user needs to select the fuel source for each ethanol plant capacity (Figure 27, label 5). There is an option to set the fuel equally for all capacities (Figure 27, label 6). This section reports the fuel consumption to cover the energy requirements (Figure 27, label 7), as well as the emissions related to the processing plant (using Method 1; Figure 27, label 8).

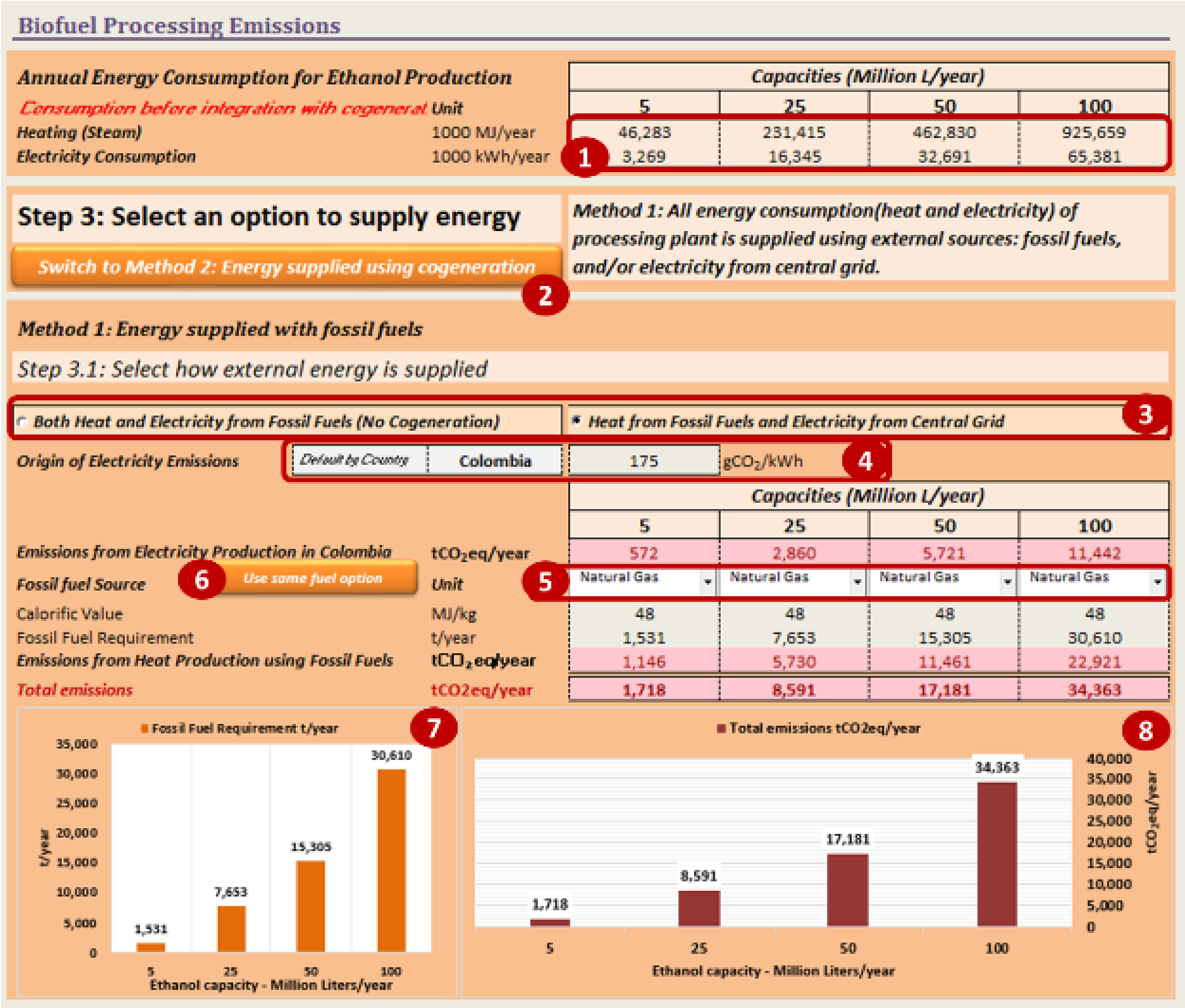
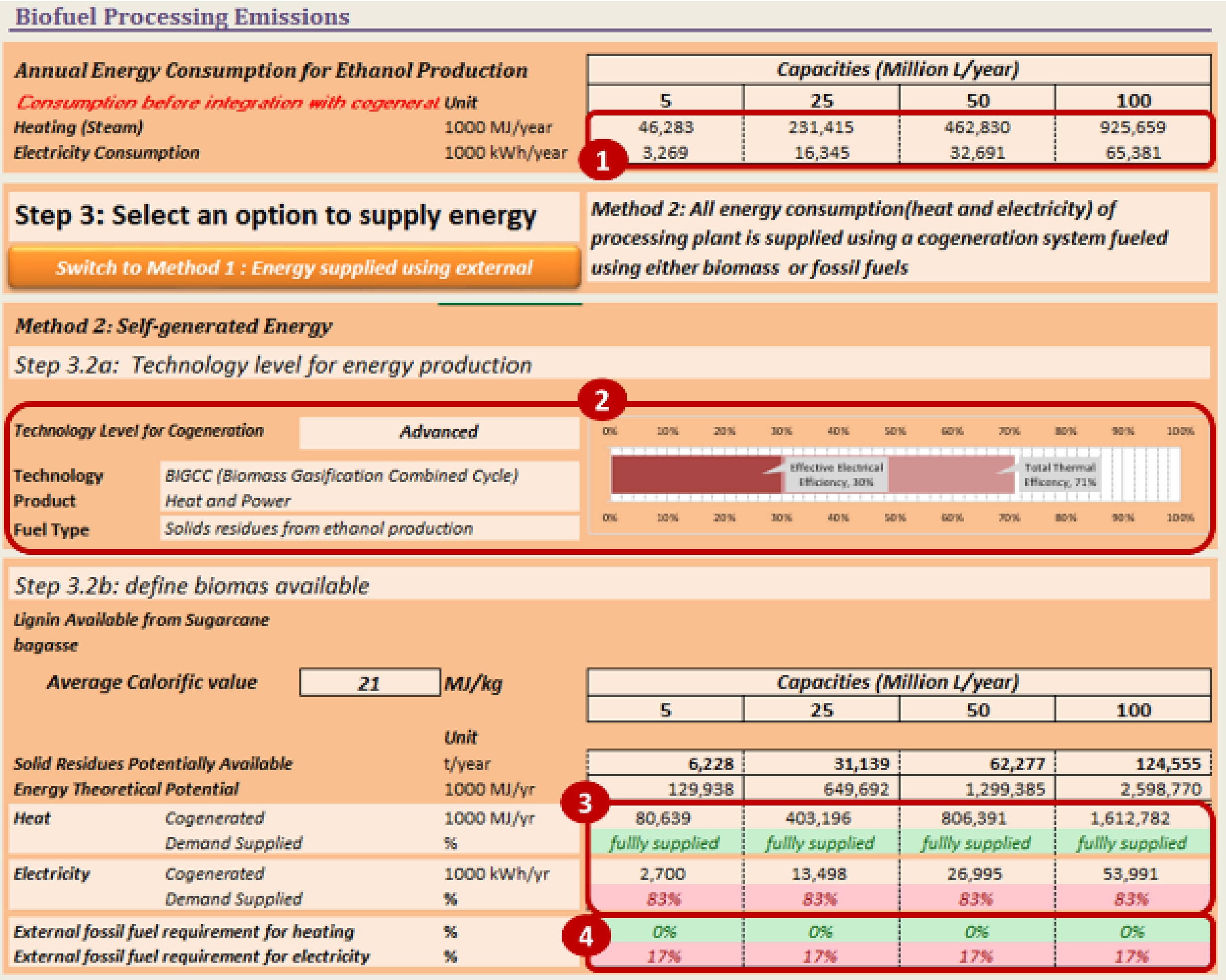


Figure 27: GHG emissions: Biofuel Processing Emissions (Method 1)

Figure 28 shows the display structure of GHG emissions of the processing step when energy cogeneration is considered (Method 2, Part a). This section also reports the annual energy consumption of the 2G ethanol processing plant at the different default capacities (prior integration with cogeneration; Figure 28, label 1). This section reports the technology used for cogeneration (In alignment with the selection made in Data Entry, see section 5.2.2), and the thermal and electric efficiencies used in the calculations (Figure 28, label 2). This section also reports what amount of the total energy requirement of the ethanol plant is able to be covered by the cogeneration of lignin (Figure 28, label 3). In the sugarcane bagasse case, 100% of the demand of steam is covered, while 83% of the total electricity demand is covered by lignin cogeneration. The remaining percentage of external fossil fuel required to cover the demand of both steam and electricity is also reported (Figure 28, label 4). Figure 29 shows the continuation of the display structure of the processing step when energy cogeneration is considered (Method 2, Part b). The user needs to select the fuel source to cover the remaining energy requirements for each ethanol plant capacity (Figure 29, label 1). There is an option to set the fuel equally for all capacities (Figure 29, label 2). This section reports the fuel consumption to cover the remaining energy requirements (Figure 29, label 3). The user needs to select the electricity emission factor of the country from a dropdown list, in order to calculate the avoided emissions by using the generated electricity with available lignin (Figure 29, label 4). Predefined emissions factors for all countries were gathered from the IPCC databases. This section then reports the emissions related to additional fuel requirements (from natural gas in this case) and emission saving by electricity generation by lignin. Next, the total emissions of the processing plant are reported (Figure 29, label 5). The coverage of heat and electricity by the cogeneration of lignin is graphically reported (Figure 29, label 6), as well as the total emissions of the processing step (Figure 29, label 7).


