GHG savings ([25]) for solid biomass pathways

Table 95. GHG savings for forest systems producing wood chips. GHG savings are calculated according to the COM(2016) 767. Standard electrical efficiency of 25% and standard thermal efficiency of 85% are applied for biomass pathways. GHG savings are calculated relative to the FFC reported in COM(2016) 767 (also listed in section 7.1 of this report). No land use emissions are included in these results nor are CO_2 emissions from the combustion of biomass or other indirect effects.

Woodchips – GHG savings	Forest biomass production system	Transport distance	TYPICAL [%]		DEFAULT [%]	
			Heat	Electricity	Heat	Electricity
	Forest residues	1 to 500 km	93	89	**91**	**87**
		500 to 2500 km	89	84	**87**	**81**
		2500 to 10 000 km	82	73	**78**	**67**
		Above 10000 km	67	51	**60**	**41**
	SRC (Eucalyptus)	2500 to 10 000 km	64	46	**61**	**41**
	SRC (Poplar - Fertilised)	1 to 500 km	89	83	**87**	**81**
		500 to 2500 km	85	78	**84**	**76**
		2500 to 10 000 km	78	67	**74**	**62**
		Above 10000 km	63	45	**57**	**35**
	SRC (Poplar – No fertilisation)	1 to 500 km	91	87	**90**	**85**
		500 to 2500 km	88	82	**86**	**79**
		2500 to 10 000 km	80	70	**77**	**65**
		Above 10000 km	65	48	**59**	**39**
	Stemwood	1 to 500 km	93	89	**92**	**88**
		500 to 2500 km	90	85	**88**	**82**
		2500 to 10 000 km	82	73	**79**	**68**
		2500 to 10 000 km	67	51	**61**	**42**
	Wood industry residues	1 to 500 km	94	92	**93**	**90**
		500 to 2500 km	91	87	**90**	**85**
		2500 to 10 000 km	83	75	**80**	**71**
		Above 10000 km	69	54	**63**	**44**

([25]) The use of 'GHG savings' as a metric to assess climate change mitigation effects of bioenergy pathways compared to fossil fuels has been designed and defined by the EU in several legislative documents (RED, FQD, COM(2010) 11, COM(2016) 767). While this may have merits of simplicity and clarity for regulatory purposes, it should be remembered that: "*analyses that report climate-mitigation effects based on Attributional LCA generally have assumed away all indirect and scale effects on* $CO_{2\text{-}eq}$ *emission factors and on activity within and beyond the targeted sector. Unfortunately, there is no theoretical or empirical basis for treating indirect and scale effects as negligible*." (Plevin et al., 2013)

GHG savings ([25]) for solid biomass pathways

Table 95. GHG savings for forest systems producing wood chips. GHG savings are calculated according to the COM(2016) 767. Standard electrical efficiency of 25% and standard thermal efficiency of 85% are applied for biomass pathways. GHG savings are calculated relative to the FFC reported in COM(2016) 767 (also listed in section 7.1 of this report). No land use emissions are included in these results nor are CO_2 emissions from the combustion of biomass or other indirect effects.

	Forest biomass production system	Transport distance	TYPICAL [%]		DEFAULT [%]	
			Heat	Electricity	Heat	Electricity
Woodchips – GHG savings	**Forest residues**	1 to 500 km	93	89	**91**	**87**
		500 to 2500 km	89	84	**87**	**81**
		2500 to 10 000 km	82	73	**78**	**67**
		Above 10000 km	67	51	**60**	**41**
	SRC (Eucalyptus)	2500 to 10 000 km	64	46	**61**	**41**
	SRC (Poplar - Fertilised)	1 to 500 km	89	83	**87**	**81**
		500 to 2500 km	85	78	**84**	**76**
		2500 to 10 000 km	78	67	**74**	**62**
		Above 10000 km	63	45	**57**	**35**
	SRC (Poplar – No fertilisation)	1 to 500 km	91	87	**90**	**85**
		500 to 2500 km	88	82	**86**	**79**
		2500 to 10 000 km	80	70	**77**	**65**
		Above 10000 km	65	48	**59**	**39**
	Stemwood	1 to 500 km	93	89	**92**	**88**
		500 to 2500 km	90	85	**88**	**82**
		2500 to 10 000 km	82	73	**79**	**68**
		2500 to 10 000 km	67	51	**61**	**42**
	Wood industry residues	1 to 500 km	94	92	**93**	**90**
		500 to 2500 km	91	87	**90**	**85**
		2500 to 10 000 km	83	75	**80**	**71**
		Above 10000 km	69	54	**63**	**44**

