An Optimisation Framework for the Strategic Design of BioSNG Supply Chains

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Supporting information

A.1. Input data

Set of feedstocks F	Set of available feedstocks F^a	Set of new energy crops F^e	Set of resources I	Set of technologies K
Forestry	Forestry	Miscanthus	Forestry	Int_Gasif
Straw	Straw		Straw	
Miscanthus	Waste		Miscanthus	
Waste			Waste	
			BioSNG	
			power	

Set of transportation modes L	Set of final products P	Set of segments for cost linearisation S	Set of time periods T	Link between feedstocks and Technologies F_k
Truck	BioSNG	1	20_25	(forestry, straw, waste, miscanthus).Int_Gasif
Trailer	power	2	25_30	
Rail		3	30_35	
		4	35_40	

Set of regions G		Set of Local distribution zones (LDZs) Z	Link for regions that supply LDZs G_z	
C1	H1	EA	C1.NO	H2.NT
C2	H2	EM	C2.NO	H2.EA
D1	H3	NE	D1.NW	H3.NT

D3	I2	NO	D1.NO	J1.NT
D4	J1	NT	D3.NW	J1.SO
D6	J2	NW	D4.NW	J2.SE
D7	J3	SC	D6.NW	J3.SO
E1	J4	SE	E1.NE	J4.SE
E2	K1	SO	E2.NE	K1.SW
E3	K2	SW	E2.NO	K2.SO
E4	K3	WM	F2.EM	K2.SW
F1	K4	WN	F3.EM	K4.SW
F2	L1	WS	G1.SW	L1.WS
F3	L2		G1.WM	L2.WS
G1	M2		G2.EM	L2.WN
G2	M3		G2.WM	M2.SC
G3	M5		H1.EA	M3.SC
	M6			M5.SC

Topology, $\eta_{iggʹl}$		
(forestry, straw, waste, miscanthus).M6.truck.M5	(forestry, straw, waste, miscanthus).M6.rail.M5	(biosng).M6.trailer.M5
(forestry, straw, waste, miscanthus).M6.truck.M2	(forestry, straw, waste, miscanthus).M6.rail.M2	(biosng).M6.trailer.M2
(forestry, straw, waste, miscanthus).M6.truck.M3	(forestry, straw, waste, miscanthus).M6.rail.M3	(biosng).M6.trailer.M3
(forestry, straw, waste, miscanthus).M5.truck.M6	(forestry, straw, waste, miscanthus).M5.rail.M6	(biosng).M5.trailer.M6
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(forestry, straw, waste, miscanthus).M2.truck.M6	(forestry, straw, waste, miscanthus).M2.rail.M6	(biosng).M2.trailer.M6
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(forestry, straw, waste, miscanthus).M2.truck.C2	(forestry, straw, waste, miscanthus).M2.rail.C2	(biosng).M2.trailer.C2
(forestry, straw, waste, miscanthus).M2.truck.D1	(forestry, straw, waste, miscanthus).M2.rail.D1	(biosng).M2.trailer.D1
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(forestry, straw, waste, miscanthus).H3.truck.J4	(forestry, straw, waste, miscanthus).H3.rail.H1	(biosng).H3.trailer.J4
(forestry, straw, waste, miscanthus).H3.truck.I2	(forestry, straw, waste, miscanthus).I2.rail.H2	(biosng).H3.trailer.I2
(forestry, straw, waste, miscanthus).H3.truck.H2	(forestry, straw, waste, miscanthus).I2.rail.H3	(biosng).H3.trailer.H2
(forestry, straw, waste, miscanthus).H3.truck.H1	(forestry, straw, waste, miscanthus).I2.rail.J4	(biosng).H3.trailer.H1