Biofuel Processing Emissions

Annual Energy Consumption for Ethanol Production		Capacities (Million L/year)			
Consumption before integration with cogeneral	Unit	5	25	50	100
Heating (Steam)	1000 MJ/year	46,283	231,415	462,830	925,659
Electricity Consumption	1000 kWh/year	3,269	16,345	32,691	65,381

1

Step 3: Select an option to supply energy

Switch to Method 1 : Energy supplied using external

Method 2: All energy consumption(heat and electricity) of processing plant is supplied using a cogeneration system fueled using either biomass or fossil fuels

Method 2: Self-generated Energy

Step 3.2a: Technology level for energy production

2

Technology Level for Cogeneration	Advanced
Technology	BIGCC (Biomass Gasification Combined Cycle)
Product	Heat and Power
Fuel Type	Solids residues from ethanol production

Step 3.2b: define biomas available

Lignin Available from Sugarcane bagasse

Average Calorific value 21 MJ/kg

		Unit	Capacities (Million L/year)			
			5	25	50	100
Solid Residues Potentially Available		t/year	6,228	31,139	62,277	124,555
Energy Theoretical Potential		1000 MJ/yr	129,938	649,692	1,299,385	2,598,770
Heat	Cogenerated	1000 MJ/yr	80,639	403,196	806,391	1,612,782
	Demand Supplied	%	fullly supplied	fullly supplied	fullly supplied	fullly supplied
Electricity	Cogenerated	1000 kWh/yr	2,700	13,498	26,995	53,991
	Demand Supplied	%	83%	83%	83%	83%
External fossil fuel requirement for heating		%	0%	0%	0%	0%
External fossil fuel requirement for electricity		%	17%	17%	17%	17%

3

4

Figure 28: GHG emissions: Biofuel Processing Emissions (Method 2, Part a)

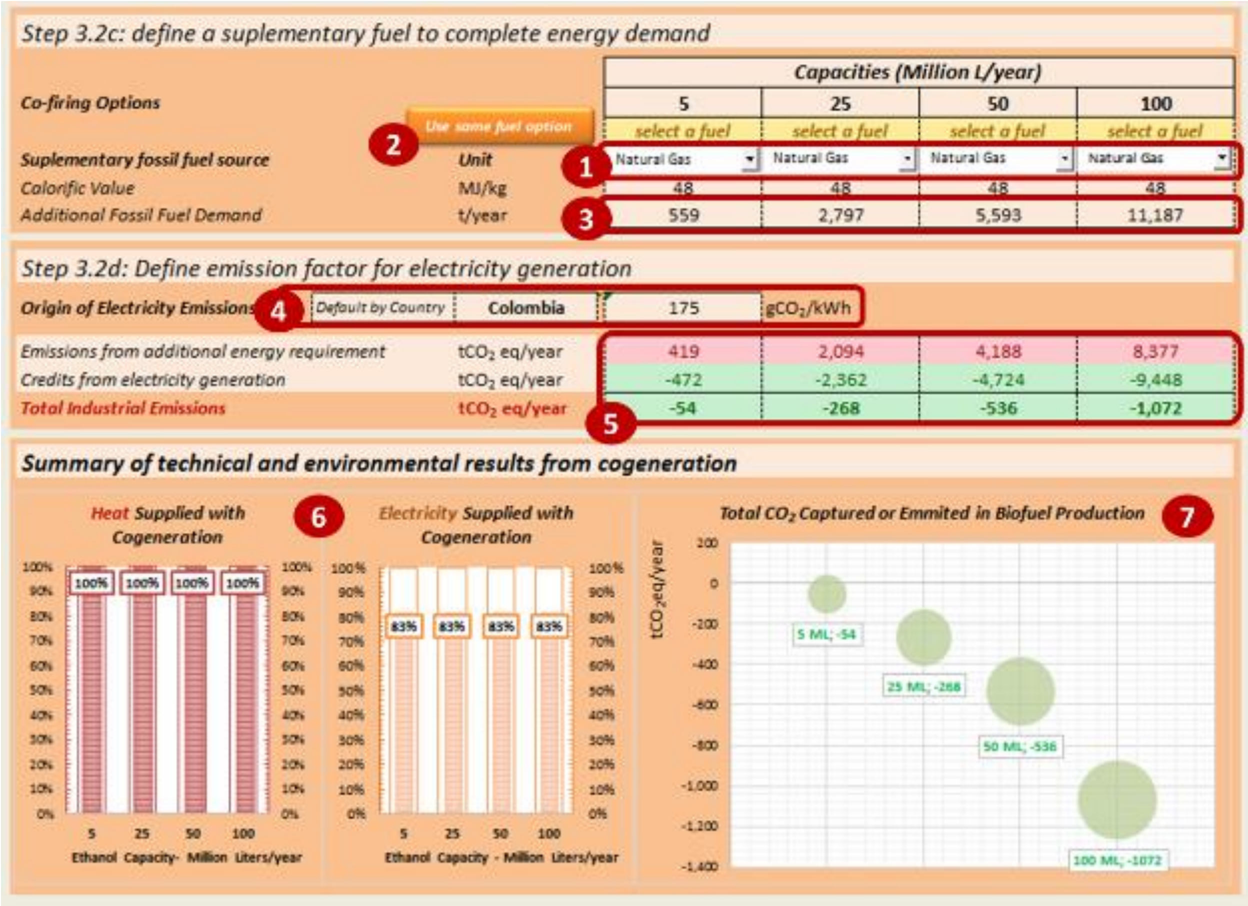


Figure 29: GHG emissions: Biofuel Processing Emissions (Method 2, Part b)

The results of the GHG emissions analysis are summarized by summing the emissions of each step, reported in kg CO_2-eq per litre ethanol (Figure 30, label 1). Emissions of gasoline are also reported (Figure 30, label 2). At this stage, the user may choose either to look at the Summary of Results-Comparative, Summary of Results-By Feedstock or Summary of Results-Labour (Figure 30, label 3). The structure is identical for each all single feedstocks and multi-feedstock operation.

