UK & GLOBAL BIOENERGY RESOURCE MODEL (2024)

User Guide

Report for: Department for Energy Security and Net Zero

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1. USER GUIDE OVERVIEW

The purpose of this document is to provide a detailed description of the structure of the UK & Global Bioenergy Resource Model (2024).

This guide outlines the model architecture and the key principles followed in the development of the model as well as providing a description of the sheets and tables within the model. This guide does not provide details on the data and assumptions used in the model. This information can be found in the accompanying *Methodology* document and *Background Workbooks* (Table 1-1).

Table 1-1 List of the documentation associated with the UK & Global Bioenergy Resource Model (2024) v1.0

Document	Description
UK & Global Bioenergy Resource Model (2024) v1.0	The excel file containing the model described in this document.
User Guide	This document. Provides a description of the structure and function of the model.
Methodology	The methodology document contains a detailed description of the assumptions and supporting data used in the model.
Background Workbooks	A set of Excel workbooks that contain detailed derivations of all of the feedstock availability estimates.

2. QUICK START GUIDE

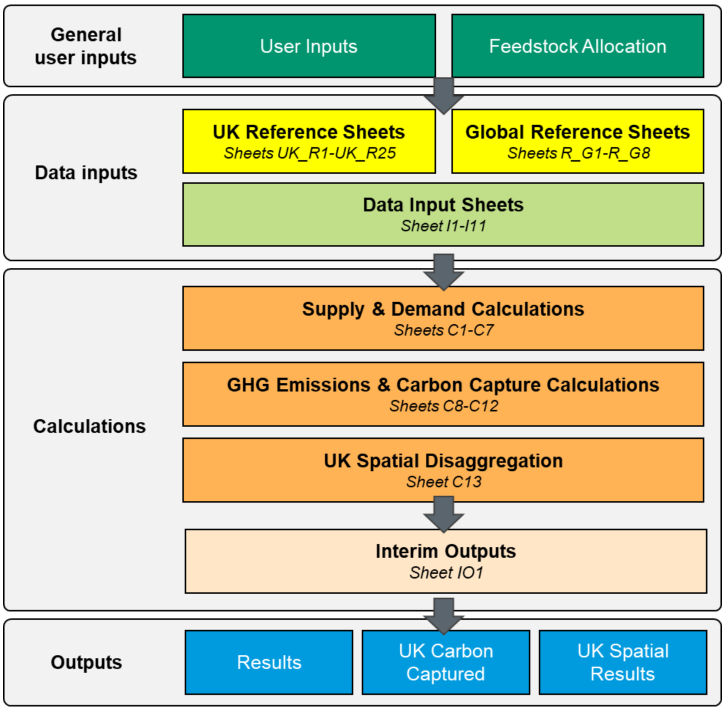
A high-level overview of the model structure is given in Figure 2-1 and shows the model split into four modules. For the general user, the relevant modules are the *General User Inputs* and the *Outputs.* These modules allow the user to explore the potential availability of bioenergy resources to the UK. The *Data Input* and *Calculations* modules should not be altered by the general user.

The general user input sheets are the main "controls" of the model. The user can select from a series of pre-configured inputs to develop a corresponding scenario regarding the availability of bioenergy resources to the UK. These inputs are described in more detail in Section 4.

The *Feedstock Allocation* sheet allows the user to assign available feedstock to conversion technologies. This assignment is required to evaluate the GHG savings, which is dependent on the conversion technology selected.

The results from the model are presented in the Outputs module. The *Results* sheet contains an overview of the resource availability in the UK, from both domestic and international sources. A guide to interpreting these results is given in Section 2.1. The *UK Carbon Captured* sheet contains an overview of the amount of carbon captured under the configured scenario. The *UK Spatial Results* sheet contains an overview of the estimated spatial distribution of domestic resources in the UK.

Figure 2-1 Overview of the model structure.



2.1 GUIDANCE FOR INTERPRETING THE MODEL OUTPUTS

The availability of bioenergy resources to the UK is presented in the *Results* sheet. This sheet contains both the domestic resources, produced in the UK, and imported resources.

2.1.1 Resource Availability

For both domestic and imported resources the 2020 results reflect the **actual** quantity of the resources used for bioenergy in the UK in 2020. For 2025 – 2050, the results reflect the **potential** quantity of the resources that could be available to the UK, based on the scenario the user has configured.

The results for all domestic UK resources are presented in terms of the **primary energy content**. Similarly, imported agricultural processing residues, energy crops, sawmill residues and small roundwood are reported in terms of the **primary energy content**. However, biodiesel, bioethanol, aviation fuel and road fuel are reported in terms of the **energy content of the finished fuel,** as this is how they are assumed to be imported.

2.1.2 Impact of the model operating mode

When interpreting the results, it is important for the user to consider the operating mode of the model. The user can opt to run the model to consider the global resource production or the global resource surplus (see Section 4.1.2 for details), which has a significant impact on the outputs. This is because when considering the global resource surplus, the model assesses competing demand for feedstocks internationally. As a result, the quantity of resources available to the UK is significantly reduced compared to the results when considering global resource production, due to high competing demand for the resources in the IEA scenarios used. This also results in an increase in the availability of some resources such as bioethanol in later years (e.g. 2045 2050), as competing demand decreases.

3. MODEL ARCHITECTURE

The model has been constructed following a repeated architecture approach. The following section describes the main principles followed in this approach.

3.1 WORKBOOK STRUCTURE

The worksheets that comprise the model i.e. the workbook can be categorised as defined in Table 3-1. The worksheets have been colour coded to denote specific functions.

Table 3-1 Worksheet tab colour key

Tab Colour	Description
User Inputs	Contain the controls for the model that allow the general user to choose the variable parameters for the scenario they would like to investigate.
Results	Display the outputs of the model for the scenario that the user has configured.
Inputs	Contain the key assumptions that underpin the model. These inputs should only be modified by advanced users. These sheets are also labelled with the prefix “I”
Calculations	Contain the calculations that underpin the model. These sheets **should not** be modified. These sheets are also labelled with the prefix “C”
Interim Outputs	Contain interim outputs of the model that are used to generate the results sheets. These sheets are also labelled with the prefix “IO”
Feedstock Availability Data	Contain the data regarding feedstock availability, exported from the background workbooks. These sheets are also labelled with the prefix “R_UK” when referring to UK feedstocks and “R_G” when referring to global feedstocks.
Administrative Sheet	Contains standard, non-technical, information that facilitates the operation of the model.

3.2 WORKSHEET STRUCTURE

Worksheets have been designed to follow similar structures. In general, headings and sub-headings have been used to group similar data/calculations and a high level explanatory commentary has been provided throughout each work sheet. Cells within the worksheets are colour coded to denote their function. These functions are explained in Table 3-2.

Figure 3-1 Example of a calculation sheet that references parameters selected on the *User Input* sheet.

	Name	Number
Selected global supply scenario:	IMAGE SSP2 Middle of the Roa	2
Selected global demand scenario:	Announced Pledges Scenario	2
Infrastructure constraints applied?	No	FALSE
Trade constraints applied?	No	FALSE

Some calculation sheets contain cells that reference parameters selected on the *User Input* sheet. An example of this is shown in Figure 3-1. These references to the *User Input* sheet are used to configure the calculations to the selected scenario.

Table 3-2 Cell function colour coding

Cell Style	Description
Reference data	Imported datasets or reference data. These cells should not be edited in the general use of the model, although reference data may be updated periodically.
Input data	Key assumptions that are used in the calculations in the model. These should not be edited by the general user. The more advanced user may wish to update these parameters to explore alternative scenarios.
Calculation 1	Default colour for cells containing calculations. These cells should not be edited.
Calculation 2	Secondary colour for cells containing calculations. Typically used to distinguish different calculations within the same table. These cells should not be edited.
Linked Cell	Linked cells reference other cells without performing any manipulation or calculations. These cells should not be edited.
Output	Highlight outputs of the model. These cells should not be edited.
Explanation	Explanatory information and notes.
Warning Text	Formatting will be activate if the error check in cell H2 on each sheet detects any errors, including (#NA!, #REF!, #NUM!, #VALUE!, #DIV/0!, #NAME)

3.3 DATA STRUCTURE

Structured referencing has been used throughout the model. Descriptive names have been combined with the suffixes following a standard naming convention described in Table 3-1. Where possible, direct references to cells have been avoided. This allows the user to easily identify what table and cell is referenced. Users may navigate directly to a named table or range by pressing “Ctrl + G” and selecting the desired name.

