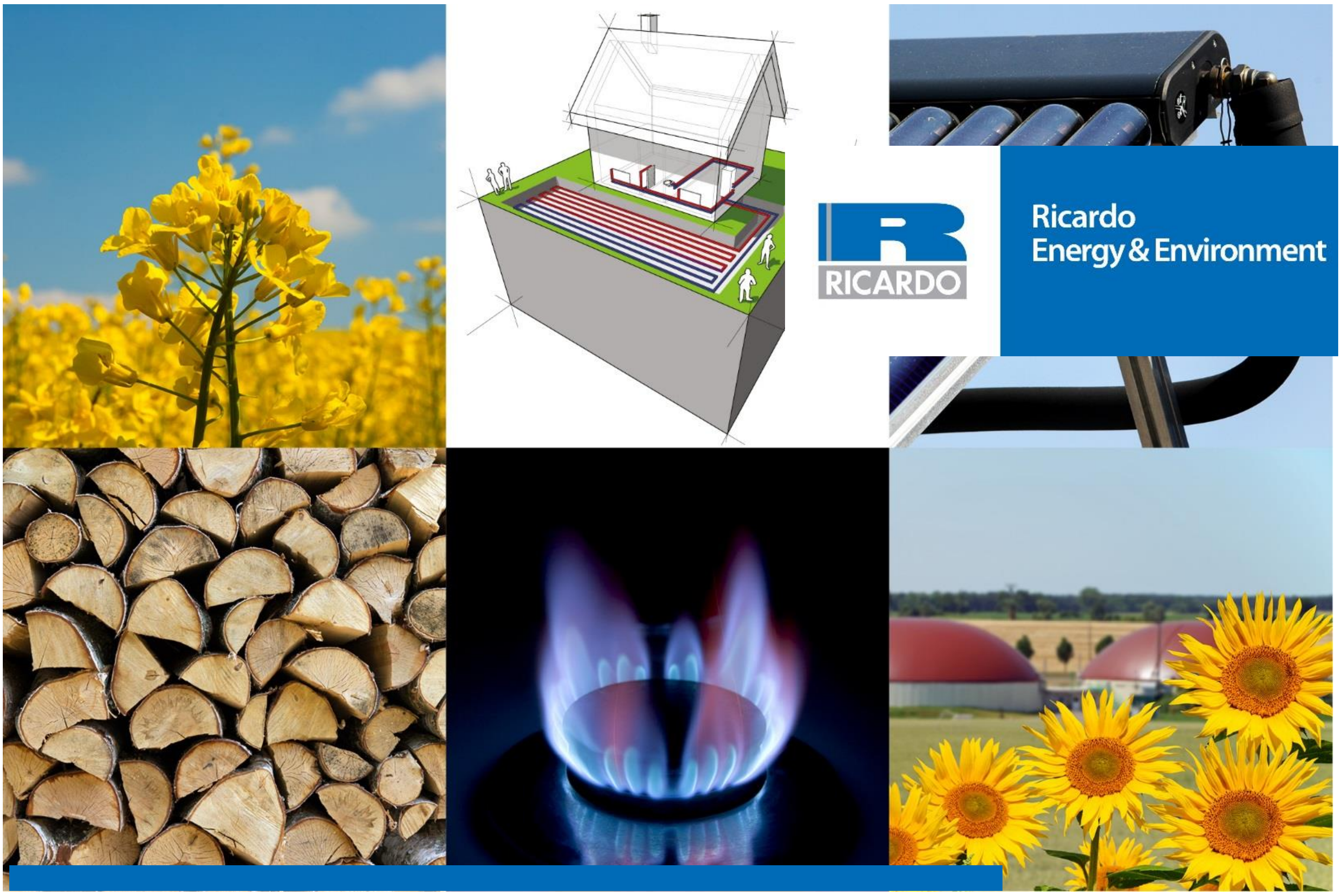

Biomass Feedstock Availability

Final report

ED 662421043 | Issue Number 3 | Date 06/03/2017

Customer:

BEIS

Customer reference:

N/A

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06 March 2017

Ricardo Energy & Environment reference:

Ref: ED662421043- Issue Number 3

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1 Introduction

In 2010/11 AEA Technology plc produced a study and model for DECC on the UK and Global Bioenergy Resource (AEA, 2011). The model estimated the potential bioenergy resource available to the UK from domestically sourced and imported feedstocks from 2010 to 2030. BEIS subsequently commissioned Ricardo Energy & Environment[1] to update, improve and expand the model, and make it suitable for publication and use by the general public. This report documents changes which were made to the original model during this update. A separate user guide to the revised model gives a description of the updated model, and how it functions. A full description of the models principles is given in the original report accompanying the model (AEA, 2011).

2 Changes to the model

A number of key changes were made to the model:

- extending the timeframe to 2050
- inclusion of sustainability constraints for solid and gaseous biomass
- improvement of the way sustainability criteria are included for liquid biofuels
- inclusion of a placeholder for ILUC emissions
- improvement of the input feedstock template for UK feedstocks to allow more information on price sensitivity to be included
- complete separation of all input data and assumptions from calculations, and facility for user to edit input data and assumptions if required.
- inclusion of additional UK and international feedstocks
- reporting of land use requirements for biofuels and perennial energy crops supply

Each of these changes is discussed in more detail below.