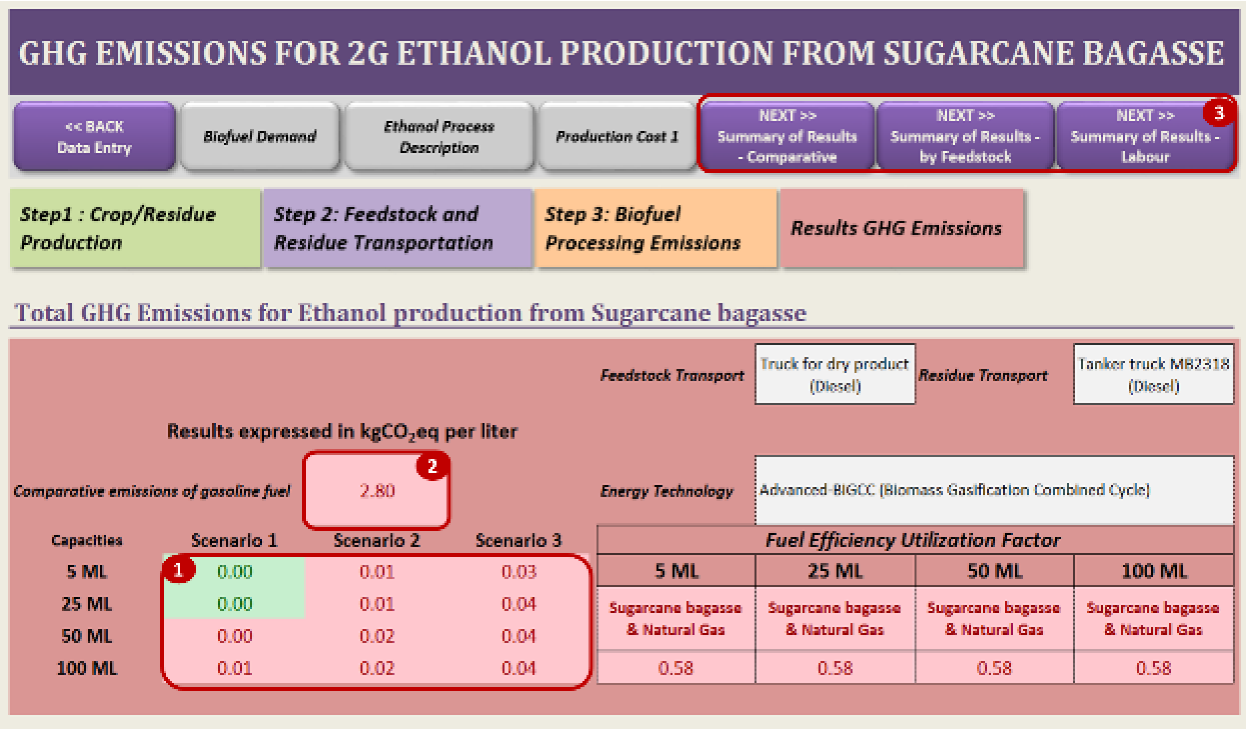


Figure 30: GHG emissions: Results

6 Assumptions and Limitations of the *2G Ethanol Component*

Before starting the analysis, the user should become familiar with the assumptions and limitations of the tool and take them into consideration during the analysis and most especially when interpreting the results.

The basic assumptions of the *2G Ethanol Component* are:

1. Plant sizes and investment lifetime. Four different processing plant sizes (with annual capacities of 5, 25, 50 and 100 million litres) are considered. The investment lifetime is 20 years.
2. Labour demand. The estimation of the potential impact of 2G ethanol production on labour demand concerns only the workers who will be employed in feedstock production and in processing activities. However, those who work in transporting feedstock from the farm to the plant and liquid biofuels from the plant to the distribution areas are not considered.
3. Own production residues price. When agricultural/forestry residues are considered as feedstock, under the own production scheme, the cost is assumed as 0 USD/tonne assuming that all costs (e.g. machinery, labour) are allocated to the related crop.
4. Other assumptions. The number of 300 working days per year is assumed. However, the user may insert a different number in order to allow for country differences.

The details of key assumptions and calculation equations are presented in the Annex.

7 The Results of the *2G Ethanol Component*

These paragraphs show all the results of the *2G Ethanol Component*. The analysis examines the profitability of ethanol production using different lignocellulosic feedstocks, in comparison with a gasoline equivalent price and international price of ethanol. These prices are break-even prices, i.e. prices corresponding to the point at which costs and revenues are equal (profit is zero). An ethanol production cost is lower than the break-even price indicates that production is profitable.

Results are reported in different sheets of the Microsoft Excel files, as presented below:

1) Summary of results by feedstock (Summary of results multi-feedstock);
2) Summary of results - comparative; and
3) Labour analysis.

7.1 The Summary of Results by Feedstock

At the top of the worksheet, summary information is reported. Feedstock selection specifies the selected crop. For example, Figure 31, label 1 refers to sugarcane bagasse-based 2G ethanol production while label 2 shows the price of feedstock for each selected scheme. For each production scheme, Figure 31, label 3 exhibits a window (titled *Include Scenario*) where the user has the option to show the results of the selected scheme in the Summary of Results by Feedstock sheet. Furthermore, the user can return to the Data Entry sheet (Figure 31, label 4), or go to the sheets which show the processing budget structure (Figure 31, label 5) at any time. Finally, the other results are included in the Summary of Results Comparative and Labour Analysis (Figure 31, label 6).

Different indicators of economic profitability of liquid biofuel production by feedstock type are then reported in different sections of this worksheet:

a) the Production Cost and Investment section focuses on the comparison between the production cost of ethanol obtained by plants of different sizes and the equivalent price of gasoline;
b) the Operating Results section reports on the biomass requirement for each crop with respect to the national biomass availability; the number of plants which could be implemented based on the available biomass; the maximum attainable production on 2G ethanol given the available biomass; and the number of new jobs which might be created by establishing the plant;
c) The Financial Analysis section shows the results of the financial evaluation for each plant by applying the NPV and IRR.
d) The GHG Analysis section focuses on the comparison between the GHG emissions of 2G ethanol compared to equivalent emissions of gasoline, and summary of results related to the cogeneration system.

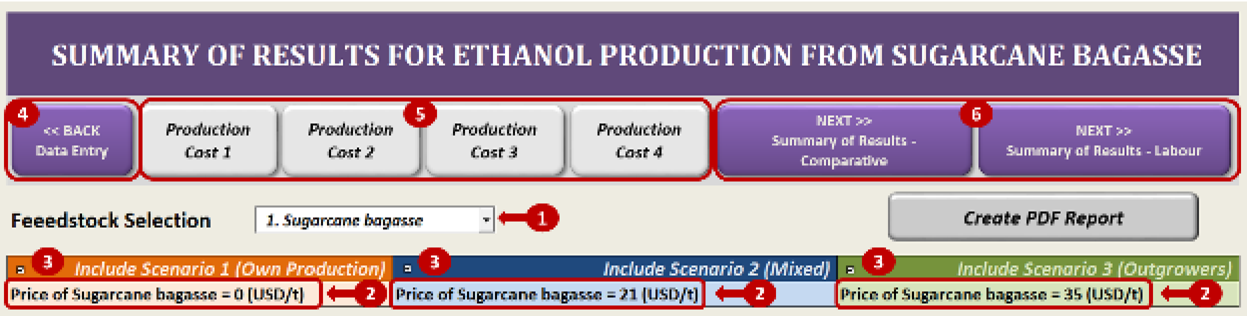


Figure 31: Summary of Results by Feedstock

7.1.1 Production cost and investment results

In this section, a comparison between the biofuel production costs and the prices of alternative energy sources together with the investment costs for all plant sizes is shown.

The fossil fuel equivalent prices and the international prices of liquid biofuel are compared with biofuel production costs under any production scheme in order to assess their profitability. Figure 32 shows the case of a fossil fuel net exporter country (label 1) and refers to 2G ethanol from sugarcane bagasse. Given that Colombia is a net exporter, FGP price of gasoline equivalent is used (Figure 32, label 3) and a comparison is made between production costs and FOB prices of 2G ethanol (Figure 32, label 4). The user can also decide to include the value of co-products in the production costs by clicking in the appropriate window (Figure 32, label 5). Moreover, the tool allows the user to compare a range of production costs corresponding to plants of different sizes (Figure 32, labels 6 and 7).

Under all production schemes, large-sized plants are found to be more competitive than small-sized ones. However, the transition from 25 to 50 million litres and from 50 to 100 million litres exhibits a lower reduction in production costs than between 5 and 25 million litres (Figure 32, label 6 and 7). Figure 32 shows the strong advantage of plants with an annual capacity exceeding 5 million litres.

The configuration of results is identical when multi-feedstock operation is selected.

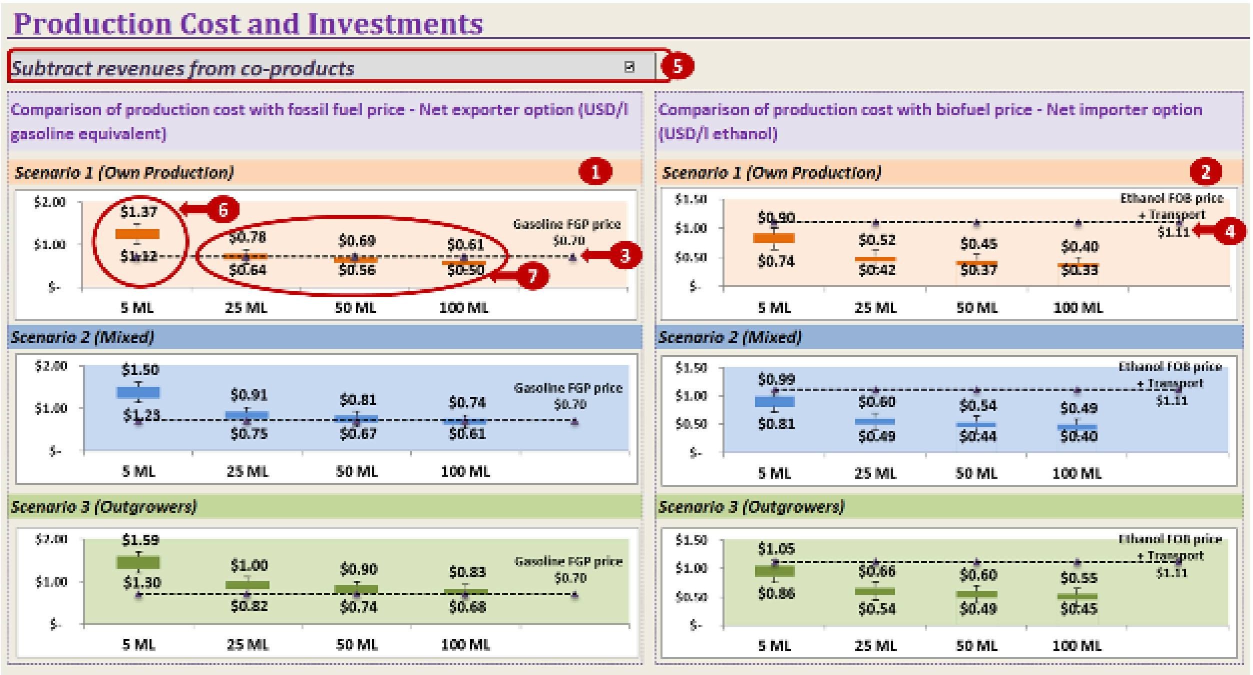


Figure 32: Production Cost and Investment Results: Comparison of Fossil Fuels and Biofuels Basis