Some tables contain “Index” or “Match” columns. These columns are included to simplify Index/Match formulae in calculation or linked cells.

Table 3-3 Suffixes used for structured referencing throughout the model.

Suffix	Description
“_n”	A single number e.g. a constant
“_a”	An array of values e.g. a list of feedstocks
“_t”	A reference to a table

4. USER INPUTS

The 'User inputs' sheet is the main interface for users. It includes controls on scenario selection, other key assumptions, while the ‘Feedstock allocation’ is where feedstocks are assigned to conversion technologies.

4.1 USER INPUTS

This sheet is split into three sections – UK inputs, Global inputs and Sustainability inputs. As such, the model requires the following inputs from the user:

4.1.1 UI-1 UK Inputs

Input	Description
UI1.1 UK feedstock scenarios	Allows the user to choose the resource scenarios to be modelled. For most UK feedstocks the model contains a number of scenarios which reflect different assumptions about how accessible resources may be, the uncertainty in the resource estimate, or the impact of policies measures. For energy crops (SRC willow, Miscanthus, maize, wheat and sugar beet), the scenario choices here refer to assumptions about changes in crop yield. Note that maize refers to whole crop maize for use in anaerobic digestion. Energy crop resources are dependent on assumptions about land availability. This is chosen in UI-1.2 UK land availability scenarios below. The same scenario must be chosen for landfill gas and residual biogenic waste as the availability of landfill gas is dependent on the residual waste scenario. All forestry related resources (small roundwood, sawmill residues and forestry harvesting residues) should be set to the same scenario as estimates are interlinked.
UI1.2 UK land availability scenario	Allows the user to select the UK land availability scenario to be modelled. For energy crops, (SRC willow, Miscanthus, maize, wheat and sugar beet) a scenario defining the amount of land available for each crop must be chosen. Full descriptions are given in the user guide and methodology document. The land areas for each availability scenarios are stored on sheet I8_UK_Land. The scenario names used in the UI1.2 UK land availability scenario are defined in I1.4.1_UK_land_availability_scenarios_t.

4.1.2 U-I2 Global resources

Input	Description
UI-2.1 Global resources: supply and bioenergy demand scenarios	Allows the user to select the overarching scenario for global supply For global resource modelling the model includes three overarching views of how the world will be developed based on the SSPs developed for climate modelling. The scenario determines the land availability for crops, the supply of forestry resources and various supply constraints.
	Allows the use to select the overarching scenario for bioenergy demand. For global bioenergy demand the model contains three scenarios based on those developed in the IEAs World Energy Outlook (2021). The scenario determines the demand outside the UK for global biomass resources which is used if surplus results are selected
UI-2.2 Land for energy crops	Allows the user to set the percentage of abandoned pasture land that can be used to grow bioenergy crops. The model contains estimates of abandoned agricultural land which can be used to grow energy crops. This is split into abandoned crop land and abandoned pasture land. Abandoned land refers specifically to land that has been released from agricultural or pastoral uses. Growing annual energy crops on pasture land which has been permanent pasture can cause significant loss of carbon from the soil. Losses may be less if perennial energy crops are grown. Growing energy crops on abandoned crop land is much less likely to lead to additional carbon loss from the soil. To minimise the risk that the modelled energy crop production leads to soil carbon losses it is recommended that no abandoned pasture land is made available to grow energy crops, i.e. the percentage here is set to zero. If you wish to override this, then the percentage of abandoned pasture land that can be used for energy crops can be set here. It is not recommended to set the percentage of abandoned pasture land available for energy crops to a high value.
UI-2.3 Global Forestry Scenarios	Allows the user to select the global forestry model inputs. The model contains the output of three scenarios from a global forestry model, which estimates availability of feedstock from the forestry industry based on assumptions around sustainable levels of harvesting. The forestry model contains a number of parameters including the rate at which production of timber is assumed to grow, and the availability of forestry residues for bioenergy.
UI- 2.4 Global Supply Constraints	Allows the user to choose whether to reduce resource estimates due to constraints imposed by lack of infrastructure or trade arrangements. The availability of biomass resources to use in the bioenergy sector can be restricted if infrastructure to collect, process and transport them is limited. Resource availability, particular for the export market, can also be restricted if sufficiently developed trading and market arrangements are not in place.

Input	Description
	If the user considers that these two factors are important, then they can choose to apply 'constraints' to model the impact of these factors. Effectively the model will reduce the resource available from each region by a certain fraction, that is dependent on the region and the overarching global scenario chosen (see Section 5.3 for details).
UI-2.5. Set the end use for global UCO/tallow feedstocks	Allows the user to specify mix of transport fuels produced from UCO and tallow. Within the model, it is assumed that UCO and tallow resources available overseas are converted to either a road transport fuel or SAF, before being transported to the UK. As the GHG criteria and production yields for these two fuels are different, it is necessary to define whether these resources are converted to a road transport fuel or sustainable aviation fuel (SAF).
UI-2.6 Fuels produced from non-exportable resources	Allows specify mix of transport fuels produced from 'non-exportable' resources. Within the model, global resources which are not suitable for long distance transport are assumed to be used in the region of origin to satisfy regional bioenergy demand. It is assumed that any of these 'non-exportable' resources not needed to meet regional demand could be transformed into a liquid transport fuel which can be exported to the UK. As the GHG criteria and production yields for these two fuels are different, it is necessary to define whether these resources are converted to a road transport fuel or sustainable aviation fuel (SAF).
UI-2.7 Proportion of non-crop feedstocks not included in the model	Allows the user to specify the contribution of non-modelled waste feedstocks to transport fuels production. Over time the model assumes that an increasing proportion of liquid biofuel (bioethanol and biodiesel) demand is produced from feedstocks which are not food and fodder crops i.e. they are produced from feedstocks which are wastes or residues or lignocellulosic energy crops. While the main wastes and residues which are likely to be used for biofuel production are included in the model there are a number of niche waste feedstocks which it has not been possible to include. Exclusion of these niche feedstocks may mean that demand for the modelled wastes and residues for liquid biofuel production is therefore overestimated. The user can adjust for this by specifying the percentage of the feedstocks required for these advanced 'non-crop' biofuels which comes from these unmodelled niche waste feedstocks.

4.1.3 UI3 Import Assumptions

<table>
<tr><th>Input</th><th>Description</th></tr>
<tr><td>UI-3.1 Operating mode for the global resource part of the model</td><td>Allows the user to specify the operating mode for the global resource part of the model.
The model estimates how much bioenergy is available for import into the UK by assuming the UK has access to a certain fraction of the biomass that is available globally.
This can be done in two ways:
1. Global resource production: this assumes that the biomass that is available globally which the UK can access is the total global biomass resource.
2. Global resource surplus: this assumes that the biomass that is available globally which the UK can access is surplus resources, after other regions have used regionally available resources to meet the regional demand for resources. This is calculated by subtracting regional demand for bioenergy (based on IEA forecasts) from regional resource availability.</td></tr>
<tr><td>UI-3.2 Fraction of global resources accessible to UK:</td><td>Allows the user to Select import scenario for global resources.
The model assumes that the UK can import a fraction of the total global resource or the total global surplus. That import fraction is specified here.
For the general user the model contains predefined scenarios. Advanced users may create additional scenarios in I9 using the scenario slots marked "EMPTY".
Note, 2020 imports reflect actual values for imports</td></tr>
<tr><td>UI-3.3 Methodology for combining import fractions and GHG criteria</td><td>Allows the user to specify how to combine assumptions on import fractions and GHG criteria.
If the UK's GHG criteria have been applied in UI-4, then only a fraction of the global resource is likely to meet these criteria i.e. be GHG compliant.
The model can combine the import fractions chosen in UI-3.2 with the GHG compliant fraction in two ways:
1. The model combines the import fraction with the GHG compliance fraction and applies the product to the fraction of the global resource.
This operating mode assumes that all countries wishing to import biomass have similar GHG saving criteria to the UK and that the fraction of the resource that meets these criteria is the same for them.
This assumption may be conservative, as long transport distances increase GHG emissions for resources substantially. Consequently, if supply is satisfied by import from regions closer to the region in deficit than the UK is, more of the global resource could meet the GHG saving criteria than modelled i.e. availability to the UK could be higher.
2. The model applies the minimum of the import fraction and the GHG compliance fraction.
This operating mode assumes that the UK draws its imports from those regions where exported resources can</td></tr>
</table>

Input	Description
	meet the UKs GHG saving criteria – typically those closer geographically to the UK. It is assumed that other regions which have GHG saving criteria and need to import resources are also able to import from neighbouring regions.