2.1 Timeframe for model

The timeframe for the previous model was 2010 to 2030. The timeframe in the new model runs from 2015 to 2050, with all results calculated for every 5 year time period (2015, 2020, 2025 etc.)

2.2 Treatment of sustainability

The previous version of the model only considered sustainability for liquid biofuels. In this version of the model, the sustainability of solid and gaseous biomass is also considered. The structure has also been adjusted to allow for the inclusion of ILUC emissions, as well as emissions directly associated with the production of the feedstock or biofuel.

2.2.1 Sustainability constraints for solid and gaseous biomass

Subsequent to delivery of the original spreadsheet model to DECC, DECC developed a methodology to allow the impact of sustainability criteria (which were being introduced under the RHI and RO) on the resource estimates produced by the model to be calculated. A spreadsheet[2] showing how this was implemented by DECC was supplied to Ricardo Energy & Environment and it was agreed through discussion with DECC, that the approach used in the spreadsheet created by DECC would be implemented in the new version of the model.

In the methodology developed by DECC and implemented in the model, the percentage of a feedstock resource which would meet sustainability criteria is assessed by comparing typical greenhouse gas emissions associated with the feedstock against the relevant sustainability standard. For solid and gaseous biomass feedstocks used to produce heat and power, this requires two additional assumptions:

[1] Ricardo Energy & Environment is a trading name of Ricardo-AEA Ltd which was formed in November 2012 when Ricardo plc acquired the assets and goodwill of AEA Technology plc
[2] Comparison of DECC to CCC Bioenergy Scenarios - 2015 v2 3, supplied by DECC to Ricardo Energy & Environment.

(i) about the assumed end use of the feedstock (e.g. for heat, power, or heat and power i.e. CHP) so that the correct sustainability criteria can be applied,

(ii) a typical conversion efficiency for converting the feedstock to heat and power. This is necessary because unlike liquid biofuels, the GHG criteria in the RHI and RO are expressed per unit of electricity or heat output.

As the GHG emissions associated with production of biomass feedstocks can vary, five GHG emissions are defined per feedstock, varying linearly from a low to high value. A distribution profile is then chosen, to determine the percentage of the total feedstock resource which has emissions at that level. Three distribution profiles are included:

- central - a 'square distribution'; an equal fraction of the feedstock (20%) is assumed to have emissions at each of the levels defined
- low weighted - a pessimistic view; a skewed distribution in which a greater proportion of the feedstocks are assumed to have higher emissions
- high weighted - an optimistic view: a skewed distribution in which a greater proportion of the feedstocks are assumed to have lower emissions

An overall ‘pass rate’ for a feedstock is then calculated based on the emissions associated with its production, the emissions profile distribution chosen, the assumed end use and conversion efficiency of the technology chosen in the assumed end use.

Emissions associated with the feedstock may be input by the user; assumptions for the default values included in the tool are given in the assumptions log in the model.

Sustainability criteria are set to those currently implemented in the RO and RHI, but can be modified by the user, and can be set for every five year period.

Full details of how to change all parameters is given in the user guide.

2.2.2 Sustainability constraints for liquid biofuels

In the previous version of the model, typical biofuels crops were identified for each region, and typical GHG emissions were estimated for biofuels produced from these crops, allowing for improvements over time in yield and production efficiency. The GHG saving which the biofuels could achieve were then calculated and compared with the GHG saving specified in the Renewable Energy Directive (RED), to decide whether the biofuel could be considered sustainable and therefore suitable for import into the UK (and EU). For fuels where the ‘typical’ GHG saving calculated was less than that required by the RED, a proportion of the fuel produced was assumed to meet the criteria. The proportion of fuel meeting the criteria depended on the magnitude of the difference between the typical value and the criteria.

In this revised version of the model, the same approach is applied as for solid and gaseous biofuels, i.e. five emissions values per biofuels have been created and then a distributions profile is applied. The typical values for biofuel production used last time have been retained as the central value and then an estimate of the percentage variation between typical and high values and typical and low values is used to derive high and low values. The percentage variation, as well as the typical values, may be set by the user.

In the case of biofuels, the RED specifies that savings of at least 50% must be achieved from 2017 onwards (as compared to 35% currently), but from 2018 the saving must be at least 60 % for biofuels produced in installations in which production started on or after 1 January 2017. The default data set in the tool thus sets the savings required to increase from 50% to 60% over time.

2.2.3 ILUC emissions

For both solid and gaseous feedstocks, and liquid biofuels, the model includes a place holder for indirect land use change (ILUC) emissions associated with feedstock production. For wood from forestry this ILUC factor could be used to represent any additional changes in carbon stock not included in the feedstock production emissions. In the default data set, this is set to zero for each feedstock, as there are currently no widely accepted values for ILUC emissions, but this is an input which the user can update.