Figure 33 (label 1) shows the total investment costs of implementing production through plants of different sizes (5, 25, 50, 100 million litres). The investment includes the cogeneration unit. In case the user selects no cogeneration in the data entry, only the investment of 2G ethanol plant will be shown.

Figure 33: Production Cost and Investment Results: Investments by Plant Size

The next section shows the composition of the production cost for all selected plant sizes and for any production scheme. Figure 34 shows the different elements which compose the production cost of different schemes for a plant: feedstock, other chemical inputs, energy, depreciation and maintenance, other costs, co-products revenues. For example, in the case of 2G ethanol production from sugarcane bagasse, chemical input and depreciation & maintenance are the principal contributors to the overall biofuel production cost.

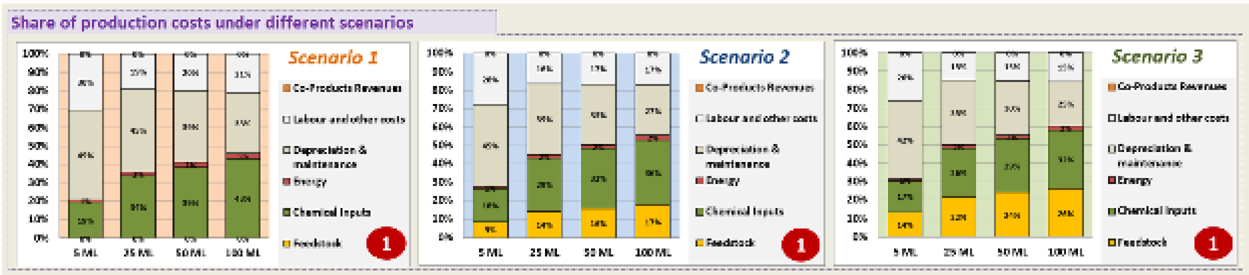


Figure 34: Production Cost and Investment Results: Share of Production Costs under Different Scenarios

7.1.2 Operating results

This section reports information on the opportunity to produce biofuel based on the feedstock availability for each selected crop/residue.

Figure 35 shows whether the biomass requirement (label 1) for each plant size can be satisfied by the available biomass (label 2): the production is feasible only for plant sizes for which the requirement is lower than the available biomass.

Furthermore, Figure 35 includes the number of plants potentially supplied based on the available feedstock for bioenergy purposes. For the example of Colombia, it would be feasible to implement 7 plants of 5 million litres (label 3) or 1 plant of 25 million litres (label 4) for sugarcane bagasse-based 2G ethanol, while it is unfeasible to install a plant of 50 or 100 million litres (label 5). Further information on the plant sizes is reported above this figure. It is important for the user to note that if biomass is available for a certain plant size, then a sentence stating this will be highlighted in green. If this is not the case, then the sentence will be highlighted in red (label 6).

Figure 35 also shows the maximum attainable 2G ethanol production for the selected crops/residues based on the total amount required to respect the mandatory blending indicated in the Biofuel Demand sheet (see the target biofuel production in country, sub-paragraph 5.1). In this example, 2G ethanol sugarcane bagasse-based biofuel is feasible to completely produce the required amount (label 7). Additionally, the total amount of liquid biofuel which is possible to produce from the selected crops is reported (label 8).

Finally, the figure indicates the number of jobs created in 2G ethanol processing for any plant size (label 9).

The configuration of operating results is identical when multi-feedstock operation is selected.

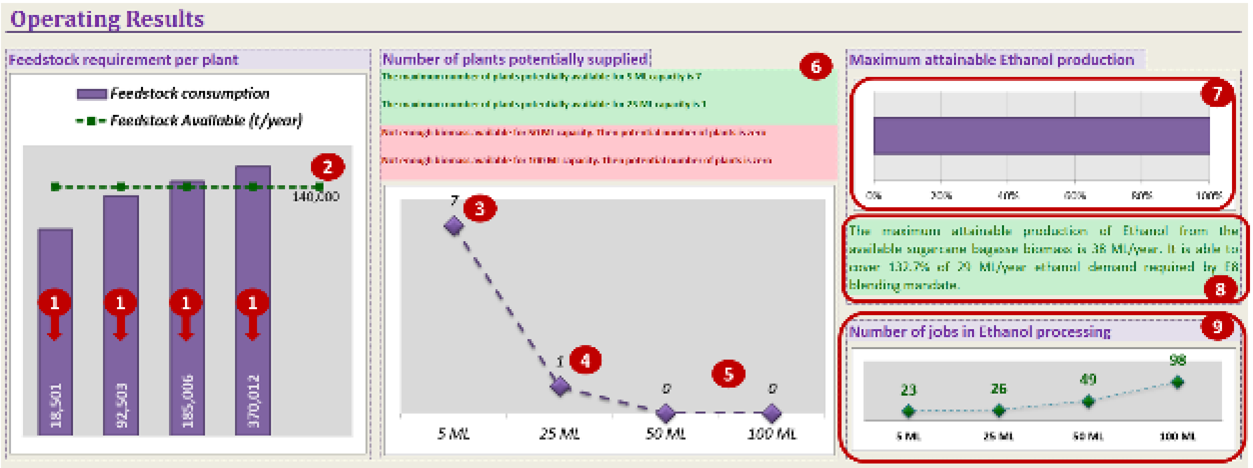


Figure 35: Operating Results: Feedstock Consumption, Number of Plants, Biofuels Production

7.1.3 Financial analysis results

The information presented in this section aims at providing the user with a summary of financial parameters related to liquid biofuel production: NPV and IRR.

When using NPV, the selection criterion is to consider positively all investments with a net present value greater than zero, when discounted at a suitable discount rate, which is most often the opportunity cost of capital. The example reported in Figure 36 shows that the production of liquid biofuels is more profitable in bigger plant sizes: in fact, NPV is negative for a 5 million litres plant in Scenarios 2 and 3 (Figure 36), showing that such a plant size does not represent a profitable investment. On the contrary, NPV is positive for larger plant sizes (Figure 36).

When using the IRR, the selection criterion is to accept all independent projects with an internal rate of return greater than the discount rate adopted, which generally is the opportunity cost of capital. In the example reported here (Figure 36), IRR increases with increased plant dimensions. The chart shows that there is a strict correlation between NPV and IRR: the latter is zero when the former is negative.

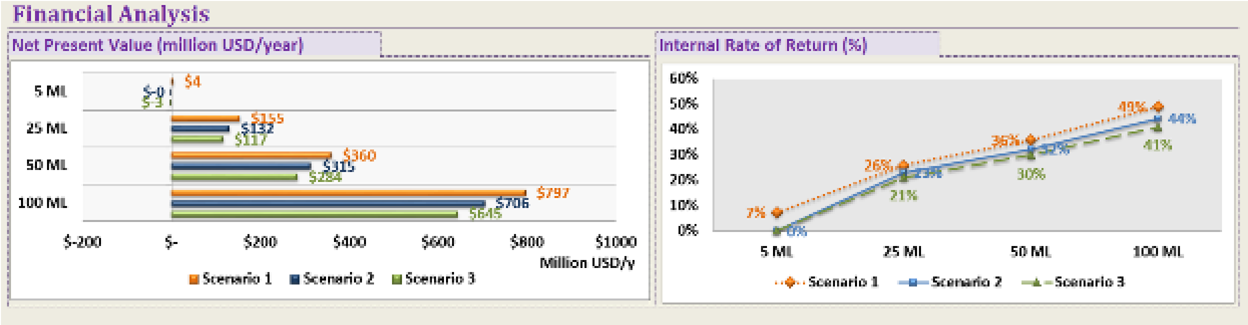


Figure 36: Financial Indicators of Liquid Biofuels Production

7.1.4 GHG Analysis

This section reports information on the GHG emissions of 2G ethanol production and targeted savings in comparison to equivalent emissions of gasoline production. This section also informs on contribution of total GHG emissions of the different steps for 2G ethanol production, and performance parameters of the Cogeneration system.