([25]) The use of 'GHG savings' as a metric to assess climate change mitigation effects of bioenergy pathways compared to fossil fuels has been designed and defined by the EU in several legislative documents (RED, FQD, COM(2010) 11, COM(2016) 767). While this may have merits of simplicity and clarity for regulatory purposes, it should be remembered that: "*analyses that report climate-mitigation effects based on Attributional LCA generally have assumed away all indirect and scale effects on* $CO_{2\text{-eq}}$ *emission factors and on activity within and beyond the targeted sector. Unfortunately, there is no theoretical or empirical basis for treating indirect and scale effects as negligible*." (Plevin et al., 2013)

Table 96. GHG savings for forest systems producing wood pellets or briquettes (Part 1). GHG savings are calculated according to the COM(2016) 767. Standard electrical efficiency of 25% and thermal efficiency of 85% are applied. GHG savings are calculated relative to the FFC reported in COM(2016) 767 (also listed in section 7.1 of this report). No land use emissions are included in these results nor are CO_2 emissions from the combustion of biomass or other indirect effects.

Wood pellets – GHG savings (Part 1)	Forest biomass production system		Transport distance	TYPICAL [%]		DEFAULT [%]	
				Heat	Electricity	Heat	Electricity
	Forest residues	case 1	1 to 500 km	58	37	**49**	**24**
			500 to 2500 km	58	37	**49**	**25**
			2500 to 10000 km	55	34	**47**	**21**
			Above 10000 km	50	26	**40**	**11**
		case 2a	1 to 500 km	77	66	**72**	**59**
			500 to 2500 km	77	66	**72**	**59**
			2500 to 10000 km	75	62	**70**	**55**
			Above 10000 km	69	54	**63**	**45**
		case 3a	1 to 500 km	92	88	**90**	**85**
			500 to 2500 km	92	88	**90**	**86**
			2500 to 10000 km	90	85	**88**	**81**
			Above 10000 km	84	76	**81**	**72**
	SRC (Eucalyptus)	case 1	2500 to 10000 km	40	11	**32**	**-2**
		case 2a	2500 to 10000 km	56	34	**51**	**27**
		case 3a	500 to 10000 km	70	55	**68**	**53**
	SRC Poplar (Fertilised)	case 1	1 to 500 km	54	32	**46**	**20**
			500 to 10000 km	52	29	**44**	**16**
			Above 10000 km	47	21	**37**	**7**
		case 2a	1 to 500 km	73	60	**69**	**54**
			500 to 10000 km	71	57	**67**	**50**
			Above 10000 km	66	49	**60**	**41**
		case 3a	1 to 500 km	88	82	**87**	**81**
			500 to 10000 km	86	79	**84**	**77**
			Above 10000 km	80	71	**78**	**67**

Case 1 refers to pathways in which a natural gas boiler is used to provide the process heat to the pellet mill. Process electricity is purchased from the grid.
Case 2a refers to pathways in which a boiler fuelled with pre-dried wood chips is used to provide the process heat to the pellet mill. Process electricity is purchased from the grid.
Case 3a refers to pathways in which a CHP, fuelled with pre-dried wood chips, is used to provide heat and power to the pellet mill.

Table 97. GHG savings for forest systems producing wood pellets or briquettes (Part 2). GHG savings are calculated according to the COM(2016) 767. Standard electrical efficiency of 25% and thermal efficiency of 85% are applied. GHG savings are calculated relative to the FFC reported in COM(2016) 767 (also listed in section 7.1 of this report). No land use emissions are included in these results nor are CO_2 emissions from the combustion of biomass or other indirect effects.