(forestry, straw, waste, miscanthus).I2.truck.H2	(forestry, straw, waste, miscanthus).I2.rail.J2	(biosng).I2.trailer.H2
(forestry, straw, waste, miscanthus).I2.truck.H3	(forestry, straw, waste, miscanthus).I2.rail.J1	(biosng).I2.trailer.H3
(forestry, straw, waste, miscanthus).I2.truck.J4	(forestry, straw, waste, miscanthus).J4.rail.J2	(biosng).I2.trailer.J4
(forestry, straw, waste, miscanthus).I2.truck.J2	(forestry, straw, waste, miscanthus).J4.rail.I2	(biosng).I2.trailer.J2
(forestry, straw, waste, miscanthus).I2.truck.J1	(forestry, straw, waste, miscanthus).J2.rail.J3	(biosng).I2.trailer.J1
(forestry, straw, waste, miscanthus).J4.truck.J2	(forestry, straw, waste, miscanthus).J2.rail.J1	(biosng).J4.trailer.J2
(forestry, straw, waste, miscanthus).J4.truck.I2	(forestry, straw, waste, miscanthus).J2.rail.I2	(biosng).J4.trailer.I2
(forestry, straw, waste, miscanthus).J4.truck.H3	(forestry, straw, waste, miscanthus).J2.rail.J4	(biosng).J4.trailer.H3
(forestry, straw, waste, miscanthus).J2.truck.J3	(forestry, straw, waste, miscanthus).J3.rail.K2	(biosng).J2.trailer.J3
(forestry, straw, waste, miscanthus).J2.truck.J1	(forestry, straw, waste, miscanthus).J3.rail.K1	(biosng).J2.trailer.J1
(forestry, straw, waste, miscanthus).J2.truck.I2	(forestry, straw, waste, miscanthus).J3.rail.J1	(biosng).J2.trailer.I2
(forestry, straw, waste, miscanthus).J2.truck.J4	(forestry, straw, waste, miscanthus).J3.rail.J2	(biosng).J2.trailer.J4
(forestry, straw, waste, miscanthus).J3.truck.K2	(forestry, straw, waste, miscanthus).M3.rail.C2	(biosng).J3.trailer.K2
(forestry, straw, waste, miscanthus).J3.truck.K1	(forestry, straw, waste, miscanthus).C2.rail.M3	(biosng).J3.trailer.K1
(forestry, straw, waste, miscanthus).J3.truck.J1	(forestry, straw, waste, miscanthus).D1.rail.E4	(biosng).J3.trailer.J1
(forestry, straw, waste, miscanthus).J3.truck.J2	(forestry, straw, waste, miscanthus).E4.rail.D1	(biosng).J3.trailer.J2
(forestry, straw, waste, miscanthus).M3.truck.C2	(forestry, straw, waste, miscanthus).D4.rail.D6	(biosng).M3.trailer.C2
(forestry, straw, waste, miscanthus).C2.truck.M3	(forestry, straw, waste, miscanthus).D6.rail.D4	(biosng).C2.trailer.M3
(forestry, straw, waste, miscanthus).D1.truck.E4	(forestry, straw, waste, miscanthus).D3.rail.E3	(biosng).D1.trailer.E4
(forestry, straw, waste, miscanthus).E4.truck.D1	(forestry, straw, waste, miscanthus).E4.rail.E1	(biosng).E4.trailer.D1
(forestry, straw, waste, miscanthus).D4.truck.D6	(forestry, straw, waste, miscanthus).E1.rail.E4	(biosng).D4.trailer.D6
(forestry, straw, waste, miscanthus).D6.truck.D4	(forestry, straw, waste, miscanthus).E3.rail.F3	(biosng).D6.trailer.D4