Figure 37 shows the GHG emissions of 2G ethanol production for the different plant capacities and feedstock scenarios schemes (label 1). The ethanol emissions are compared with emissions for gasoline production (label 2), and target savings selected by the user (label 3). The user can select (label 4) whether report the emissions in product basis (kg CO_2-eq/litre) or in energy basis (kg CO_2-eq/MJ). This section also reports total GHG emission saving in comparison to gasoline (label 5) as well as contribution of the different steps of the life cycle (label 6). Note that for sugarcane bagasse-based 2G ethanol in Colombia, the contribution of the processing step is negative (for the three scenarios) since in this step is where possible savings can be achieved by the action of the cogeneration of lignin. Moreover, the contribution of feedstock increases in scenarios 2 and 3 in comparison to scenario 1 since higher emission factor was entered for sugarcane bagasse under own production scheme. Finally, performance parameters of the cogeneration system are reported in this section (label 7).

The display is analogue for the results when multi-feedstock operation is selected.

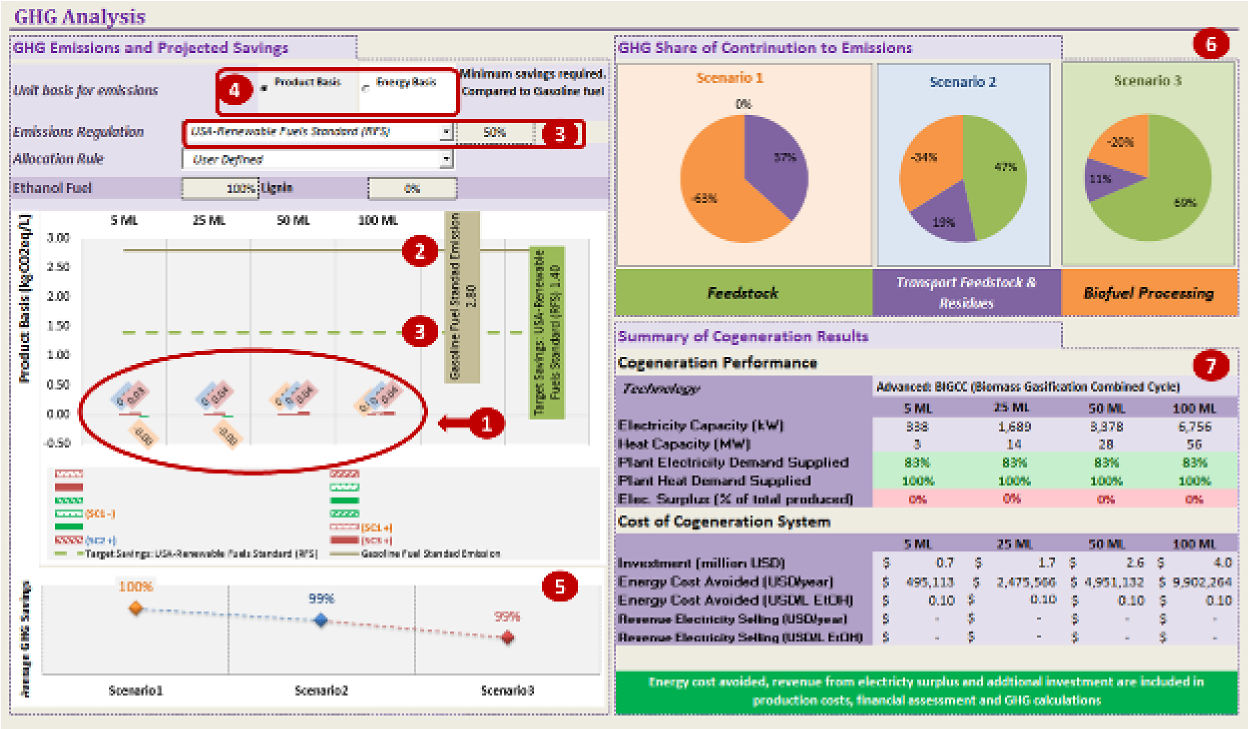


Figure 37: GHG Analysis Results

7.2 The summary of comparative results

In the Summary of Results by Feedstock sheet it is possible to look at the results selecting one crop/residue at a time, however in this Summary of Results Comparative sheet all of the key results for the 4 targeted crops/residues are simultaneously reported (Applicable only for single feedstock operation). The following indicators are reported: the maximum attainable biofuel production; the maximum number of plants potentially supplied; and a comparison of production costs, NPV and IRR, and GHG emissions.

The maximum attainable biofuel production indicates whether liquid biofuel obtained from the selected crops/residues is enough to respect the amount expected in mandatory blending included in the Biofuel Demand section. For the example of Colombia, both sugarcane bagasse and napier grass 2G ethanol are feasible for the production of the considered biofuels amount. However, oil palm empty fruit bunches is not enough to even cover the considered biofuel amount (Figure 38, label 1). The number of plants potentially supplied is based on the available biomass, selected plant sizes and targeted crops (Figure 38, labels 2 to 5).

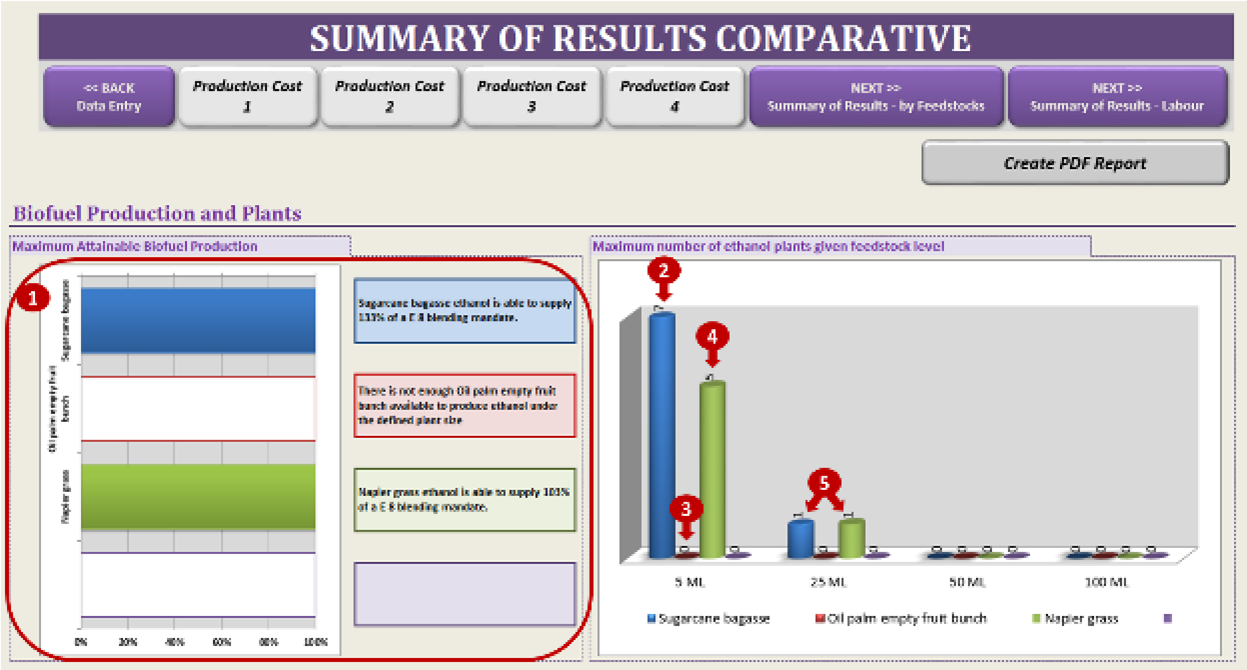


Figure 38: Maximum Attainable Biofuel Production and Number of Plants Potentially Supplied

Figure 39 presents the overall results of the production costs (label 1) and financial analysis (label 2) for sugarcane bagasse, empty fruit bunches, and napier grass 2G based ethanol under the mixed scheme. Production costs of ethanol are compared with the prices of liquid biofuels and fossil fuels (Figure 39, labels 3 and 4). If the production costs and financial parameters are competitive, the number is highlighted in green. If not, then it is highlighted in red (label 5).