2.3 UK feedstocks

2.3.1 Additional feedstocks

To reflect the growing interest in the use of crops for anaerobic digestion, an estimate of biogas production from maize has now been included. As this feedstock competes with other crops for land, estimates have been produced reflecting the maximum and minimum amount of biogas which could be produced, depending on whether production of maize or other crops suitable for liquid biofuels or perennial 'woody' energy crops, is set as the preferred option. The choice of which crop to maximise is set by the user. Table 2.1 summarises how the feedstock estimates in the model are combined for each of the different scenarios choices. More information on the assumptions about land availability for each crop are also given in the background workbooks which have been provided separately to this report.

2.3.2 New input template

The template used to record estimates of UK feedstocks was updated to reflect the new timeframe for the model (2015 to 2050). The other major improvement which has been made is to add lines to clearly identify the competing non-bioenergy feedstock uses. The template now contains four estimates of the resource which would go to competing non-bioenergy uses

a) Competing use which is independent of the price of the feedstock
b) Price dependent competing use at £4/GJ
c) Price dependent competing use at £6/GJ
d) Priced dependent competing use at £10/GJ

(£4, £6 and £10 are considered to be the price points currently representing the prices paid for biomass, though waste and some residues are cheaper than this).

The competing use which is independent of the price of the feedstock is subtracted from the estimate of the potential resource to give an estimate of the 'accessible resource'. Price dependent competing uses are subtracted from this to give the 'unconstrained bioenergy resource' at each of the three price points. The impact of other barriers on the availability of resource is then estimated as previously.

This project did not include a full analysis of competing uses, rather, the information from the previous model was updated and the competing uses from the chemical sector have not been included.

2.3.3 Update of UK feedstock resource estimates

All of the UK feedstock resource estimates were updated. A series of feedstock workbooks have been produced for each of the UK feedstocks, these contain sheets detailing literature sources used, and how assumptions and data points were derived. A comparison of the old and new estimates is given in Section 3.

Table 2.1 UK Feedstock estimates (names refer to workbooks within the model) used for different set scenarios choices

Perennial vs annual energy crops	When annual crops maximised	Energy Crops	Bioethanol Crops	Biodiesel Crops	Biomethane Crops
Maximise production perennial energy crops	n/a	Energy_Crops_Max	Bioethanol_Crops_Min	Biodisesel_Crops_Min	Biomethane_Crops_Min
Maximise production of annual energy crops	Maximise production of crops for liquid biofuels	Energy_Crops_Min	Bioethanol_Crops_Max	Biodisesel_Crops_Max	Biomethane_Crops_Min
Maximise production of annual energy crops	Maximise production of crops for biogas	Energy_Crops_Min	Bioethanol_Crops_Min	Biodisesel_Crops_Min	Biomethane_Crops_Max

2.4 Global data sets

2.4.1 Additional feedstocks

To reflect the growing international trade in UCO and tallow, estimates of the global availability of these two resources was made and included in the model. A background workbook for these resources details literature sources used, and how assumptions and data points were derived.

2.4.2 Update of global feedstock resource estimates

Estimates of global forestry resources (small roundwood, forestry residues, and sawmill coproducts) were updated and extended to 2050 by Forest Research, based on updated data from their Carbine model and FAO data. Full details are given the feedstock workbook for this resource.

Estimates of global biofuels and woody energy crop production are driven by assumptions about the amount of spare agricultural land available. This was previously based on estimates by Hoogwijk (2005), who had produced estimates of land availability based on two of the scenarios (A1 and A2) contained in the IPCC Special Report on Emissions Scenarios (2000). One of the scenarios was used for the BAU and BAU +high investment scenarios, and one for the low development scenario. The data comes from the IMAGE framework that simulates the environmental consequences of human activities worldwide.

This data has now been replaced with estimates of land availability under three of the shared socioeconomic pathways (SSPs) being developed for long term climate analysis, which represent alternative futures of societal development. BAU/continuing trends is based on SSP2, High investment/globalisation on SSP1 and Low investment/regionalisation on SSP3. Key characteristics of the SSP scenarios are given in the workbooks on global annual energy crops and perennial energy crops which support the model. The data set on land availability was provided by the University of Utrecht, and was produced using the same IMAGE ecological-environmental model as was used by Hoogwijk.

The base year for Image modelling land availability data is pre 2010, and scenarios have diverged by 2010. The base year of this model is 2015, so for consistency in this model, the data for 2010 and 2015 data for the high and low scenarios are set to values from the BAU scenario for these years. All values for abandoned pasture land are set to Image land availability model SSP1 Scenario, which is the basis for the high investment scenario in this model. This is a high sustainability scenario in which the Aichi biodiversity targets are assumed to be achieved, resulting in high levels of protected areas and less abandoned pasture land being available. As the UK is committed to the Aichi targets, the SSP1 values are assumed for all scenarios

In the previous model the estimates made by Hoogwijk, were constrained based on data from Van Vuuren (2009), which estimated areas which were unavailable for crop growing e.g. because they were too severely degraded or because of water scarcity. This approach has been retained in this version and uses the same data from Van Vuuren.

Overall estimates of abandoned agricultural land in 2030, are significantly lower in the revised data set – only 9% of the previous estimate for the BAU scenario (Table 2.2). Estimates of abandoned 'rest land' are reduced by over half (57%). For results run using the default settings, use of abandoned 'rest' land is set to zero, so results will be significantly impacted by the reduction in the estimate of agricultural land available. In earlier years, planting rate constraints for perennial energy crops, rather than land availability tend to constrain energy crop potentials but the reduced estimates of land availability become a constraint in later years.