(forestry, straw, waste, miscanthus).D3.truck.E3	(forestry, straw, waste, miscanthus).F3.rail.E3	(biosng).D3.trailer.E3

(forestry, straw, waste, miscanthus).E4.truck.E1	(forestry, straw, waste, miscanthus).F3.rail.H2	(biosng).E4.trailer.E1
(forestry, straw, waste, miscanthus).E1.truck.E4	(forestry, straw, waste, miscanthus).H2.rail.F3	(biosng).E1.trailer.E4
(forestry, straw, waste, miscanthus).E3.truck.F3	(forestry, straw, waste, miscanthus).D6.rail.L1	(biosng).E3.trailer.F3
(forestry, straw, waste, miscanthus).F3.truck.E3	(forestry, straw, waste, miscanthus).L1.rail.D6	(biosng).F3.trailer.E3
(forestry, straw, waste, miscanthus).E3.truck.D6	(forestry, straw, waste, miscanthus).D6.rail.G3	(biosng).E3.trailer.D6
(forestry, straw, waste, miscanthus).D6.truck.E3	(forestry, straw, waste, miscanthus).G3.rail.D6	(biosng).D6.trailer.E3
(forestry, straw, waste, miscanthus).F3.truck.H2	(forestry, straw, waste, miscanthus).G3.rail.F2	(biosng).F3.trailer.H2
(forestry, straw, waste, miscanthus).H2.truck.F3	(forestry, straw, waste, miscanthus).F2.rail.G3	(biosng).H2.trailer.F3
(forestry, straw, waste, miscanthus).D6.truck.L1	(forestry, straw, waste, miscanthus).G3.rail.J1	(biosng).D6.trailer.L1
(forestry, straw, waste, miscanthus).L1.truck.D6	(forestry, straw, waste, miscanthus).J1.rail.G3	(biosng).L1.trailer.D6
(forestry, straw, waste, miscanthus).D6.truck.G3	(forestry, straw, waste, miscanthus).I2.rail.J3	(biosng).D6.trailer.G3
(forestry, straw, waste, miscanthus).G3.truck.D6	(forestry, straw, waste, miscanthus).J3.rail.I2	(biosng).G3.trailer.D6
(forestry, straw, waste, miscanthus).G3.truck.F2	(forestry, straw, waste, miscanthus).F1.rail.G3	(biosng).G3.trailer.F2
(forestry, straw, waste, miscanthus).F2.truck.G3	(forestry, straw, waste, miscanthus).G3.rail.F1	(biosng).F2.trailer.G3
(forestry, straw, waste, miscanthus).G3.truck.J1	(forestry, straw, waste, miscanthus).D3.rail.G3	(biosng).G3.trailer.J1
(forestry, straw, waste, miscanthus).J1.truck.G3	(forestry, straw, waste, miscanthus).G3.rail.D3	(biosng).J1.trailer.G3
(forestry, straw, waste, miscanthus).G3.truck.H2	(forestry, straw, waste, miscanthus).G2.rail.L1	(biosng).G3.trailer.H2
(forestry, straw, waste, miscanthus).H2.truck.G3	(forestry, straw, waste, miscanthus).L1.rail.G2	(biosng).H2.trailer.G3
(forestry, straw, waste, miscanthus).G3.truck.L2		(biosng).G3.trailer.L2
(forestry, straw, waste, miscanthus).L2.truck.G3		(biosng).L2.trailer.G3
(forestry, straw, waste, miscanthus).I2.truck.J3		(biosng).I2.trailer.J3
(forestry, straw, waste, miscanthus).J3.truck.I2		(biosng).J3.trailer.I2
(forestry, straw, waste, miscanthus).I2.truck.K1		(biosng).I2.trailer.K1