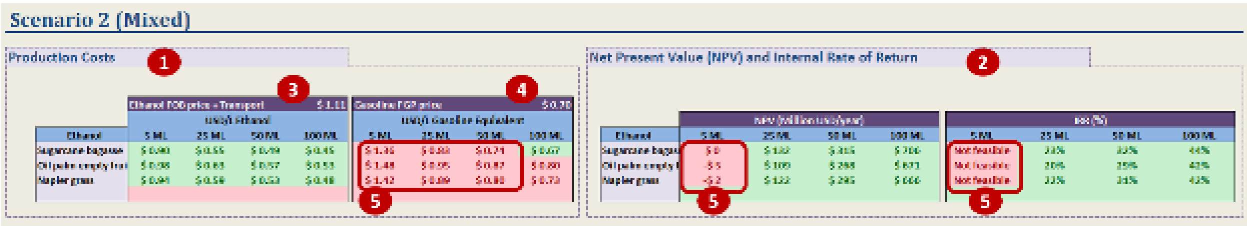


Figure 39: Summary of Results - Comparative (comparison among production costs, NPV and IRR)

Figure 40 shows the GHG emissions for sugarcane bagasse, empty fruit bunches, and napier grass 2G based ethanol under the own production scheme (label 1). The user can select to report the GHG emissions on product basis or energy basis (label 2). Finally, the user can select the feedstock scheme (scenarios) for comparing the emissions (label 3).

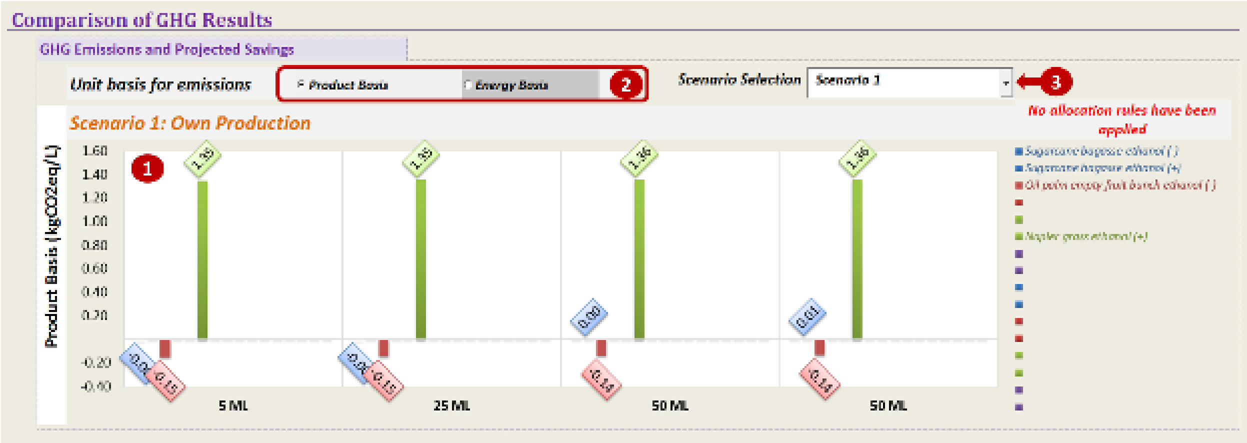


Figure 40: Summary of Results - Comparative (GHG emissions)

7.3 The labour analysis results

This worksheet reports the specific results related to the biofuel production impact on labour demand and on land use[13].

In this section, the user can compare the estimation of the number of workers and land area required for implementing 2G ethanol processing activity. One plant size at a time can be examined: at the top of the worksheet the user should identify the appropriate plant size (Figure 41, label 1). Figure 41 shows a checkbox where the user can select which feedstock crops to include (label 2).

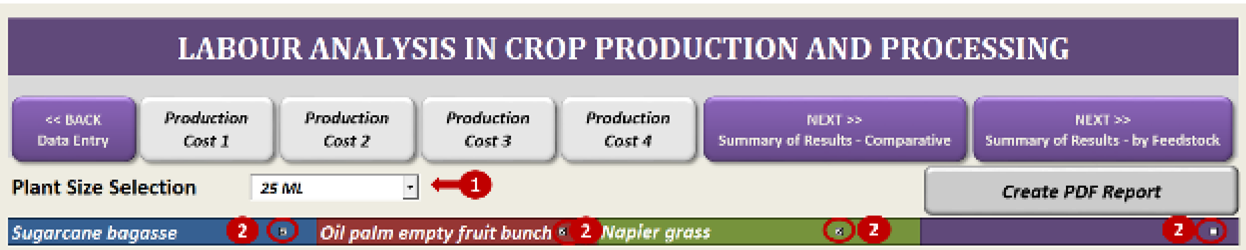


Figure 41: Labour and Land Requirements Analysis

The user can estimate the total number of people potentially employed (on and off-farm) as a result of the implementation of different plant sizes under different production schemes. Figure 42 reports the results of the Colombia country example simulation. On the left side of Figure 42 (label 1), the results for the outgrowers scheme are shown, while in the middle and on the right side the user can compare, respectively, the results for mixed and own production schemes (labels 2 and 3). The user should note that in general, when the total feedstock is produced by the factory itself (own production scheme), the number of new jobs potentially created tends to be lower than in the other schemes.

Therefore, when moving from the own production scheme to the mixed one (where an increased number of small farmers are involved), social benefits in terms of increased labour demand will be generated. The user should consider that, as already highlighted under the Assumptions and Limitations section, labour demand is estimated only with reference to direct employment (holdings in agriculture and workers in the

[13] The development of biofuels production is expected to generate employment opportunities at both farm and processing levels. Also, land used for feedstock production is computed on the basis of the quantity of raw material required to supply plants of different sizes under different production schemes.

manufacturing sectors for feedstock processing and biofuel conversion). This could lead to an underestimation of the total labour demand, due to the exclusion of indirect employment.

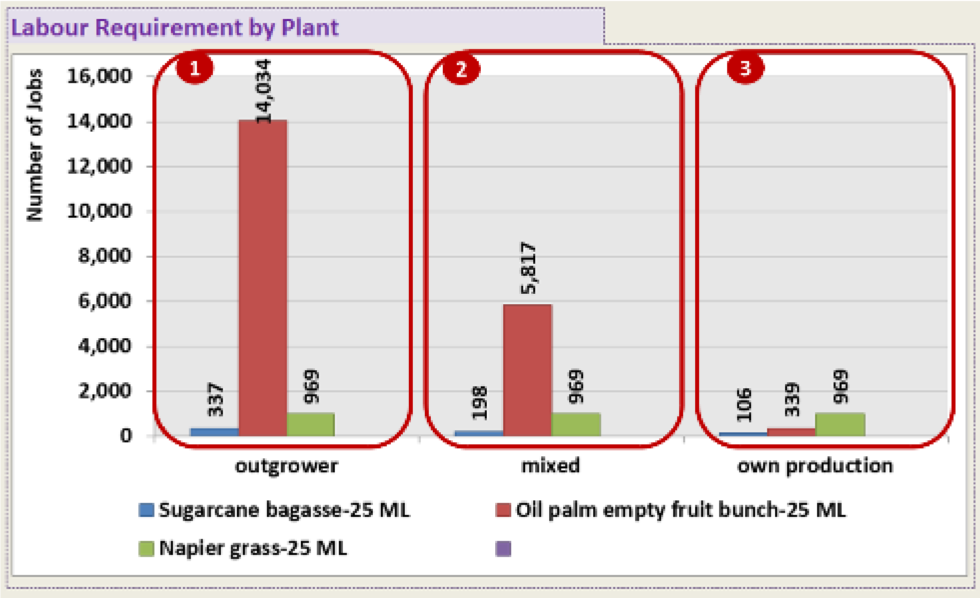


Figure 42: Employment Opportunities Related to Biofuels Production

The previous figure reported the number of workers who would be employed if liquid biofuel production were implemented in the country. Estimations of the potential impact of 2G ethanol production on labour demand were shown for different plant sizes, feedstock crops/residues and production schemes.

The information presented in Figure 43 aims at providing the user with the number of people who would be employed in different levels of the chain (the data refers to a 25-litre plant). For each plant size, feedstock crop and production scheme, this figure reports the share of workers who will be involved in biofuel production both on-farm and on-plant levels: it demonstrates that, when an increasing number of outgrowers is involved in feedstock production, labour used in various agricultural operations (land preparation, sowing and other operations) is higher than labour adopted in plant processing operations.