2.4.3 Update of global demand for biomass

The energy demand scenarios that the demand for woody biomass and 1G biofuels are calculated from have been updated from data from those in the IEA's 2009 World Energy Outlook to the 2016 World Energy Outlook (IEA, 2016). The changes in demand for woody biomass and 1G biofuels that this leads to, are summarised in Table 2.3.

Table 2.2 Estimates of abandoned land available to grow biofuels and energy crops in 2030

	Agricultural land (Mha)	'Rest' land (Mha)	Total (Mha)
Previous version of model			
BAU scenario	650	339	989
High investment scenario	650	339	989
Low development scenario	320	400	720
Current model			
BAU scenario	123	466	668
High investment scenario	435	466	900
Low development scenario	141	466	607
Reduction from previous version			
BAU scenario	-91%	-57%	-79%
High investment scenario	-80%	-57%	-72%
Low development scenario	-86%	-64%	-74%

Table 2.3 Estimates of global demand in model in 2030

	BAU demand	High demand
Demand for 1G biofuels		
Previous model	4,566	4,301
Current model	4,692	5,977
% change	3%	55%
Woody biomass (including for 2G biofuels)		
Previous model	6,814	25,232
Current model	8,122	17,395
% change	19%	-31%

2.5 Separation of input data and assumptions

All input data and background assumptions have now been separated from calculations and are contained in the following background assumptions sheets.

- Sustainability data
- Assumed end use
- Land availability data
- Perennial energy crop data
- Biofuels data
- UK crop yields
- Global constraint data
- Global demand data
- Global demand – biomass type

Full details of what is contained on each background assumptions sheet are given in the user guide. Some key assumptions may be changed by the model user in the set key assumptions sheet.

The source of the default data which is included on each of these sheets is given in the assumptions log in the model. There are also background workbooks giving more information on the perennial energy crop data and biofuels data used for the global estimates. Where revised data was available input assumptions were updated.

2.6 Estimation of land use requirement

An additional results sheet was included in the model showing estimates of the land use associated with the forecast supply of biofuels, biogas from crops, perennial energy crops and short rotation forestry. These are estimated using the same assumptions about crop yield and biogas and biofuels yield from crops as in the UK resource estimates. These are recorded in the UK crop yields input data sheet. An estimate is also made of the land use internationally that is required to supply the quantity of bioethanol, biodiesel and woody energy crops available for import to the UK. This is based on the information on crop yields and biofuels yield contained in the input data sets in perennial energy crop data and biofuels data input sheets. This land use is broken down by region. An implicit assumption is that the international supply of biomass to the UK is sourced in the same proportions as countries which have a global surplus, i.e. if 10% of the ‘surplus’ occurs in South America, then 10% of the international supply which the UK imports comes from South America. Taking account of the probability of different regions supplying the UK (because of proximity, trade routes etc.) was not possible within the scope of this revision to the model.

3 Revised supply scenarios

This section of the report compares results from this version of the model with the previous one completed in 2010. Results for UK resources and international resources are compared separately in order to help identify where differences arise.

Full details of the assumptions behind the estimates of feedstock resource in the previous version of the model are given in Annex 2 of the previous report, and details of feedstock resource estimates in this version of the model are given in the background workbooks which have been provided separately to this report.

3.1 UK Feedstock Resource Estimates

Estimates of the total unconstrained potential resource available and the accessible resource (the resource available after price independent competing uses have been removed) in 2030 are shown in Figure 3.1, Figure 3.2 and Table 3.1. The feedstock resource ‘biogas from crops’ was not estimated in the previous model. As this competes for land with other crop based feedstocks (bioethanol from crops and biodiesel from crops) this has led to reductions in the estimates of these crops. In the case of Short Rotation Forestry the reduction in resource reflects the fact that no significant quantities of SRF have yet been planted, so (given the time for the plantation to mature) no resource is expected to be available by 2030. Overall the total underlying resource in 2030 is estimated to be 34% less than in the previous model, and the accessible resource (after price independent competing uses are removed) is estimated to be about 28% lower. Changes in individual resources vary, but the change in the overall total is largely driven by the fact that the SRF resource (estimated as 143 PJ in 2030 in the previous model) is now considered not available in 2030 (as significant planting of this resource has not occurred in the period 2010 to 2015). There are also significant reductions in the total waste and landfill gas resource. In terms of the accessible resource the main reduction comes in the energy crops estimate, due to more conservative assumptions about what could be planted by 2030.

Table 3.2 and Table 3.3 show the resource available at £4, £6 and £10/GJ in 2030, if no barriers which constrain supply are removed (Table 3.2) and if all constraints to supply are removed. These tables also allow for the competing uses of feedstocks. In both cases, the total resource estimated is, depending on the price level between 22% and 31% less than that estimated previously (based on the estimates of the minimum amounts available from crop based feedstocks).