(forestry, straw, waste, miscanthus).K1.truck.I2		(biosng).K1.trailer.I2
(forestry, straw, waste, miscanthus).F1.truck.G3		(biosng).F1.trailer.G3
(forestry, straw, waste, miscanthus).G3.truck.F1		(biosng).G3.trailer.F1
(forestry, straw, waste, miscanthus).G2.truck.L1		(biosng).G2.trailer.L1
(forestry, straw, waste, miscanthus).L1.truck.G2		(biosng).L1.trailer.G2

Scalars		
Avf	1	Availability factor for renewable energy plants
Cf	0.8	Capacity factor for renewable energy plants
$LimP$	43800000	Upper bound for production in regions [GWh year^{-1}]
$LimD$	43800000	Upper bound for demand in regions [GWh year^{-1}]
Tr	0.35	Tax rate
α	8760/1000	Operating period in a year [hr year^{-1}]. Divided into 1000 for units consistency
μ	0.4	Steam to power generation efficiency
γ	1/3600	Conversion factor
ψ	9863.014	Conversion factor
λ	3.6e-3	Conversion factor

Links	$AD_{gg/l}$ [km]	Links	$AD_{gg/l}$ [km]	Links	$AD_{gg/l}$ [km]
M6.M5.truck	158.4901887	M6.M5.rail	189.6338414	M6.M5.trailer	158.4901887
M6.M2.truck	230.0077204	M6.M2.rail	188.6230712	M6.M2.trailer	230.0077204
M6.M3.truck	315.3521119	M6.M3.rail	374.5196292	M6.M3.trailer	315.3521119
M5.M6.truck	158.4901887	M5.M6.rail	189.6338414	M5.M6.trailer	158.4901887
M5.M2.truck	159.0559682	M5.M2.rail	188.1605692	M5.M2.trailer	159.0559682
M2.M6.truck	230.0077204	M2.M6.rail	188.6230712	M2.M6.trailer	230.0077204
M2.M5.truck	159.0559682	M2.M5.rail	188.1605692	M2.M5.trailer	159.0559682
M2.M3.truck	134.5107312	M2.M3.rail	187.0191201	M2.M3.trailer	134.5107312
M2.C2.truck	187.418925	M2.C2.rail	212.6953253	M2.C2.trailer	187.418925
M2.D1.truck	238.5182818	M2.D1.rail	235.5116038	M2.D1.trailer	238.5182818
M3.M6.truck	315.3521119	M3.M6.rail	374.5196292	M3.M6.trailer	315.3521119
M3.M2.truck	134.5107312	M3.M2.rail	187.0191201	M3.M2.trailer	134.5107312
M3.D1.truck	153.0474494	M3.D1.rail	129.9549895	M3.D1.trailer	153.0474494
C2.M2.truck	187.418925	C2.M2.rail	212.6953253	C2.M2.trailer	187.418925
C2.D1.truck	124.2303568	C2.D1.rail	167.6445597	C2.D1.trailer	124.2303568
C2.C1.truck	83.62597673	C2.C1.rail	108.3613848	C2.C1.trailer	83.62597673
D1.M3.truck	153.0474494	D1.M3.rail	129.9549895	D1.M3.trailer	153.0474494
D1.M2.truck	238.5182818	D1.M2.rail	235.5116038	D1.M2.trailer	238.5182818
D1.C2.truck	124.2303568	D1.C2.rail	167.6445597	D1.C2.trailer	124.2303568
D1.C1.truck	110.5393801	D1.C1.rail	187.7413039	D1.C1.trailer	110.5393801
D1.E2.truck	147.538	D1.D4.rail	175.7153229	D1.E2.trailer	147.538
D1.D4.truck	103.7638019	C1.C2.rail	108.3613848	D1.D4.trailer	103.7638019
C1.C2.truck	83.62597673	C1.D1.rail	187.7413039	C1.C2.trailer	83.62597673