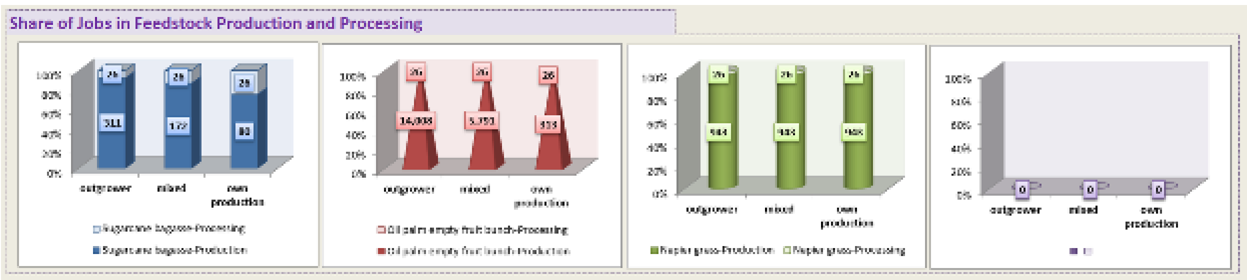


Figure 43: Share of Agriculture - Processing Jobs

In this worksheet, the user can also find information about the land required to produce the feedstock needed to supply the biofuel processing plants. For example, Figure 44 refers to a 25 million litre plant and displays the own production (label 1), mixed (label 2) and outgrower (label 3) schemes. The outgrowers' scheme requires significantly more land than the own-production scheme, as farmers produce feedstock using a higher input level.

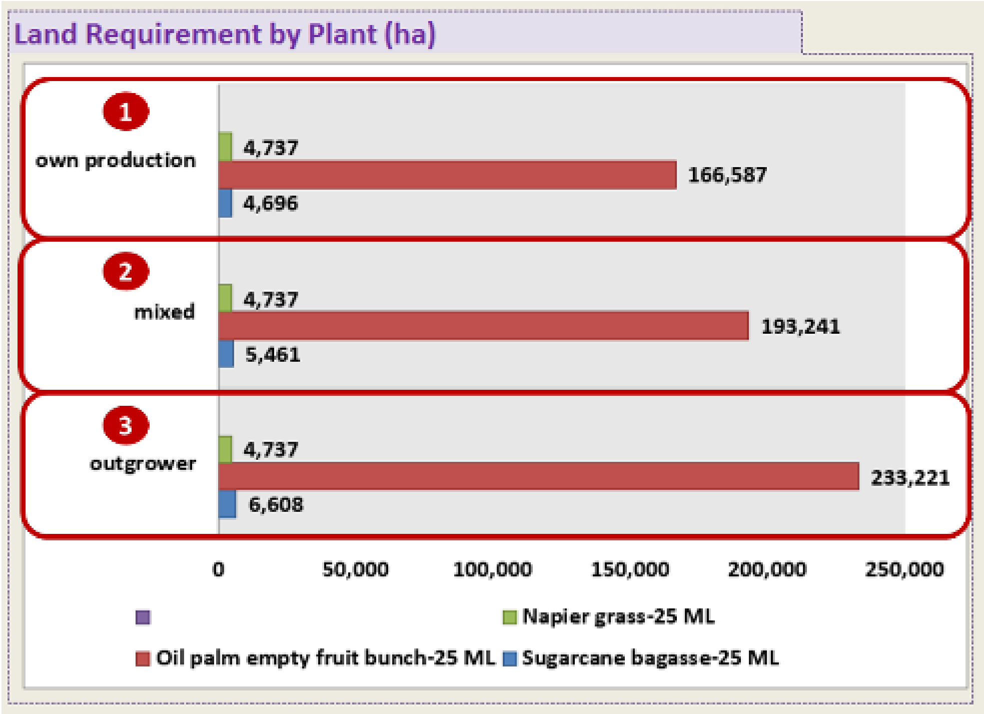


Figure 44: Comparative Land Requirement

8 Annex

8.1 Methodology and outputs

This section describes the methodology integrated in the *2G Ethanol* sections of the *Transport Sub-Module* and includes a description of the databases which support the analysis. The databases are not visible to the user, but their structure and content might be important for those who will update them and/or work on the improvement of the tool.

8.1.1 Processing budget structure: calculation of the production costs of liquid biofuels

i. Inputs

The energy and mass balance data for ethanol production options and specified capacities were obtained from ASPEN Plus™ V7.1. These data were utilized to generate the inputs required for each selected plant capacity (5, 25, 50, 100 million litres per year) as presented in the following table. Most of this data can be also accessed by activating the display in mass and energy balances button located in the data entry (see section 5.2.4).

	Capacities (Million litres per year)	
	5	25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Feedstock	Unit	Unit Price (USD)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Sugarcane bagasse Scenario 1	t/year	$ 0.00	18,501	$ -	92,503	$ -
Sugarcane bagasse Scenario 2	t/year	$ 21.00	18,501	$ 388,513	92,503	$ 1,942,564
Sugarcane bagasse Scenario 3	t/year	$ 35.00	18,501	$ 647,521	92,503	$ 3,237,607

Other chemical inputs	Unit	Unit Price (USD)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Sulfuric Acid	t/year	$ 150.00	430	$ 64,521	2,151	$ 322,604
Water	m3/year	$ 0.08	-	$ -	-	$ -
Ammonia	t/year	$ 150.00	308	$ 46,207	1,540	$ 231,037
Enzyme	t/year	$ 1,400.00	475	$ 664,912	2,375	$ 3,324,561
Yeast	t/year	$ 2,000.00	9	$ 18,000	45	$ 90,000
Subtotal				$ 793,640		$ 3,968,202

Energy inputs	Unit	Unit Price (USD)	Quantity (Unit)	Total (USD/year)	Quantity (Unit/year)	Total (USD/year)
Steam	t/y	$ 12.00	-	$ -	-	$ -
Electricity	kWh/y	$ 0.09	569,517	$ 51,257	2,847,586	$ 256,283
Subtotal				$ 51,257		$ 256,283

Figure 45: Budget Structure: Feedstock, Chemical Inputs, and Energy Inputs

There are three optional sources for feedstock prices. The tool provides the user with a grid to select the feedstock price according to the participation level of factory and out-growers in feedstock production (Figure 45).

Updated prices for Chemical Commodities can be found at: http://www.icis.com/chemicals/channel-info-chemicals-a-z/ (Figure 45). Local commodity prices must be provided by the user.

The heat carrier is low pressure steam. Low pressure steam can be produced using a standard low technology boiler, where the unit price represents its production cost (Figure 45).

ii. Labour and miscellaneous costs

For the labour calculation, it was assumed that the 2G ethanol plant is operating 24 hours per day during 333 days per year, or its equivalent 8000 hours per year, while the remaining 35 days are employed in maintenance tasks. The daily operation of a plant was divided into three shifts of 8 hours each, and for each shift the number of workers was calculated based on the rule of thumb reported by Van Gerpen (2008). This rule states that a requirement of at least 1 unskilled worker for each 1 million gallons of biodiesel is needed. In the same way, the number of skilled workers should be at least 1 for every 4 unskilled workers.

	Capacities (Million litres per year)	
	5 Operating hours per year 7,992	25 Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Labour and miscellaneous cost	Unit	Unit Price (USD/hour)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Unskilled worker	# Employee	$ 2.20	18	$ 316,800	21	$ 369,600
Skilled worker	# Employee	$ 4.40	5	$ 176,000	5	$ 176,000
Miscellaneous costs			25%	$ 123,200	25%	$ 136,400
Subtotal				$ 616,000		$ 682,000

Figure 46: Budget Structure: Labour and Miscellaneous Costs

The miscellaneous costs comprise the cost of operating supplies and laboratory charges required for the daily processing of 2G ethanol. Consequently, 25% of the total labour cost was established as default to cover this expenditure and is identified as a miscellaneous percentage, i.e.:

Miscellaneous Costs (US$/year)

$$\text{Miscellaneous Cost [US\$/year]} = \text{Miscellaneous Percentage [\%]} * \text{Total Labor Cost [US\$/year]}$$

iii. Transport of feedstock

The value of transporting feedstock from farms to plants results from the multiplication of the unit price (USD per t) per quantity (km) per tons of feedstock (Figure 47).

	Capacities (Million litres per year) 5	Capacities (Million litres per year) 25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Transportation	Unit	Unit Price (USD/t/unit)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Feedstock (farm to plant)	km	$ 0.10	5	$ 9,250	10	$ 92,503
Subtotal				$ 9,250		$ 92,503

Figure 47: Budget Structure: Transport Costs of Feedstock

iv. Depreciation and maintenance costs

The depreciation was calculated using the straight-line method. It assumes that the item will depreciate by a constant amount over its economic life or depreciation period. The individual investment costs are predefined for each plant size. The values for the specific investment costs were calculated for each of the established capacities (5, 25, 50 and 100 million litres per year) using the Aspen Economic Analyzer V 7.1 tool (http://www.aspentech.com/products/aspen-icarus-process-evaluator.aspx).