4.1.4 UI4 GHG Criteria Inputs

Input	Description
UI-4.1 Application of GHG savings criteria to resources	UK legislation specifies minimum GHG savings that must be achieved when using biomass resources for energy. The GHG saving which must be achieved is specified for each type of energy (heat, power, renewable gas, road transport fuels, aviation fuels) individually. The model allows the user to choose whether to apply these criteria or not. This can be useful to assess the impacts that the UK criteria have on resource availability estimates. When the GHG criteria are applied the feedstock allocation sheet must be completed. To allow the calculation of GHG emissions savings the model contains estimates of typical emissions associated with production, processing and transport of feedstocks to the UK. These emissions can vary depending on a number of factors. To allow for these uncertainties the model assumes a range around the typical value and a distribution across that range. At present UK legislation does not require the inclusion of emissions associated with Indirect Land Use Change (ILUC) when assessing if GHG savings criteria are met. The advanced user may choose to include ILUC emissions. If this option is chosen the user must complete the tables of estimated ILUC emissions in I5 and I6 In cases when carbon capture and storage is installed then this generates a carbon credit/negative emissions. The user can choose whether to allow for this carbon credit when assessing if resources meet the GHG saving criteria.

4.2 FEEDSTOCK ALLOCATION

This sheet allows the user to define the proportion of each global and UK feedstock which is assigned to a conversion technology:

1. **FA-1.1 UK Feedstock Allocation Check:** this table shows the total allocation of each UK feedstock to each conversion technology. Values exceeding 100% are flagged in red.
2. **FA-1.2 UK Feedstock Allocation:** this allows the user to set the percentage of given UK feedstock assigned to each conversion technology. Note that only compatible feedstock and conversion technology combinations are included.
3. **FA-2.1 Imported Feedstock Allocation Check:** this table shows the total allocation of each imported feedstock to each conversion technology. Values exceeding 100% are flagged in red.
4. **FA-1.2 Imported Feedstock Allocation:** this allows the user to set the percentage of a given imported feedstock assigned to each conversion technology. Note that only compatible feedstock and conversion technology combinations are included.

4.3 OUTPUTS

The main model outputs are contained in the 'Results' sheet, while additional UK-specific results are provided in the 'UK spatial results' and 'UK carbon captured' sheets.

4.3.1 Results

Output	Description
Unit selection	The user can select which units the outputs should be presented in. The pre-set unit options are PJ, Mtoe and Mt.
O1.1 Resource overview	Provides a summary of all model outputs across UK feedstocks and different global resources.
O1.2 UK feedstocks	Provides an overview of the potential feedstocks available in the UK in primary energy content.
O1.3 Global resources available to the UK	Provides an overview of the user selected scenarios, and of international resources available to the UK through trade. The results can be viewed as 'Global resources by resource type' or 'Global resources by region'.

4.3.2 UK Spatial results

This sheet provides an overview of the estimated distribution of UK resources across UK regions. The UK resource potential is split across the following regions:

a. O2.1 North East (England)
b. O2.2 North West (England)
c. O2.3 Yorkshire and The Humber
d. O2.4 East Midlands (England)
e. O2.5 West Midlands (England)
f. O2.6 East (England)
g. O2.7 London
h. O2.8 South East (England)
i. O2.9 South West (England)
j. O2.10 Wales
k. O2.11 Scotland
l. O2.12 Northern Ireland

4.3.3 UK Carbon captured

This sheet provides an overview of the mass of carbon dioxide (CO_2) captured by BECCS technologies deployed in the UK.

Output	Description
O3.1 Total CO_2 captured in the UK (from use of domestic and imported feedstocks)	Summarises the mass of carbon captured in the UK under the defined scenario resulting from use of both domestic and imported feedstocks.
O3.2 CO_2 captured in the UK from use of domestic feedstocks	Summarises the mass of carbon captured in the UK under the defined scenario resulting from use of domestic feedstocks only.
O3.3 CO_2 captured in the UK from use of imported feedstocks	Summarises the mass of carbon captured in the UK under the defined scenario resulting from use of imported feedstocks only.

5. INPUT SHEETS

The model contains 11 input sheets which contain key user input data that underpin the calculations in the model. These **input sheets should not be edited** in the general operation of the model but should be periodically reviewed by the model owner to ensure that the assumptions are still valid.

5.1 I1_GENERAL

I1_General contains general model parameters that are used widely throughout the model. These parameters are summarised in Table 5-1.

Table 5-1 - Description and names of the tables contained within I1_General.

Input	Table Name	Description
I1.1 Timeline	I1.1.1_Timeline_t	Defines the time series used in the model calculations. By default, the timeline is 2020 – 2050 in 5-year intervals.
I1.2 Global Scenarios	I1.2.1_Global_supply_scenarios_t	Contains the master list of global supply scenario names.
	I1.2.2_Global_demand_scenarios_t	Contains the master list of global demand scenario names.
I1.3 Global Regions	I1.3.1_Global_regions_t	Defines the regions used in the global calculations.
I1.4 UK land availability scenarios	I1.4.1_UK_land_availability_scenarios_t	Contains the names and descriptions of the UK land availability scenarios.
I1.5 UK Feedstocks	I1.5.1_UK_feedstocks_t	Contains the master list of the UK feedstocks in the model.
I1.6 Global feedstock grouping	Global_feedstock_group_t	Contains a list of the feedstocks contained in the model and identifies compatible conversion technologies. The table also assigns the feedstocks into the aggregated categories that are used in reporting the results.
I1.7 Conversion technologies	I1.7_Conversion_technologies_a	Contains the master list of conversion technologies used in the model.
I1.8 Carbon credit - Conversion technologies	I1.8_UK_Carbon_credit_t	This table contains the list of UK feedstocks that may be used in carbon capture. The advanced user can choose to allow carbon credits to be considered in the overall calculation of carbon captured using the "Allow carbon credit" column. An entry of "1" indicates carbon credits are allowed for the feedstock/conversion technology pair. An entry of "0" indicates carbon credits are not allowed for the feedstock/conversion technology pair.
	I1.8_Global_Carbon_credit_t	This table contains the list of global feedstocks that can be imported to the UK and may be used in carbon capture. The advanced user can choose to allow carbon credits to be considered

Input	Table Name	Description
		in the overall calculation of carbon captured using the "Allow carbon credit" column. An entry of "1" indicates carbon credits are allowed for the feedstock/conversion technology pair. An entry of "0" indicates carbon credits are not allowed for the feedstock/conversion technology pair.

5.2 I2_GLOBAL_SUPPLY

This sheet contains input data that is used to calculate the supply of global crop based resources i.e. crop based biodiesel/bioethanol and perennial energy crops in **C1 Global supply crops**. The contents of I2_Global_supply are summarised in Table 5-2.