Figure 3.1 Estimates of potential UK bioenergy resource in 2030

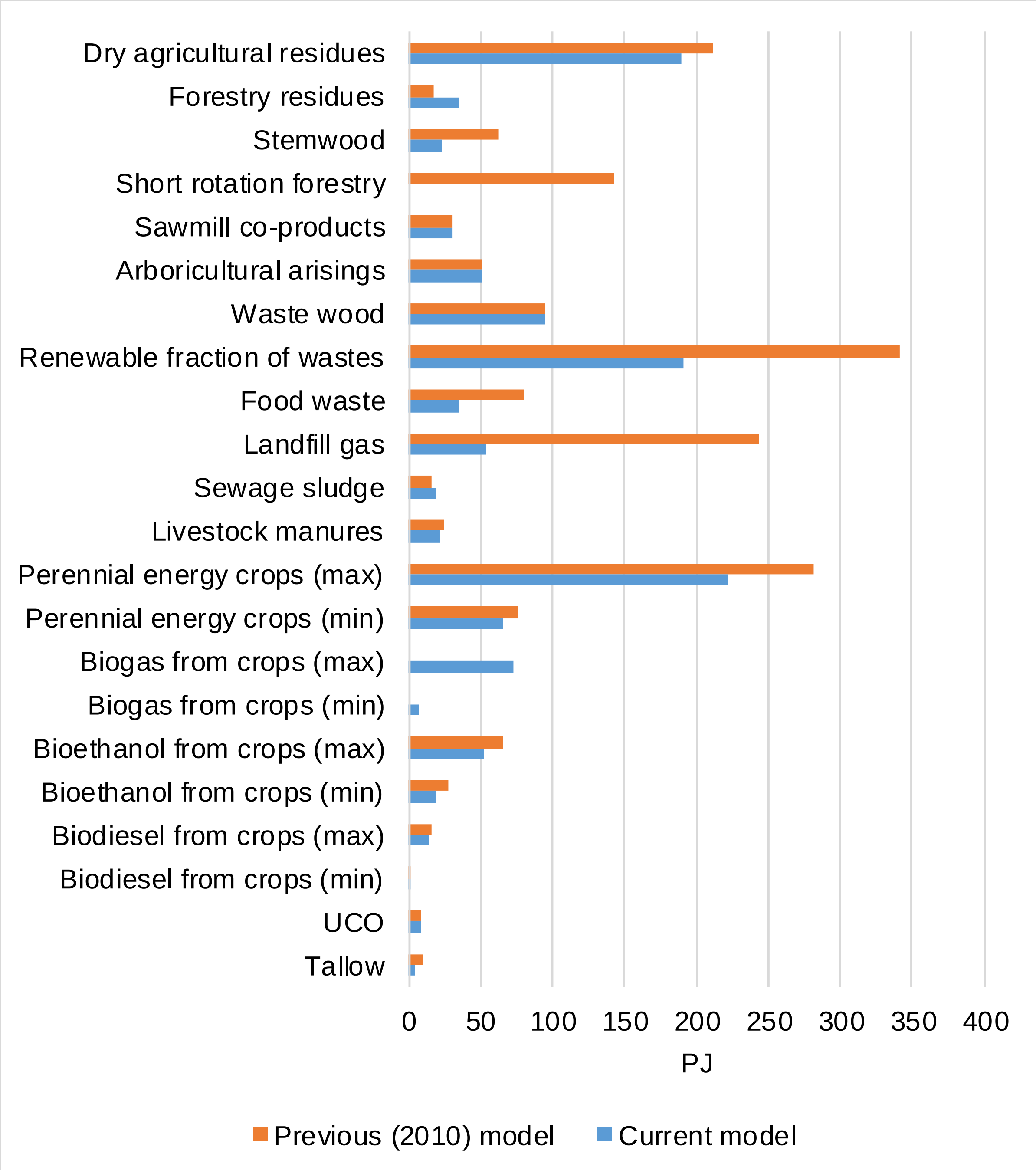

Figure 3.2 Estimates of accessible UK bioenergy resource in 2030

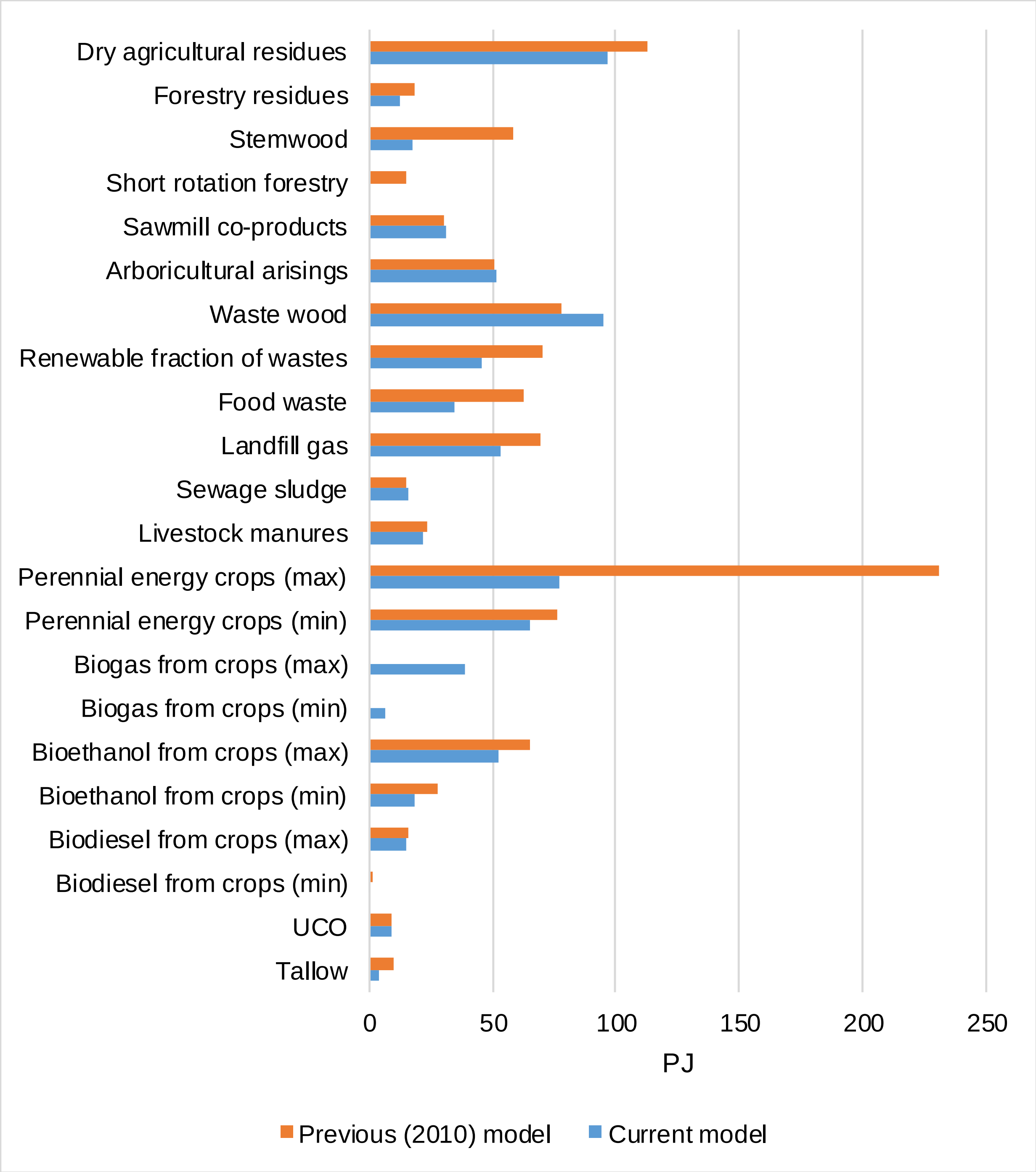

Table 3.1 Estimates of total and accessible UK bioenergy resource in 2030

	Total resource			Accessible resource		
	Previous (2010) model	Current model	Difference	Previous (2010) model	Current model	Difference
	PJ	PJ	%	PJ	PJ	%
Dry agricultural residues	211	190	-10%	113	97	-14%
Forestry residues	18	36	97%	18	13	-29%
Stemwood	63	23	-63%	58	17	-70%
Short rotation forestry	143	0	-100%	15	0	-100%
Sawmill co-products	30	31	1%	30	31	1%
Arboricultural arisings	50	51	2%	50	51	2%
Waste wood	95	95	0%	78	95	21%
Renewable fraction of wastes	342	190	-44%	70	45	-35%
Food waste	80	34	-57%	63	34	-45%
Landfill gas	243	53	-78%	69	53	-23%
Sewage sludge	16	20	24%	15	16	11%
Livestock manures	25	22	-12%	24	22	-8%
Perennial energy crops (max)	282	221	-22%	231	77	-66%
Perennial energy crops (min)	76	66	-14%	76	66	-14%
Biogas from crops (max)	n.e.	73		n.e	39	
Biogas from crops (min)	n.e	7		n.e	7	
Bioethanol from crops (max)	65	52	-20%	65	52	-20%
Bioethanol from crops (min)	28	19	-34%	28	19	-34%
Biodiesel from crops (max)	16	15	-8%	16	15	-8%
Biodiesel from crops (min)	1	1	-50%	1	1	-50%
UCO	9	9	0%	9	9	0%
Tallow	10	4	-60%	10	4	-60%
Total (based on maximums)	1699	1120	-34%	935	672	-28%
Total (based on minimums)	1441	850	-41%	729	580	-20%