C1.D1.truck	110.5393801	C1.E2.rail	46.22479208	C1.D1.trailer	110.5393801
C1.E2.truck	69.37038008	E2.C1.rail	46.22479208	C1.E2.trailer	69.37038008
E2.C1.truck	69.37038008	E2.D4.rail	175.3610692	E2.C1.trailer	69.37038008
E2.D1.truck	147.538	E2.E4.rail	84.46416569	E2.D1.trailer	147.538
E2.D4.truck	133.9431981	E2.E3.rail	93.19821734	E2.D4.trailer	133.9431981
E2.E4.truck	67.73980587	E2.E1.rail	106.3587162	E2.E4.trailer	67.73980587
E2.E3.truck	88.548	D4.D1.rail	175.7153229	E2.E3.trailer	88.548
E2.E1.truck	80.5	D4.E2.rail	175.3610692	E2.E1.trailer	80.5
D4.D1.truck	103.7638019	D4.E4.rail	93.34879908	D4.D1.trailer	103.7638019
D4.E2.truck	133.9431981	D4.D3.rail	47.19137674	D4.E2.trailer	133.9431981
D4.E4.truck	83.61300401	D4.D7.rail	47.96674999	D4.E4.trailer	83.61300401
D4.D3.truck	42.50639218	E4.D4.rail	93.34879908	D4.D3.trailer	42.50639218
D4.D7.truck	50.95029148	E4.E2.rail	84.46416569	D4.D7.trailer	50.95029148
E4.D4.truck	83.61300401	E4.E3.rail	49.63032571	E4.D4.trailer	83.61300401
E4.E2.truck	67.73980587	E4.F1.rail	105.0050657	E4.E2.trailer	67.73980587
E4.E3.truck	41.35519413	E4.D3.rail	88.11571241	E4.E3.trailer	41.35519413
E4.F1.truck	87.50529146	E1.E2.rail	106.3587162	E4.F1.trailer	87.50529146
E4.D3.truck	59.75961183	E1.E3.rail	70.50003363	E4.D3.trailer	59.75961183
E1.E2.truck	80.5	E1.F1.rail	115.6782391	E1.E2.trailer	80.5
E1.E3.truck	80.43	E1.F3.rail	142.991231	E1.E3.trailer	80.43
E1.F1.truck	116.5909027	E3.E4.rail	49.63032571	E1.F1.trailer	116.5909027
E1.F3.truck	93.92645191	E3.E2.rail	93.19821734	E1.F3.trailer	93.92645191

E3.E4.truck	41.35519413	E3.E1.rail	70.50003363	E3.E4.trailer	41.35519413
E3.E2.truck	88.548	E3.F1.rail	59.85140176	E3.E2.trailer	88.548
E3.E1.truck	80.43	E3.D3.rail	118.5657575	E3.E1.trailer	80.43
E3.F1.truck	53.55809733	D3.D4.rail	47.19137674	E3.F1.trailer	53.55809733
E3.D3.truck	79.00380596	D3.E4.rail	88.11571241	E3.D3.trailer	79.00380596
D3.D4.truck	42.50639218	D3.D7.rail	50.07167328	D3.D4.trailer	42.50639218
D3.E4.truck	59.75961183	D3.F1.rail	171.9255279	D3.E4.trailer	59.75961183
D3.D7.truck	38.9801007	D3.D6.rail	55.91944243	D3.D7.trailer	38.9801007
D3.F1.truck	98.99590329	D7.D3.rail	50.07167328	D3.F1.trailer	98.99590329
D3.D6.truck	41.08180596	D7.D4.rail	47.96674999	D3.D6.trailer	41.08180596
D7.D3.truck	38.9801007	D7.D6.rail	47.78835436	D7.D3.trailer	38.9801007
D7.D4.truck	50.95029148	D6.D7.rail	47.78835436	D7.D4.trailer	50.95029148
D7.D6.truck	41.81490666	D6.D3.rail	55.91944243	D7.D6.trailer	41.81490666
D6.D7.truck	41.81490666	D6.F1.rail	135.9943046	D6.D7.trailer	41.81490666
D6.D3.truck	41.08180596	D6.G2.rail	85.54441544	D6.D3.trailer	41.08180596
D6.F1.truck	102.6770973	D6.L2.rail	267.8747385	D6.F1.trailer	102.6770973