Table 5-2 - I2_Global_supply input description

Sheet section	Description
I2.1 Abandoned land availability	Defines the availability of land for growing annual/perennial crops. Data is input in million hectares (Mha) for each **supply scenario** and **region**. Land areas are input for two categories of land: - Abandoned agricultural land. - Abandoned pasture land. In the model, abandoned land specifically refers to land that has been released from agricultural or pastoral uses. Within each land category, land is split into two sub-categories: - Non-degraded land (used to grow annual and perennial crops) - Mildly degraded land (used to grow perennial crops only) Non-degraded and mildly-degraded land are set as a percentage of the total land available in each category.
I2.2 Bioethanol/Biodiesel land priority	Defines the priority for the utilisation of non-degraded land to produce sugar/starch crop for bioethanol production. This is set as a percentage of available non-degraded land. Land not allocated to bioethanol production is assumed to be utilised for oil crop (i.e. biodiesel) production.
I2.3 Current biofuels production	Defines the baseline year (i.e. 2020) production quantities of bioethanol and biodiesel for each model region in PJ.
I2.4 Perennial energy crop yields	This section defines: - The yield in the baseline year for perennial energy crops on non-degraded abandoned agricultural land in each model region, in units of GJ/ha. - The yield reduction associated with producing perennial energy crops on other land types, as a percentage of the non-degraded abandoned agricultural land yield. - The yield increase over time, as a percentage increase compared to the previous timestep, where the yield in the previous time step also accounts for yield reduction due to land type (if applicable).
I2.5 Annual energy crop yields	This section defines: - The representative bioethanol/biodiesel crop for each region and the corresponding crop yield (tonnes per hectare). - The crop yield reductions based on land type, as a percentage of the default yield. - The annual crop yield change for each region and each supply scenario.

Sheet section	Description
	- The yield of bioethanol and biodiesel (GJ per tonne of feedstock) for each region. - The annual change in bioethanol/biodiesel yield.

5.3 I3_GLOBAL_SUPPLY_CONSTRAINTS

This sheet contains input data that is used to constrain the availability of **global** resources. It is split into two sections. The first addresses the availability of global perennial energy crops as limited by planting rates. The second addresses trade, infrastructure and market constraints that can be used to limit the quantity of global resources brought to market. The contents of I3_Global_supply_constraints are summarised in Table 5-3

Table 5-3 - I3_Global_supply_constraints input description.

Sheet section	Description
I3.1 Perennial energy crop planting rate	This section defines constraints applied to the availability of global perennial energy crops due to limitations of planting rates. These limitations are defined by: - The first year in which perennial energy crops are harvested in each region. - The initial area which can be planted with perennial energy crops in kilohectares (kha) for each region. - The annual rate at which perennial energy crop plantations can expand in each region, for each supply scenario. This is set as a percentage. Together, these parameters limit the amount of land that can be used to produce perennial energy crops in C1_Global supply crops.
I3.2 Supply constraints – Infrastructure	This section defines the constraints on feedstock supply in relation to **infrastructure**. The constraints are defined as the percentage of the resource that is unavailable i.e. 0% indicates all the resource is available and 100% indicates none of the resource is available. Constraints are defined for each resource, region and supply scenario.
I3.3 Supply constraints – Market/trade	This section defines the constraints on feedstock supply in relation to **market and trade**. The constraints are defined as the percentage of the resource that is unavailable i.e. 0% indicates all the resource is available and 100% indicates none of the resource is available. Constraints are defined for each resource, region and supply scenario.

Infrastructure and market/trade constraints can be individually switched on or off by the user. If both sets of constraints are switched on, only the most constraining is applied. For annual and perennial energy crops, these constraints are applied to the land available for production in C1_Global_supply_crops. For all other resources, these constraints are applied to the total available resource in C2_Global_supply.

5.4 I4_GLOBAL_DEMAND

This sheet contains demand input data that is both time-sensitive and scenario-dependent, for domestic demand for first generation biofuels, crop-based and non-crop solid biomass, and gaseous biomass. The data contained in I4_Global_demand is summarised in Table 5-4.

Table 5-4 - I4_Global_demand input description

Sheet section	Description
I4.1 Total demand for biofuels	Contains the total demand for liquid biofuels in each region, for each demand scenario. This estimate is made in PJ.
I4.2 Bioethanol proportion of total biofuel demand	Contains an estimate of the percentage of bioethanol in the total liquid biofuel demand. The remainder is assumed to be biodiesel.
I4.3 Crop-based demand	Contains an estimate of the demand for crop based bioethanol/biodiesel. This estimate is made in PJ.
I4.4 Biodiesel UCO/Tallow demand	Contains an estimate of the demand for biodiesel produced from UCO/tallow. This estimate is made in PJ.
I4.5 Gaseous biomass demand	Contains the demand for gaseous biomass in each region, for each demand scenario. This estimate is made in PJ.
I4.6 Proportion of gaseous demand to be met by manure	Contains an estimate of the percentage of the demand for gaseous biomass that is met by manure.
I4.7 Solid biomass demand	Contains the demand for solid biomass in each region, for each demand scenario. This demand does not include the demand for solid biomass to produce transport fuels. This estimate is made in PJ.

5.5 I5_UK_GHG_EMISSIONS

This sheet contains background data and assumptions required to assess the GHG emissions resulting from feedstocks **produced and used** in the UK.

Sheet section	Description
I5.1 UK Direct Emissions	This section contains typical direct emissions input data by UK feedstock and input form for 2020 in gCO_2/MJ, and defines both direct emissions savings over time, and the distribution of direct emissions.
I5.2 UK ILUC Emissions	This section contains typical ILUC emissions input data by UK feedstock and input form for 2020 in gCO_2/MJ, and defines both ILUC emissions savings over time, and the distribution of ILUC emissions.
I5.3 UK Carbon Capture	Contains the carbon content of UK feedstocks in tCO_2/PJ.

5.6 I6_GLOBAL_GHG_EMISSIONS

This sheet contains background data and assumptions required to assess the GHG emissions resulting from global feedstocks.

Sheet section	Description
I6.1 Global direct emissions	This section contains typical direct emissions input data by Global feedstock and input form for 2020 in gCO_2/MJ, and defines both direct emissions savings over time, and the distribution of direct emissions.
I6.2 Global ILUC emissions	This section contains typical ILUC emissions input data by Global feedstock and input form for 2020 in gCO_2/MJ, and defines both ILUC emissions savings over time, and the distribution of ILUC emissions.
I6.3 Global carbon capture	Contains the carbon content of Global feedstocks in tCO_2/PJ.

5.7 I7_CONVERSION_TECH

This sheet contains inputs to determine the conversion technologies used for different feedstocks, which in turn is used to determine the sustainability of resources.

Sheet section	Description
I7.1 Setup	This section defines the GHG limit for the fossil fuel comparator for each energy vector, as defined in I7.2, and sets the net calorific value.
I7.2 Set energy vectors	This section allows the user to define the comparator for the conversion technologies for conversion of global feedstock. For UK feedstocks, the feedstock form and comparator can be defined. This is used to determine the GHG limit for assessing the sustainability of resource. If a new technology is added, this table must be extended and a comparator defined
I7.3 Global conversions	Contains the conversion efficiencies for Global feedstocks. To update for a new conversion technology, efficiencies are required for each compatible feedstock.
I7.4 UK conversions	Contains the conversion efficiencies for UK feedstocks. To update for a new conversion technology, efficiencies are required for each compatible feedstock.
I7.5 CO_2 Capture rate	Contains the rate at which CO_2 is captured by each conversion technology over time.
I7.6 Overseas domestic feedstock conversion efficiencies	This section contains the conversion efficiencies for feedstocks which may be converted overseas prior to being exported, including: - Waste to bioethanol - Waste to biodiesel - UCO / Tallow to biodiesel - Non-exportable biomass to sustainable aviation fuel (SAF) - Non-exportable biomass to road transport fuel
I7.7 Global manure conversion efficiency	This section contains the assumed conversion efficiency for conversion of global manure to biogas.

5.8 I8_UK_LAND

This sheet contains the land areas that are assigned to each energy crop in the UK.

Sheet section	Description
I8.1 Land availability	This sheet contains the input scenarios for land availability in kha over time, for crop resources. The advanced user may add their own scenario to one of the empty tables. Scenario names and descriptions are entered in I1.4.1_UK_land_availability_scenarios_t

5.9 I9_IMPORTS

This sheet contains UK import percentages for the different import methodologies.