Table 3.2 Accessible resource in 2030, if no barriers to supply are overcome

	Previous (2010) model			Current model			Change (%)			Change (PJ)		
	£4/GJ	£6/GJ	£10/GJ	£4/GJ	£6/GJ	£10/GJ	£4/GJ	£6/GJ	£10/GJ	£4/GJ	£6/GJ	£10/GJ
Dry agricultural residues	77	83	95	66	71	81	-14%	-14%	-14%	-11	-12	-14
Forestry residues	2	6	9	2	5	7	-29%	-25%	-24%	-1	-2	-2
Stemwood	11	22	31	0	3	7	-95%	-86%	-77%	-10	-19	-24
Short rotation forestry	0	1	2	0	0	0		-100%	-100%	0	-1	-2
Sawmill co-products	16	18	21	5	15	19	-68%	-18%	-11%	-11	-3	-2
Arboricultural arisings	17	21	30	6	8	13	-66%	-62%	-55%	-11	-13	-16
Waste wood	78	78	78	74	95	95	-6%	21%	21%	-4	17	17
Renewable fraction of wastes	35	39	42	30	35	35	-13%	-10%	-17%	-5	-4	-7
Food waste	33	39	46	17	19	21	-48%	-52%	-55%	-16	-21	-25
Landfill gas	38	40	42	35	35	35	-9%	-12%	-17%	-4	-5	-7
Sewage sludge	11	11	13	14	15	15	36%	29%	17%	4	3	2
Livestock manures	8	11	15	0	1	9	-99%	-91%	-40%	-8	-10	-6
Perennial energy crops (max)	65	150	231	27	39	62	-58%	-74%	-73%	-38	-111	-169
Perennial energy crops (min)	65	76	76	23	33	52	-64%	-57%	-31%	-42	-43	-23
Biogas from crops (max)	0	0	0	4	16	23				4	16	23
Biogas from crops (min)	0	0	0	4	7	7				4	7	7
Bioethanol from crops (max)	44	52	62	6	22	36	-87%	-57%	-42%	-38	-30	-26
Bioethanol from crops (min)	19	23	27	3	11	15	-83%	-52%	-45%	-16	-12	-12
Biodiesel from crops (max)	11	15	15	1	7	12	-87%	-50%	-23%	-10	-7	-3
Biodiesel from crops (min)	1	1	1	1	1	1	-30%	-45%	-47%	0	0	-1
UCO	5	7	7	7	7	7	21%	0%	-9%	1	0	-1
Tallow	5	9	10	4	4	4	-27%	-56%	-60%	-1	-5	-6
Total (based on maximums)	**457**	**600**	**749**	**298**	**395**	**482**	**-35%**	**-34%**	**-36%**	**-159**	**-206**	**-267**
Total (based on minimums)	**422**	**483**	**545**	**291**	**362**	**423**	**-31%**	**-25%**	**-22%**	**-131**	**-121**	**-122**

Table 3.3 Accessible resource in 2030, if all barriers to supply are overcome

	Previous (2010) model			Current model			Change (%)			Change (PJ)		
	£4/GJ	£6/GJ	£10/GJ	£4/GJ	£4/GJ	£6/GJ	£10/GJ	£4/GJ	£4/GJ	£6/GJ	£10/GJ	£4/GJ
Dry agricultural residues	113	113	113	97	97	97	-14%	-14%	-14%	-16	-16	-16
Forestry residues	18	18	18	13	13	13	-29%	-29%	-29%	-5	-5	-5
Stemwood	58	58	58	2	8	14	-96%	-86%	-77%	-56	-50	-45
Short rotation forestry	15	15	15	0	0	0		-100%	-100%	-15	-15	-15
Sawmill co-products	30	30	30	10	25	27	-68%	-18%	-11%	-21	-5	-3
Arboricultural arisings	50	50	50	17	19	23	-66%	-62%	-55%	-33	-31	-28
Waste wood	78	78	78	74	95	95	-6%	21%	21%	-4	17	17
Renewable fraction of wastes	70	70	70	45	45	45	-35%	-35%	-35%	-25	-25	-25
Food waste	63	63	63	34	34	34	-45%	-45%	-45%	-28	-28	-28
Landfill gas	69	69	69	53	53	53	-23%	-23%	-23%	-16	-16	-16
Sewage sludge	15	15	15	16	16	16	11%	11%	11%	2	2	2
Livestock manures	24	24	24	0	2	12	-99%	-94%	-48%	-23	-22	-11
Perennial energy crops (max)	231	231	231	77	77	77	-66%	-66%	-66%	-153	-153	-153
Perennial energy crops (min)	76	76	76	66	66	66	-14%	-14%	-14%	-10	-10	-10
Biogas from crops (max)	0	0	0	39	39	39				39	39	39
Biogas from crops (min)	0	0	0	7	7	7				7	7	7
Bioethanol from crops (max)	65	65	65	37	44	48	-44%	-32%	-26%	-29	-21	-17
Bioethanol from crops (min)	28	28	28	3	11	15	-89%	-61%	-48%	-25	-17	-13
Biodiesel from crops (max)	16	16	16	15	15	15	-8%	-8%	-8%	-1	-1	-1
Biodiesel from crops (min)	1	1	1	1	1	1	-50%	-50%	-50%	-1	-1	-1
UCO	9	9	9	9	9	9	0%	0%	0%	0	0	0
Tallow	10	10	10	4	4	4	-60%	-60%	-60%	-6	-6	-6
Total (based on maximums)	**935**	**935**	**935**	**543**	**596**	**622**	**-42%**	**-36%**	**-33%**	**-392**	**-339**	**-313**
Total (based on minimums)	**729**	**729**	**729**	**451**	**504**	**530**	**-38%**	**-31%**	**-27%**	**-277**	**-224**	**-198**

3.2 Global supply estimates

The amount of solid biomass and biofuels available to the UK in 2030 in the current and previous model are compared in Table 3.4 and Table 3.5.