D6.G2.truck	65.30631366	F1.E4.rail	105.0050657	D6.G2.trailer	65.30631366
D6.L2.truck	143.801	F1.E3.rail	59.85140176	D6.L2.trailer	143.801
F1.E4.truck	87.50529146	F1.E1.rail	115.6782391	F1.E4.trailer	87.50529146
F1.E3.truck	53.55809733	F1.F3.rail	82.14137727	F1.E3.trailer	53.55809733
F1.E1.truck	116.5909027	F1.F2.rail	88.32752234	F1.E1.trailer	116.5909027
F1.F3.truck	86.39445075	F1.G1.rail	139.7736388	F1.F3.trailer	86.39445075
F1.F2.truck	80.93120575	F1.G2.rail	148.7354086	F1.F2.trailer	80.93120575
F1.G1.truck	124.6598106	F1.D6.rail	135.9943046	F1.G1.trailer	124.6598106
F1.G2.truck	100.998411	F1.D3.rail	171.9255279	F1.G2.trailer	100.998411
F1.D6.truck	102.6770973	G2.D6.rail	85.54441544	F1.D6.trailer	102.6770973
F1.D3.truck	98.99590329	G2.F1.rail	148.7354086	F1.D3.trailer	98.99590329
G2.D6.truck	65.30631366	G2.F2.rail	126.1923604	G2.D6.trailer	65.30631366
G2.F1.truck	100.998411	G2.G1.rail	79.80542502	G2.F1.trailer	100.998411
G2.F2.truck	111.7117948	G2.G3.rail	55.27144132	G2.F2.trailer	111.7117948
G2.G1.truck	71.44139965	G2.L2.rail	219.4725338	G2.G1.trailer	71.44139965
G2.G3.truck	54.30261174	F2.G2.rail	126.1923604	G2.G3.trailer	54.30261174
G2.L2.truck	95.86068634	F2.F1.rail	88.32752234	G2.L2.trailer	95.86068634
F2.G2.truck	111.7117948	F2.F3.rail	124.5241522	F2.G2.trailer	111.7117948
F2.F1.truck	80.93120575	F2.H1.rail	156.1702819	F2.F1.trailer	80.93120575
F2.F3.truck	100.3564397	F2.H2.rail	145.660294	F2.F3.trailer	100.3564397
F2.H1.truck	143.8708916	F2.J1.rail	152.5905968	F2.H1.trailer	143.8708916
F2.H2.truck	91.84949281	F2.G1.rail	110.0580636	F2.H2.trailer	91.84949281
F2.J1.truck	108.7138916	G1.G2.rail	79.80542502	F2.J1.trailer	108.7138916
F2.G1.truck	110.3826049	G1.G3.rail	39.64915837	F2.G1.trailer	110.3826049
G1.G2.truck	71.44139965	G1.F1.rail	139.7736388	G1.G2.trailer	71.44139965
G1.G3.truck	42.21578791	G1.F2.rail	110.0580636	G1.G3.trailer	42.21578791
G1.F1.truck	124.6598106	G1.J1.rail	108.8289523	G1.F1.trailer	124.6598106
G1.F2.truck	110.3826049	G1.K1.rail	138.2183132	G1.F2.trailer	110.3826049
G1.J1.truck	107.0302867	G1.L2.rail	139.6671088	G1.J1.trailer	107.0302867
G1.K1.truck	89.73528669	G3.G2.rail	55.27144132	G1.K1.trailer	89.73528669

G1.L2.truck	84.72728669	G3.G1.rail	39.64915837	G1.L2.trailer	84.72728669
G3.G2.truck	54.30261174	F3.F2.rail	124.5241522	G3.G2.trailer	54.30261174
G3.G1.truck	42.21578791	F3.F1.rail	82.14137727	G3.G1.trailer	42.21578791
F3.F2.truck	100.3564397	F3.E1.rail	142.991231	F3.F2.trailer	100.3564397
F3.F1.truck	86.39445075	F3.H1.rail	143.2560743	F3.F1.trailer	86.39445075
F3.E1.truck	93.92645191	L1.L2.rail	207.9871961	F3.E1.trailer	93.92645191