Sheet section	Description
I9.1 UK Share of Global GDP in 2050	This table contains the UK's share of total global GDP for each of the supply scenarios. Note: The UKs GDP as a share of net importing regions is calculated in C6.2 GDP of net importers.
I9.2 UK Imports in 2020	This table contains data on the quantity of each resource imported to the UK in 2020 and calculates this as the share of resource surplus/production.
I9.3 Selected scenario	This table selects the relevant UK import scenario from I9.4 or I9.5 depending on user inputs.
I9.4 Imports as proportion of surplus	This section contains assumptions on the import percentages for the UK when global resource availability is assessed on a surplus basis. The values for 2020 are set based on known imports. Advanced users may add their own assumptions for 2025 - 20250 to *Imports_surplus_UK_accessibility_scenario_3_t*.
I9.5 Imports as proportion of production	This section contains assumptions on the import percentages for the UK when global resource availability is assessed on a production basis. The values for 2020 are set based on known imports. Advanced users may add their own assumptions for 2025 – 20250 to *Imports_production_UK_accessibility_scenario_3_t*

5.10 I10_UK_SPATIAL

This sheet specifies the distribution of UK resources across the regions modelled.

Sheet section	Description
I10.1 UK Spatial disaggregation	Collects the data for spatial disaggregation of the UK feedstocks from the relevant reference data sheets.

5.11 I11_GDP

This sheet holds data on UK and Global GDP.

Sheet section	Description
I11.1 - UK GDP	This section contains UK GDP data for 2020, forecasted to 2050. Depending on the user inputs, the relevant forecast scenario is selected.
I11.2 – Global GDP	This section contains Global GDP data for 2020, forecasted to 2050. Depending on the user inputs, the relevant forecast scenario is selected.

6. CALCULATION MODULES

This section provides an overview of the calculation modules included within the model, outlining each calculation sheets, how input data is linked, and the logic of the calculation steps which have been implemented.

6.1 C1_GLOBAL_SUPPLY_CROPS

Table 6-1 – Calculations in C1_Global_supply_crops

Calculation	Description
C1.1 Unconstrained land availability	Calculates the total availability of land for annual/perennial crop production, based on the products of the inputs defined in I2.1 Abandoned land availability.
C1.2 Supply to meet domestic 1G demand	Calculates the supply of bioethanol and biodiesel that can be produced domestically in each region, to meet the regional demand for these fuels. The land area needed to meet domestic 1G biofuel demand is calculated in C3.9 Land needed to meet additional 1G biofuel demand. It is assumed that any land currently used for 1G biofuel production remains utilised for this purpose. Any additional land required is abandoned agricultural/pasture land. These calculations subtract the additional land required regionally to meet 1G biofuel demand from the total pool of available land calculated in C1.1 and partition this land between bioethanol and biodiesel production. Note, that sugar, starch and oil crops can only be produced on non-degraded land, and the use of abandoned agricultural land is prioritised over abandoned pasture land. Following the regional calculations, the remaining available land and remaining demand for 1G biofuels across all regions is determined. The share of the remaining available demand that can be met by the available remaining land is then calculated.
C1.3 Supply constraint calculations	Determines supply constraints for **perennial energy crop** production. Two supply constraints are applied to perennial energy crop production: 1. Market/trade or infrastructure constraints 2. Planting rate constraints Input data for constraints is held in I3_Global_supply_constraints. For market/trade and infrastructure constraints. If both constraints are applied by the user, the most constraining of the 2 is applied. The planting rate constraint for perennial energy crops is calculated based on the first year of planting, the initial area of new plantation and the annual growth. Since the growth is annual and cumulative the calculation is done in five tables to cover each year between the time stamps (e.g. 2030, 2035, etc). A new plantation area of the size of the initial area plus growth is added every year. For example, in year 1 an area of 100 kha is available and the annual growth is 20%; therefore, in year 2 there is a total area of 220 kha and in year 3 of 364 kha.
C1.4 Constrained land availability for energy crops	Calculates the land available for perennial energy crop production. The total amount of land available for perennial energy crop production is calculated as available unconstrained land (C1.1) minus land needed to meet the 1G biofuel demand (C1.2).

Calculation	Description
	The constraints calculated in C1.3 are then applied. Note, planting rates are always applied, while market/trade and infrastructure constraints can be switched on or off by the user. Available land is utilised up to a maximum of the planting rate and mildly degraded land is used preferentially to non-degraded land. Any non-degraded agricultural land not utilised for perennial energy crop production is used to produce additional 1G biofuel crops.
C1.5 Energy crop yield	**Elaborates regional perennial energy crop yields** according to land category and time based on the inputs in I2.4 Perennial energy crop yields. **Elaborates annual energy crop fuel yields** by land type and region based on the inputs in I2.5 Annual energy crop yields. The crop yields (t/ha) are multiplied by the production/conversion yields (GJ/t) to calculate the fuel yield (PJ/Mha) for bioethanol and biodiesel on different land types. The yields are adjusted for land type and for future yield increases.
C1.6 Bioenergy exports from energy crops	**Perennial energy crops** grown are calculated based on constrained land availability calculated in C1.4 and the yield calculated in C1.5 for each of the land types and summed up to calculated total growth of perennial energy crops. **Excess annual energy crops fuel production** is calculated based on constrained land availability calculated in C1.4 and the yield calculated in C1.5 for each of the land types and for both bioethanol and biodiesel. The prioritisation of land for bioethanol or biodiesel is determined based on inputs in I2.2.

6.2 C2_GLOBAL_SUPPLY

This sheet calculates the constrained supply of global resources. For 1G bioethanol, 1G biodiesel and perennial energy crops, the constrained supply is calculated in C1_Global_supply_crops and the results are aggregated in this sheet. For all other resources, this sheet takes the unconstrained supply from the respective reference datasheet and applies any market/trade or infrastructure constraints, provided they have been switched on by the user.

Table 6-2 - Calculations in C2_Global_Supply

Calculation	Description
C2.1 Bioethanol (1G)	Calculates the total supply of 1G bioethanol by summing 2020 production (I2.3), additional production to meet regional demand (C1.2) and additional production in excess of regional demand (C1.6).
C2.2 Biodiesel (1G)	Calculates the total supply of 1G biodiesel by summing 2020 production (I2.3), additional production to meet regional demand (C1.2) and additional production in excess of regional demand (C1.6).
C2.3 UCO and Tallow	Calculates the supply of UCO and tallow. The unconstrained resource availability is taken from the respective reference data sheet (R_G3_UCO and R_G_tallow). If the user has selected to apply market/trade and/or infrastructure constraints, the most constraining factor is determined and applied to the unconstrained resource to give the constrained UCO and tallow availabilities. If no constraints are applied, the constrained resource is equal to the unconstrained resource.
C2.4 Non-exportable resources	Calculates the supply of the non-exportable resources. The unconstrained resource availability is taken from the respective reference data sheets. If the user has selected to apply market/trade and/or infrastructure constraints, the most constraining factor is determined and applied to the unconstrained resource to give the constrained availabilities. If no constraints are applied, the constrained resource is equal to the unconstrained resource.
C2.5 Exportable resources	Calculates the supply of the exportable resources (except perennial energy crops*). The unconstrained resource availability is taken from the respective reference data sheets. If the user has selected to apply market/trade and/or infrastructure constraints, the most constraining factor is determined and applied to the unconstrained resource to give the constrained availabilities. If no constraints are applied, the constrained resource is equal to the unconstrained resource.
C2.6 Gaseous resources	Calculates the supply of the exportable resource. The unconstrained resource availability is taken from the respective reference data sheets. If the user has selected to apply market/trade and/or infrastructure constraints, the most constraining factor is determined and applied to the unconstrained resource to give the constrained availabilities. If no constraints are applied, the constrained resource is equal to the unconstrained resource.

* Constraints are applied to perennial energy crops in C1.3 and constrained supply is calculated in C1.6.