One of the parameters which can be set in the model is the fraction of potential global trade in bioenergy which the UK can access. In the previous model the default value for this parameter was 10% in all years. In the current version of the model the default values are 10% in 2015 and 2020, declining to 2% in 2050 in order to be consistent with the assumptions made on this aspect in the medium supply scenario of the UK Bioenergy Strategy (DECC, 2012). Two sets of results are therefore presented for the current model in Tables 3.4 and 3.5. The first shows estimates of the biomass available to the UK if the fraction of global trade which is imported in 2030 is kept at 10% as in the previous model and the second, quantities if the new default value for 2030 of 7% is applied.

In general the amount of biomass and biofuels estimated to be available is significantly lower in all of the BAU and high investment scenarios (generally between 70% and 90% less solid biomass is forecast to be available). This is mainly due to the revision of the estimated areas of abandoned agricultural land available for growing biofuels and energy crops in the model. The estimated areas have been updated to a more recent data set (as discussed in Section 2.4.2) which forecasts much smaller areas will become available. Estimates in the new model of abandoned agricultural land which is undegraded (i.e. is suitable for growing both biofuels crops and perennial energy crops) are (depending on the scenario) between 79% and 90% lower than the land availability scenario in the previous model. Estimates for mildly degraded land (suitable only for growing perennial energy crops) show very similar levels of reduction.

Changes in the low investment/regionalisation scenario are smaller, and the three scenarios show less difference in outcomes than in the previous model.

Table 3.4 Estimates of solid biomass available to the UK in 2030

Land use	Biomass Demand	Supply scenario	Previous (2010) model PJ	Current model with 2010 import assumptions PJ	Change %	Current model with new import assumptions PJ	Change %
Maximise annual 1G biofuel crops	BAU	Low	1,115	869	-22%	609	-45%
		BAU	3,509	970	-72%	679	-81%
		High	4,562	1300	-72%	910	-80%
	High	Low	102	650	539%	455	347%
		BAU	1,633	717	-56%	502	-69%
		High	2,686	879	-67%	615	-77%
Maximise perennial energy crops	BAU	Low	2322	882	-62%	618	-73%
		BAU	5305	1014	-81%	710	-87%
		High	8873	1375	-85%	963	-89%
	High	Low	498	658	32%	460	-8%
		BAU	3429	743	-78%	520	-85%
		High	7005	956	-86%	669	-90%

Table 3.5 Estimates of first generation biofuels available to the UK in 2030

Land use	Biomass Demand	Supply scenario	Previous (2010) model PJ	Current model with 2010 import assumptions PJ	Change %	Current model with new import assumptions PJ	Change %
Land use	**Biomass Demand**	**Supply scenario**	***Previous (2010) model PJ***	***Current model PJ***	***Change %***		
Maximise annual 1G biofuel crops	BAU	Low	56	50	-11%	72	27%
		BAU	667	86	-87%	124	-81%
		High	685	169	-75%	242	-65%
	High	Low	84	53	-37%	76	-10%
		BAU	699	89	-87%	127	-82%
		High	717	173	-76%	247	-66%
Maximise perennial energy crops	BAU	Low	37	50	35%	72	93%
		BAU	652	82	-87%	118	-82%
		High	503	167	-67%	238	-53%
	High	Low	64	53	-17%	76	18%
		BAU	684	89	-87%	127	-81%
		High	534	173	-68%	246	-54%

Table 3.6 Estimates of abandoned (undegraded) agricultural land used in the models

	Previous (2010) model		Current (2017) model			Change (%)		
	Low	BAU and high	Low	BAU	High	Low	BAU	High
Canada	10.5	15.4	0.0	0.0	0.0	-100%	-100%	-100%
USA	21.1	35.2	1.0	2.8	12.3	-95%	-92%	-65%
Central America	1.1	12.9	0.7	0.8	4.8	-35%	-94%	-63%
South America	1.1	85.6	4.6	4.4	10.7	332%	-95%	-88%
North Africa	1.3	0.2	0.0	0.0	0.0	-100%	-100%	-100%
West Africa	6.3	12.5	0.6	0.6	0.6	-91%	-95%	-95%
East Africa	1.3	0.6	0.4	0.3	0.8	-70%	-56%	35%
South Africa	1.3	2.5	14.1	14.7	15.9	1027%	486%	534%
Western Europe	14.6	12.4	1.8	2.2	4.6	-88%	-82%	-62%
East Europe	7.3	7.7	0.9	1.1	2.5	-87%	-85%	-67%
Former USSR	60.1	77.6	0.7	2.5	4.3	-99%	-97%	-95%
Middle East	0.0	0.0	0.0	0.0	0.0			
South Asia	0.6	1.1	0.0	0.0	0.1	-100%	-100%	-95%
East Asia	8.1	39.1	1.6	4.9	7.0	-80%	-87%	-82%
South East Asia	1.6	0.7	0.0	0.0	0.5	-100%	-100%	-33%
Oceania	41.6	56.4	0.4	1.1	10.7	-99%	-98%	-81%
Japan	0.0	0.0	0.1	0.0	0.1			
World	177.8	359.9	26.9	35.5	74.8	-85%	-90%	-79%

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