	Capacities (Million litres per year) 5	Capacities (Million litres per year) 25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Investment	Unit	Years	Total (USD)	Depreciation (USD/year)	Total (USD)	Depreciation (USD/year)
Buildings	USD	20	$ 6,996,761	$ 349,838	$ 18,377,218	$ 918,861
Plant and Equipment	USD	20	$ 26,685,106	$ 1,334,255	$ 70,089,120	$ 3,504,456
Total investment			$ 33,681,866		$ 88,466,338	
			Total	$ 1,684,093.31	Total	$ 4,423,317
Maintenance cost		20%		$ 336,819		$ 884,663.38
Subtotal				$ 2,020,912		$ 5,307,980

Figure 48: Budget Structure: Investment and Maintenance Costs

Maintenance Costs **(US$/year)**

The maintenance cost of all equipment and devices was established by default as 10% of the total annual depreciation of the investment.

Manteinance Cost [US$/year] = Maintenance Percentage [%] *
Total Depreciation Cost [US$/year]

v. Storage costs

	Capacities (Million litres per year)	
	5	25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Storage	Unit	Unit Price (USD)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Feedstock (biomass)	t	$ 0.40	3,546	$ 1,418	17,730	$ 7,092
Ligno. Residues Ethanol	litre	$ 0.05	1,000,000	$ 50,000	5,000,000	$ 250,000
Subtotal				$ 51,418		$ 257,092

Figure 49: Budget Structure: Storage Costs

vi. Other costs

Plant overheads are general expenditures defined as a charge to the production for services, facilities, payroll overhead and are established by default as 50% of total labour and maintenance costs.

Plant Overhead Cost [US$/year] = Plant Overhead Percentage [%] *
(Maintenance Cost [US$/year] + Total Labor Cost [US$/year])

General and administrative costs (rent, insurance, managerial and administrative staff salaries) are expressed as a percentage of the sum of plant overheads, maintenance, total labour costs and the other costs except the expenditure for the feedstock purchase (default value is 8%).

General and Administrative Cost [US$/year] = Gen. and Admin. Percentage [%] *
(Plant Overhead Cost [US$/year] + Maintenance Cost [US$/year] +
Total Labour Cost [US$/year] + Subtotal Input Cost [US$/year])

	Capacities (Million litres per year)	
	5	25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Other costs	Unit	Rate (%)	Total (USD/year)	Total (USD/year)
Plant overhead	USD	30%	$ 248,886	$ 429,079
General and administrative	USD	8%	$ 100,237	$ 180,162
Loan interest	USD		$ 219,943	$ 577,685
Subtotal			$ 569,065	$ 1,186,926

Figure 50: Budget Structure: Plant Overhead, General and Administrative cost

vii. Co-Products Credits

The value of co-products credits results from the multiplication of the unit price (USD per t) per tonne of each co-product (Figure 51).

	Capacities (Million litres per year)	
	5	25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Co-Products Credits	Unit	Unit Price (USD)	Quantity (Unit)	Total (USD/year)	Quantity (Unit)	Total (USD/year)
Electricity	kWh/y	$ 0.10	-	$ -	-	$ -
CO2	t/year	$ -	4,340	$ -	21,698	$ -
Lignin	t/year	$ 150.00	-	$ -	-	$ -
Subtotal				$ -		$ -

Figure 51: Budget Structure: Co-Products Credits

	Capacities (Million litres per year)	
	5	25
	Operating hours per year 7,992	Operating hours per year 7,992
Scenario 1: Own Production	Financial Assessment Sc 1 (5 ML/year)	Financial Assessment Sc 1 (25 ML/year)
Scenario 2: Mixed	Financial Assessment Sc 2 (5 ML/year)	Financial Assessment Sc 2 (25 ML/year)
Scenario 3: Outgrowers	Financial Assessment Sc 3 (5 ML/year)	Financial Assessment Sc 3 (25 ML/year)

Total Production Costs (USD/year)

	Total (USD/year)	Total (USD/l)	Total (USD/year)	Total (USD/l)
Scenario 1				
Total operating costs	$ 1,470,147	$ 0.29	$ 4,998,988	$ 0.20
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22
Total other costs	$ 569,065	$ 0.11	$ 1,186,926	$ 0.05
Co-Products Credits	$ -	$ -	$ -	$ -
Total production costs scenario 1 (USD/year)	$ 4,111,543		$ 11,750,987	
Total production costs scenario 1 (USD/l)		$ 0.82		$ 0.47
Scenario 2				
Total operating costs	$ 1,858,660	$ 0.37	$ 6,941,552	$ 0.28
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22
Total other costs	$ 569,065	$ 0.11	$ 1,186,926	$ 0.05
Co-Products Credits	$ -	$ -	$ -	$ -
Total production costs scenario 2 (USD/year)	$ 4,500,056		$ 13,693,550	
Total production costs scenario 2 (USD/l)		$ 0.90		$ 0.55
Scenario 3				
Total operating costs	$ 2,117,669	$ 0.42	$ 8,236,594	$ 0.33
Total fixed costs	$ 2,072,330	$ 0.41	$ 5,565,072	$ 0.22
Total other costs	$ 569,065	$ 0.11	$ 1,186,926	$ 0.05
Co-Products Credits	$ -	$ -	$ -	$ -
Total production costs scenario 3 (USD/year)	$ 4,759,064		$ 14,988,593	
Total production costs scenario 3 (USD/l)		$ 0.95		$ 0.60

Figure 52: Budget Structure: Total Production Costs

8.1.2 Budget structure: estimates of labour and land requirements

In order to determine the potential impact of biofuel production on employment opportunities, a methodology was built to capture the labour coefficients, biofuel conversions and other inputs of operating 2G ethanol plants and then translate them into potential employment opportunities. The final output includes the workers involved in feedstock production and those operating the processing plant as well. Workers dealing with feedstock transportation are not included. The estimation of the number of jobs potentially employed is based on the following calculation:

Number of jobs (man/year) = [on-farm labour (manual + machinery) + on-plant labour (unskilled + skilled)]

where

> On-farm labour (man/year) = {[(land required (ha) * labour manual coefficient (man day/ha)] + [(land required (ha) * labour machinery coefficient (man/day))] / working day in a year (day)}

and

On-plant labour (man/year) = unskilled labour (man/year) + skilled labour (man/year)

Estimation of the potential impact of 2G ethanol production on land requirements is based on the following calculation:

Land required (ha) = [plant size (millions of litres) / yield (t/ha) /biofuel conversion (l/t)]

8.2 Data requirements for running the *Transport Sub-Module-2G ethanol*

Table 2 includes data requirements for running the *Transport Sub-Module*.

Table 2: Data Requirements for Running the *Transport Sub-Module*

Data required	**From other BEFS RA components (see section 8.2.1)**
	• Feedstock potential: complete
	• Feedstock cost: for each crop (USD/t), i.e. market price for outgrowers scheme and cost of production for own production scheme
	• Labour coefficients: manual (man day/ha) and machinery (man hour/ha) labour for different crops, input level (high, intermediate and low). Labour coefficients for activities related to feedstock production, such as land preparation, sowing, field operation and harvesting
	• Unskilled and skilled labour requirements (man/year) for different crops and plant sizes
	• Yield (t/ha) for different crops from GAEZ (from *Crop Production Tool*)
	Additional data required
	• Price of other raw materials: chemical reagents (USD/t), water (USD/m3), electricity (USD/kWh) and heat carrier (USD/t)
	• Labour costs: unskilled and skilled workers' wages (USD per employee per hour) and miscellaneous costs (25% of the total labour costs by default)
	• Cost of feedstock transport from farm to processing plant (USD per t per km)
	    • Transport cost (USD per t per km)
	    • The average distance from the farm to the processing plant for each plant size (km)
	• Storage costs and safety stock rate (for feedstock and liquid biofuel)
	    • Stock rate of feedstock (in percentage); storage cost of feedstock (USD/t)
	    • Stock rate of liquid biofuels (in percentage); storage cost of liquid biofuels (USD/litre)
	• Other costs: plant overhead (50% of maintenance and labour costs) , general and administrative costs (8% of the sum of the plant overhead, maintenance, total labour and total input costs) by default
	• Price of fossil fuels and liquid biofuels
	    • Domestic price of fossil fuels, gasoline, (USD/litre)
	    • International price of fossil fuels, diesel and gasoline (USD/litre)
	    • Price of fossil fuel equivalent (USD/litre)
	    • International price of liquid biofuel (ethanol) (USD/litre)
	• Financial parameters
	    • Discount rate (%)
	• Low input share and intermediate input share in outgrower production
	• Share estate/outgrower in feedstock production scheme
	• Number of working days/year
	• Emission factors of feedstocks.
	• Transport distances of waste from the processing plant

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