6.3 C3_GLOBAL_DEMAND

Table 6-3 - Calculations in C3_Global_demand

Calculation	Description
C3.1 Total liquid biofuels	Calculates the total demand for bioethanol and biodiesel. This calculation is dependent on the demand scenario selected by the user. It utilises the overall demand for liquid biofuels (I4.1) and calculates the relative share of bioethanol/biodiesel according to the percentages defined in I4.2.
C3.2 Crop based bioethanol	Calculates the demand for bioethanol that is met by crop based bioethanol using assumptions set in I4.3 Crop-based demand and the total demand for bioethanol calculated in C3.1.
C3.3 Crop based biodiesel	Calculates the demand for biodiesel that is met by crop based biodiesel using assumptions set in I4.3 Crop-based demand and the total demand for biodiesel calculated in C3.1.
C3.4 Additional biofuels (1G)	Calculates the additional demand for crop based (i.e.1G) bioethanol and biodiesel with respect to the demand in 2020 by subtracting 2020 demand from the demand in a given year. Demand is calculated in C3.2.
C3.5 Land needed to meet additional 1G biofuel	Calculates the area of land needed to meet the additional biofuel demand by dividing the additional demand (C3.4) by the bioethanol/biodiesel fuel yield (C1.5). The output of these calculations is used in the calculations of supply to meet the domestic demand (C1.2).
C3.6 Non-crop based bioethanol	Calculates the share of the total bioethanol demand (C3.1) that is met by non-crop based bioethanol. The share of non-crop bioethanol is calculated as the remaining bioethanol demand not met my crop based bioethanol (I4.3). The calculated demand for non-crop bioethanol is then adjusted to exclude a portion of the total which is produced by resources not included in the model using the “Proportion of non-crop feedstocks not include in the model” user input. The remaining demand for bioethanol, produced from resources in the model, is then converted to an equivalent demand for solid biomass using the conversion efficiency defined in I7.
C3.7 Non-crop based biodiesel	Calculates the share of the total biodiesel demand (C3.1) that is met by non-crop based biodiesel. The share of non-crop biodiesel is calculated as the remaining biodiesel demand not met by crop based biodiesel (I4.3).
C3.8 Solid biomass	Calculates the total demand for solid biomass, including the demand for solid biomass for liquid biofuels. Sums the demand for solid biomass for in selected demand scenario (I4.10) and the demand for solid biomass for bioethanol (C3.6) and biodiesel (C3.7).
C3.9 Gaseous resources	Calculates the share of demand for gaseous biomass that must be met by manure. Applies the percentage of gaseous demand to be met by manure (I4.9) to the total demand for gaseous biomass (I4.5).

6.4 C4_GLOBAL_BALANCE

This sheet calculates the surplus of the resources available after demand has been met. Broadly, this means that supply calculated in C1_Global_supply_crops and C2_Global_Supply is subtracted from demand calculated in C3_Global_demand.

In the balance of supply and demand, non-exportable resources are used preferentially to exportable resources to meet domestic demand.

Calculation	Description
C4.1 Bioethanol (1G)	Calculates the surplus of 1G bioethanol after demand has been met within each region. The total demand for 1G bioethanol (C3.1) is subtracted from the total supply of 1G bioethanol (C2.1) to calculate the surplus that is available on the global market. For regions where demand exceeds supply, the deficit is separately calculated.
C4.2 Biodiesel (1G)	Calculates the surplus of 1G biodiesel after demand has been met within each region. The total demand for 1G biodiesel (C3.1) is subtracted from the total supply of 1G biodiesel (C2.1) to calculate the surplus that is available on the global market. For regions where demand exceeds supply, the deficit is separately calculated.
C4.3 Balance of supply and demand	Calculates the surplus of **non-exportable** solid biomass resources after demand for solid biomass has been met within each region, and the proportion of non-exportable resources required to meet domestic demand. The remaining demand for solid biomass after non-exportable resources have been used is calculated.
C4.4 Redistribution of Non-exportable resources	Calculates the potential availability of each non-exportable resource. The proportion of non-exportable resources remaining within a region calculated in C4.3 is used to redistribute the surplus supply within each region across each resource.
C4.5 Demand to be met by solid biomass	Using remaining demand calculated in C4.3, the surplus of **exportable** solid biomass resources in each region is calculated, as well as the proportion of exportable resources required.
C4.6 Redistribution of exportable resources	Calculates the potential availability of each exportable resource. The proportion of exportable resources remaining within a region calculated in C4.5 is used to redistribute the surplus supply within each region across each resource.
C4.7 Gaseous resources	Calculates the potential availability of manure after the domestic demand for gaseous biomass in each region has been met.
C4.8 Biodiesel from UCO and tallow	Calculates the potential availability of UCO / tallow for biodiesel after the domestic demand in each region has been met.

6.5 C5_RESOURCE_CONVERSION

This sheet calculates the availability of road transport fuel and SAF produced domestically in each region from non-exportable resources.

Calculation	Description
C5.1 Conversion of surplus non-exportable resource - Road transport fuel	Calculates the amount of road transport fuel from conversion of surplus non-exportable biomass resources, by multiplying the conversion efficiency located in I7_Conversion_tech and the amount assigned by the user.
C5.2 Conversion of surplus non-exportable resource - SAF	Calculates the amount of SAF fuel from conversion of surplus non-exportable biomass resources, by multiplying the conversion efficiency located in I7_Conversion_tech and the amount assigned by the user.
C5.3 Conversion of non-exportable resource on production basis - Road transport fuel	Calculates the amount of road transport fuel from conversion of non-exportable biomass resources on a production basis, by multiplying the conversion efficiency located in I7_Conversion_tech and the amount assigned by the user.
C5.4 Conversion of non-exportable resource on production basis - SAF	Calculates the amount of SAF from conversion of non-exportable biomass resources on a production basis, by multiplying the conversion efficiency located in I7_Conversion_tech and the amount assigned by the user.
C5.5 Allocation of global UCO/tallow production between SAF and Road transport	Calculates the amount of SAF and road transport fuel produced from global UCO/tallow production.
C5.6 Allocation of global UCO/tallow surplus between SAF and Road transport	Calculates the amount of SAF and road transport fuel produced from global UCO/tallow surplus.

6.6 C6_GLOBAL_SURPLUS

This sheet collects the calculated resource surplus available on the global market i.e. the resource remaining after demand has been met.

Calculation	Description
C6.1 Global surplus	Collects the calculated resource surplus after domestic demand for resources has been met in each region. This is collected from C4_Global_balance. For non-exportable resources, this is collected from C5.1 and C5.2 in C5_Conversion_nonexport which are linked to the surplus of non-exportable resources. The next table regroups the data from above into the feedstock groupings needed to calculate import shares.
C6.2 GDP of net importers	Calculates the total global GDP for regions that are assessed as net importers of each feedstock category. Any region that does not have a resource surplus (i.e. surplus equals zero) is assumed to be a net importer.

6.7 C7_GLOBAL_PRODUCTION

This sheet collects the calculated resource production i.e. the resource available before demand has been met.

Calculation	Description
C7.1 Global production	Collects the calculated resource production prior to demand being met. This is collected from C2_Global_supply. For non-exportable resources, this is collected from C5.3 and C5.4 in C5_Conversion_nonexport which are linked to the production of non-exportable resources. The next table regroups the data from above into the feedstock groupings needed to calculate import shares.

6.8 C8_GHG_LIMIT

This sheet calculates the GHG limit associated with each conversion pathway, adjusting for the conversion efficiency.

Calculation	Description
C8.1 Global GHG limit - converted	This section calculates the GHG limits for global resources. For each conversion technology, the GHG limit for the relevant comparator is multiplied by the conversion efficiency (both defined in I7_Conversion_tech)
C8.2 UK GHG limit - converted	This section calculates the GHG limits for UK resources. For each conversion technology, the GHG limit for the relevant comparator is multiplied by the conversion efficiency (both defined in I7_Conversion_tech)

6.9 C9_GLOBAL_GHG_EMISSIONS

This sheet determines the GHG emissions associated with the global resources over time. This is done by calculating the distribution of direct and ILUC emissions, accounting for captured emissions if relevant, and determining the pass rate. The pass rate reflects the quantity of each feedstock which meets GHG criteria, to assess the availability of sustainable feedstock by region.