Wood pellets – GHG savings (Part 2)

Forest biomass production system		Transport distance	TYPICAL [%]		DEFAULT [%]	
			Heat	Electricity	Heat	Electricity
SRC Poplar (No fertilisation)	case 1	1 to 500 km	56	35	**48**	**23**
		500 to 10000 km	54	32	**46**	**20**
		Above 10000 km	49	24	**40**	**10**
	case 2a	1 to 500 km	76	64	**72**	**58**
		500 to 10000 km	74	61	**69**	**54**
		Above 10000 km	68	53	**63**	**45**
	case 3a	1 to 500 km	91	86	**90**	**85**
		500 to 10000 km	89	83	**87**	**81**
		Above 10000 km	83	75	**81**	**71**
Stemwood	case 1	1 to 500 km	57	37	**49**	**24**
		500 to 2500 km	58	37	**49**	**25**
		2500 to 10000 km	55	34	**47**	**21**
		Above 10000 km	50	26	**40**	**11**
	case 2a	1 to 500 km	77	66	**73**	**60**
		500 to 2500 km	77	66	**73**	**60**
		2500 to 10000 km	75	63	**70**	**56**
		Above 10000 km	70	55	**64**	**46**
	case 3a	1 to 500 km	92	88	**91**	**86**
		500 to 2500 km	92	88	**91**	**87**
		2500 to 10000 km	90	85	**88**	**83**
		Above 10000 km	84	77	**82**	**73**
Wood industry residues	case 1	1 to 500 km	75	62	**69**	**55**
		500 to 2500 km	75	62	**70**	**55**
		2500 to 10000 km	72	59	**67**	**51**
		Above 10000 km	67	51	**61**	**42**
	case 2a	1 to 500 km	87	80	**84**	**76**
		500 to 2500 km	87	80	**84**	**77**
		2500 to 10000 km	85	77	**82**	**73**
		Above 10000 km	79	69	**75**	**63**
	case 3a	1 to 500 km	95	93	**94**	**91**
		500 to 2500 km	95	93	**94**	**92**
		2500 to 10000 km	93	90	**92**	**88**
		Above 10000 km	88	82	**85**	**78**

Table 98. GHG savings for agricultural biomass systems. GHG savings are calculated according to the COM(2016) 767. Standard electrical efficiency of 25% and thermal efficiency of 85% are applied. GHG savings are calculated relative to the FFC reported in COM(2016) 767 (also listed in section 7.1 of this report). No land use emissions are included in these results nor are CO2 emissions from the combustion of biomass or other indirect effects. Negative values indicate that the bioenergy pathway emits more than the fossil comparator.

Agricultural systems – GHG savings

Agriculture biomass production system	Transport distance	TYPICAL [%]		DEFAULT [%]	
		Heat	Electricity	Heat	Electricity
Agricultural Residues with density <0.2 t/m^3 ([26])	1 to 500 km	95	92	**93**	**90**
	500 to 2500 km	89	83	**86**	**80**
	2500 to 10 000 km	77	66	**73**	**60**
	Above 10000 km	57	36	**48**	**23**
Agricultural Residues with density > 0.2 t/m^3 ([27])	1 to 500 km	95	92	**93**	**90**
	500 to 2500 km	93	89	**92**	**87**
	2500 to 10 000 km	88	82	**85**	**78**
	Above 10000 km	78	68	**74**	**61**
Straw pellets	1 to 500 km	88	82	**85**	**78**
	500 to 10000 km	86	79	**83**	**74**
	Above 10000 km	80	70	**76**	**64**
Bagasse briquettes	500 to 10 000 km	93	89	**91**	**87**
	Above 10 000 km	87	81	**85**	**77**
Palm Kernel Meal	Above 10000 km	20	-18	**11**	**-33**
Palm Kernel Meal (no CH_4 emissions from oil mill)	Above 10000 km	46	20	**42**	**14**

([26]) This group of materials includes agricultural residues with a low bulk density and it comprises materials such as straw bales, oat hulls, rice husks and sugar cane bagasse bales (not exhaustive list).
([27]) The group of agricultural residues with higher bulk density includes materials such as corn cobs, nut shells, soybean hulls, palm kernel shells (not exhaustive list).

Figure 6. Illustration of GHG supply chain emissions compared to reference fossil fuel emissions for the most representative solid biomass pathways (values reported in Table 95 to Table 98). Values exclude combustion and all emissions and removals of biogenic carbon in the supply chain, except methane. Values are based on the default GHG emission values. SRC = Short Rotation Coppice. a) The calculations are based on greenhouse gas data from eucalyptus cultivation in tropical areas. b) Data are based on poplar cultivated in EU without any synthetic fertilization. c) Stemwood (NG) = pellets produced using natural gas as process fuel, all the other pathways are based on wood as process fuel (case 2a).