Calculation	Description
C9.1 Distribution of direct emissions	Calculates the distribution of global direct emissions by feedstock by multiplying the 2020 direct emissions by the typical emissions savings for the relevant emissions level.
C9.2 Distribution of ILUC emissions	Calculates the distribution of global ILUC emissions by feedstock multiplying the 2020 ILUC emissions by the typical emissions savings for the relevant emissions level.
C9.3 Distribution of total direct and ILUC emissions	Calculates the distribution of total global emissions by summing the ILUC and direct emissions.
C9.4 Pass rate	This section checks whether the total emissions calculated in C9.3, for each resource and emissions level in the emissions distribution, is lower than the GHG limit defined for the relevant fossil fuel comparator (set in I7_Conversion_tech). If the imported feedstock has been assigned to a technology with carbon capture in the UK, and the user has chosen to allow for captured CO_2 to be allowed for in assessing compliance with the GHG criteria then this is allowed for when assessing the pass rate. The CO_2 captured per MJ is calculated in C12.
C9.5 Pass rate by emissions level	If a resource at a given emissions level passes the criteria evaluated in C9.4, then this section collects the percentage of that resource that is sustainable from the user selected emissions distribution (central, high emissions and low emissions).
C9.6 Pass rate by conversion pathway	Sums the total pass rate by conversion pathway i.e. each compatible feedstock and conversion technology combination.
C9.7 Feedstock assigned to each conversion pathway	Collects the user assigned amount of feedstock which has been assigned to each conversion pathway. This accounts for the user input determining whether to assess resource availability on a global surplus, or global production basis.
C9.8 Sustainable feedstock available to the UK by conversion pathway	Calculated the amount of sustainable feedstock by conversion pathway by multiplying the proportion of each feedstock which meets GHG criteria by the amount of feedstock available (Collected above in C9.7)
C9.9 Feedstock availability by region	Sums the amount of feedstock by region which is sustainable.
C9.10 Total feedstock that meets the GHG criteria	Calculates the quantity of available feedstock that meets the GHG criteria. It is used to calculate the UK import % in 2020 in I9_Imports.

6.10 C10_UK_GHG_CRITERIA

This sheet determines the GHG emissions associated with use of feedstocks produced in the UK. This is done by calculating the distribution of direct and ILUC emissions, accounting for captured emissions if relevant, and determining the pass rate. The pass rate is used to calculate the amount of feedstock which meets GHG criteria, to calculate the quantity of feedstock available that meets the GHG criteria.

Calculation	Description
C10.1 Distribution of direct emissions	Calculates the distribution of UK direct emissions by feedstock by multiplying the 2020 direct emissions by the typical emissions savings for the relevant emissions level.
C10.2 Distribution of ILUC emissions	Calculates the distribution of UK ILUC emissions by feedstock multiplying the 2020 ILUC emissions by the typical emissions savings for the relevant emissions level.
C10.3 Distribution of total direct and ILUC emissions	Calculates the distribution of total UK emissions by summing the ILUC and direct emissions and subtracting the captured carbon emissions, as calculated in C12_UK_Carbon_Capture.
C10.4 Pass rate	This section **checks whether the total emissions** calculated in C9.3, for each resource and emissions level in the emissions distribution, is **lower than the GHG limit** defined for the relevant fossil fuel comparator (set in I7_Conversion_tech).
C10.5 Pass rate by emissions level	If a resource at a given emissions level passes the criteria evaluated in C10.4, then this section collects the percentage of that resource that is sustainable from the user selected emissions distribution (central, high emissions and low emissions).
C10.6 Pass rate by conversion pathway	Sums the total pass rate by conversion pathway i.e. each compatible feedstock and conversion technology combination.
C10.7 Amount of feedstock assigned to each pathway	Collects the user assigned amount of feedstock which has been assigned to each conversion pathway. This accounts for the user input determining whether to assess resource availability on a UK surplus, or UK production basis.
C10.8 Sustainable feedstock assigned to each pathway	Calculated the amount of sustainable feedstock by conversion pathway by multiplying the proportion of each feedstock which meets GHG criteria by the amount of feedstock available (Collected above in C9.7)
C10.9 Sustainable feedstock by technology	Sums the amount of UK feedstock by technology which is sustainable.

6.11 C11_UK_SUPPLY

This sheet extracts information on the availability of UK resources from the *Feedstock Availability Data* worksheets

Calculation	Description
C11.1 Feedstock info	Contains information on UK feedstocks (calorific values and moisture content).
C11.2 Feedstock potential	Calculates the **accessible feedstock potential in PJ**. This is done by converting reference data on unconstrained potential and competing use from units of mass to units of energy (PJ) then subtracting competing use (i.e. non-energy use) from the unconstrained potential to calculate the accessible feedstock potential.
C11.3 Feedstock price	This section collects feedstock prices.

6.12 C12_UK_CARBON_CAPTURE

This sheet calculates the potential carbon captured in the UK for the specified scenario.

Calculation	Description
C12.1 CO_2 per MJ of UK feedstock	Calculates the potential for CO_2 capture per MJ of UK feedstock for a given feedstock and conversion technology pairing, by multiplying the carbon content of a feedstock (expressed in terms of CO_2 per MJ) by the potential carbon capture rate of the corresponding conversion technology. It also calculates the amount of the captured CO_2 which should be allowed for when assessing GHG emissions against GHG criteria by checking if the user wishes to allow this. If it is to be allowed then the efficiency of the carbon capture T&S system is also taken into account.
C12.2 UK Carbon capture and storage potential	Calculates the mass of CO_2 captured from UK feedstocks by taking the potential for CO_2 based on the mass of CO_2 generated for each feedstock/conversion technology pairing and the CO_2 capture rate.
C12.3 CO_2 per MJ of global feedstock	Calculates the CO_2 per MJ of Global feedstock for a given feedstock and conversion technology, by multiplying the carbon content of a feedstock with the carbon capture rate of the corresponding conversion technology.
C12.4 CCS Potential of imported feedstocks	This table calculates the mass of CO_2 generated by multiplying the sustainable feedstock available, and the carbon content, and the mass of CO_2 captured
C12.5 Total CO_2 Captured in the UK	This table sums the total carbon captured in the UK from domestic feedstocks

6.13 C13_UK_SPATIAL_DISAGGREGATION

Table 6-4 - Description of the calculations in C10_UK_Sustainability

Calculation	Description
13.1 UK feedstock scenarios	Retrieves the percentages for spatially disaggregating UK feedstocks from I10_UK_Spatial, according to the scenario selected for each feedstock.

7. FEEDSTOCK AVAILABLITY DATA

7.1 FEEDSTOCK AVAILABILITY DATA SHEETS

Input data regarding the availability of UK resources is located in sheets R_UK1 through to R_UK25, and global resources in sheets R_G1 through to R_G8. These sheets contain key information about the feedstock and data including availability and competing uses. UK feedstock sheets also contain tables outlining the spatial data for disaggregating results.

Details on the data, assumptions and supporting calculations that underpin these estimates can be found in the *Methodology* document and/or the corresponding *Background Workbooks*.

7.1.1 Adding New UK Feedstock Scenarios

The model is designed so that new scenarios for UK based feedstocks in the model can be conveniently added as follows:

1. **Unconstrained potential**

   Add the unconstrained feedstock potential to an empty row in the appropriate table in the model, as indicated in Table 7-1 below. A scenario name and description should also be entered, and the user should ensure that units of the new input data are the same as those already in the model, indicated in Table 7-1.

2. **Competing Use**

   Add the competing use to an empty row in the appropriate table in the model, as indicated in Table 7-1 below. A scenario name and description should also be entered, and the user should ensure that units of the new input data are the same as those already in the model, indicated in Table 7-1.

3. **Spatial Disaggregation**

   Add the desired spatial disaggregation for each region to the table corresponding to the newly added scenario. These tables are located in the *Spatial Disaggregation* section of the feedstock availability data sheets (row 63 and below). Once added, navigate to the "Data" tab and click "Refresh all" (see Figure 7-1) to load the newly entered data to *UK_spatial_disaggregation_t*.

After following the above steps, the newly created scenario should be available for selection from the respective drop down menu in *UI-1.1 UK resources: availability scenarios* on the *User Input* sheet.

Figure 7-1 Location of the "Refresh All" option within the "Data" tab.

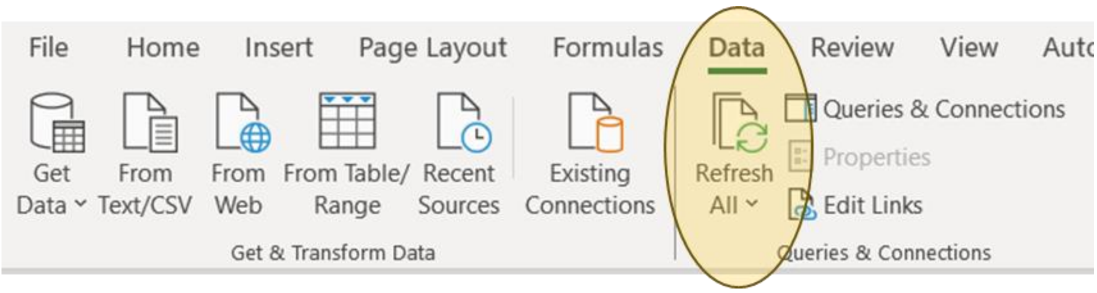


Table 7-1 Overview of key table names for UK feedstocks

Feedstock Name	Units	Unconstrained Potential	Competing Use
Agricultural Field Residues	Modt	UK_Agricultural_field_residues_unconstrained_potential_t	UK_Agricultural_field_residues_competing_use_t
Forestry harvesting residues	Modt	UK_Forestry_harvesting_residues_unconstrained_potential_t	UK_Forestry_harvesting_residues_competing_use_t
Small roundwood	Modt	UK_SRW_unconstrained_potential_t	UK_SRW_competing_use_t
Short Rotation Forestry	Modt	UK_SRF_unconstrained_potential_t	UK_SRF_competing_use_t
Sawmill residues	Modt	UK_Sawmill_unconstrained_potential_t	UK_Sawmill_competing_use_t
Arboricultural arisings	Mt	UK_Arbs_unconstrained_potential_t	UK_Arbs_competing_use_t
Waste Wood	Mt	UK_Waste_wood_unconstrained_potential_t	UK_Waste_wood_competing_use_t
Residual biogenic waste	Mt	UK_Renewable_waste_unconstrained_potential_t	UK_Renewable_waste_competing_use_t
Food Waste	Mt	UK_Food_waste_unconstrained_potential_t	UK_Food_waste_competing_use_t
Landfill gas	Modt	UK_Landfill_gas_unconstrained_potential_t	UK_Landfill_gas_competing_use_t
Sewage Sludge	Modt	UK_Sewage_sludge_unconstrained_potential_t	UK_Sewage_sludge_competing_use_t
Cattle manure and slurry	Modt	UK_Cattle_slurry_unconstrained_potential_t	UK_Cattle_slurry_competing_use_t
Pig manure and slurry	Mt	UK_Pig_slurry_unconstrained_potential_t	UK_Pig_slurry_competing_use_t
Tallow	Mt	UK_Tallow_unconstrained_potential_t	UK_Tallow_competing_use_t
UCO	odt/ha	UK_UCO_unconstrained_potential_t	UK_UCO_competing_use_t
SRC Willow	odt/ha	UK_SRC_willow_unconstrained_potential_t	UK_SRC_willow_competing_use_t
Miscanthus	t/ha	UK_Miscanthus_unconstrained_potential_t	UK_Miscanthus_competing_use_t
Maize	t/ha	UK_Maize_unconstrained_potential_t	UK_Maize_competing_use_t
Wheat	t/ha	UK_Wheat_unconstrained_potential_t	UK_Wheat_competing_use_t
Sugar beet	Mt	UK_Sugar_beet_unconstrained_potential_t	UK_Sugar_beet_competing_use_t
Brown Grease	Mt	UK_Brown_Grease_unconstrained_potential_t	UK_Brown_Grease_competing_use_t
Waste tyres biogenic fraction	Mt	UK_Waste_tyres_biogenic_fraction_unconstrained_potential_t	UK_Waste_tyres_biogenic_fraction_competing_use_t
Microalgal Oil	Mt	UK_Microalgal_Oils_unconstrained_potential_t	UK_Microalgal_Oils_competing_use_t
Agricultural processing residues	Modt	UK_Agricultural_processing_residues_unconstrained_potential_t	UK_Agricultural_processing_residues_competing_use_t

7.1.2 Adding New UK Land Availability Scenarios

The availability of SRC willow, miscanthus, maize, wheat and sugar beet in the UK is dependent on the area of land assumed to be available for their production. The model contains 3 pre-defined scenarios for land availability for these crops. The advanced user can add new land availability scenarios as follows:

1. **Scenario Name**

   Navigate to table *I1.4.1_UK_land_availability_scenarios_t* and add the name and description for the new scenario in the next *[Spare]* row in the table.

2. **Land Area**

   Navigate to the table corresponding to the newly created scenario in *I8_UK_Land* and enter the desired land areas for each of the crops. Land area should be entered in units of kilohectares (kha).

The newly added scenario should now be available for selection in *UI1.2 UK crop resources: land availability* on the *User Input* sheet.

7.1.3 Adding New Import Scenarios

Assumptions regarding imports i.e. the share of available global resources the UK can access are stored on *I9_Imports*. In addition to the 4 pre-defined scenarios, there are 2 additional slots that can be used for the advanced user to add their own assumptions.

Scenarios can be added as follows:

1. **Model Configuration**

   Select the model operating mode you wish to use from *UI-3.1 Operating mode for the global resource part of the model* and select whether to apply GHG savings criteria to resource estimates in *UI-4.1 Application of GHG savings criteria to resources*.

2. **Import Assumptions**

   If *UI-3.1 Operating mode for the global resource part of the model* is set to "Global resource production", navigate to the table *Imports_production_UK_accessibility_scenario_3_t*. If it is set to "Global resource surplus" then navigate to the table *Imports_surplus_UK_accessibility_scenario_3_t*.

   The 2020 column is set by default to the actual percentage share of resources imported in 2020 for the selected model configuration. These values should not be edited. The user may enter their own assumptions into the blank, green, cells within the table. These values should be entered as a percentage. Finally, the user should enter a scenario description into the relevant cell in *Import_scenario_setting_t.*

The newly entered scenario should now be selectable from the drop down menu in *UI-3.2 Fraction of global resources accessible to UK* on the *User Input* sheet.

7.1.4 Adding New Feedstocks

While the model has been constructed in such a manner that it is possible to add new UK or global feedstocks, it is not recommended to do so without consulting the model development team. This is because the addition of new feedstocks requires several manual adjustments to the model inputs and calculations.

For UK Feedstocks, the addition of a new feedstock necessitates that the feedstock allocation, compatible conversion technologies, direct emissions and carbon content inputs are updated. Additionally, calculations such as GHG emissions and carbon capture calculations must be modified manually. Although *[Spare]* inputs have been left throughout the model to help facilitate this, full integration of a new feedstock is complex.

Equivalent updates must be made to add new global feedstocks. However, the global feedstocks have the additional complexity that global supply and demand calculations must be modified to account for any new feedstocks.

7.1.5 Adding New Conversion Technologies

It is possible to add new conversion technologies to the model. However, it is not recommended to do so without consulting the model development team. This is because the addition of new conversion technologies requires comprehensive modifications to the GHG emission calculations for all compatible feedstocks.

Properties such as the conversion efficiency and carbon capture rate of existing technologies can be modified by the advanced user in sheet *I7_Conversion_tech*.

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