F3.H1.truck	122.7615481	L2.L1.rail	207.9871961	F3.H1.trailer	122.7615481
L1.L2.truck	103.1015811	L2.D6.rail	267.8747385	L1.L2.trailer	103.1015811
L2.L1.truck	103.1015811	L2.G2.rail	219.4725338	L2.L1.trailer	103.1015811
L2.D6.truck	143.801	L2.G1.rail	139.6671088	L2.D6.trailer	143.801
L2.G2.truck	95.86068634	L2.K1.rail	260.1929954	L2.G2.trailer	95.86068634
L2.G1.truck	84.72728669	H1.H3.rail	171.9809658	L2.G1.trailer	84.72728669
L2.K1.truck	134.097	H1.H2.rail	103.0726759	L2.K1.trailer	134.097
H1.H3.truck	93.989	H1.F2.rail	156.1702819	H1.H3.trailer	93.989
H1.H2.truck	101.3896012	H1.F3.rail	143.2560743	H1.H2.trailer	101.3896012
H1.F2.truck	143.8708916	H2.F2.rail	145.660294	H1.F2.trailer	143.8708916
H1.F3.truck	122.7615481	H2.H1.rail	103.0726759	H1.F3.trailer	122.7615481
H2.F2.truck	91.84949281	H2.H3.rail	184.3377215	H2.F2.trailer	91.84949281
H2.H1.truck	101.3896012	H2.I2.rail	63.20274604	H2.H1.trailer	101.3896012
H2.H3.truck	80.16760123	H2.J1.rail	170.0675917	H2.H3.trailer	80.16760123
H2.I2.truck	59.43867941	J1.F2.rail	152.5905968	H2.I2.trailer	59.43867941
H2.J1.truck	67.76639877	J1.H2.rail	170.0675917	H2.J1.trailer	67.76639877
J1.F2.truck	108.7138916	J1.I2.rail	134.0186374	J1.F2.trailer	108.7138916
J1.H2.truck	67.76639877	J1.J2.rail	151.7552177	J1.H2.trailer	67.76639877
J1.I2.truck	80.21307818	J1.J3.rail	89.26221817	J1.I2.trailer	80.21307818
J1.J2.truck	111.6426025	J1.K1.rail	73.09413213	J1.J2.trailer	111.6426025
J1.J3.truck	89.21959396	J1.G1.rail	108.8289523	J1.J3.trailer	89.21959396
J1.K1.truck	89.909	K1.L2.rail	260.1929954	J1.K1.trailer	89.909
J1.G1.truck	107.0302867	K1.G1.rail	138.2183132	J1.G1.trailer	107.0302867
K1.L2.truck	134.097	K1.J1.rail	73.09413213	K1.L2.trailer	134.097
K1.G1.truck	89.73528669	K1.J3.rail	146.2197612	K1.G1.trailer	89.73528669
K1.J1.truck	89.909	K1.K2.rail	238.831982	K1.J1.trailer	89.909
K1.J3.truck	95.17059396	K2.K1.rail	238.831982	K1.J3.trailer	95.17059396
K1.K2.truck	80.96501957	K2.J3.rail	142.2968611	K1.K2.trailer	80.96501957
K2.K1.truck	80.96501957	K2.K4.rail	104.6904015	K2.K1.trailer	80.96501957
K2.J3.truck	109.0916135	K4.K2.rail	104.6904015	K2.J3.trailer	109.0916135
K2.K4.truck	103.4469804	K4.K3.rail	182.5494038	K2.K4.trailer	103.4469804
K4.K2.truck	103.4469804	K3.K4.rail	182.5494038	K4.K2.trailer	103.4469804
K4.K3.truck	101.629	H3.I2.rail	236.2392788	K4.K3.trailer	101.629
K3.K4.truck	101.629	H3.H2.rail	184.3377215	K3.K4.trailer	101.629
H3.J4.truck	95.00295086	H3.H1.rail	171.9809658	H3.J4.trailer	95.00295086
H3.I2.truck	55.46907818	I2.H2.rail	63.20274604	H3.I2.trailer	55.46907818
H3.H2.truck	80.16760123	I2.H3.rail	236.2392788	H3.H2.trailer	80.16760123
H3.H1.truck	93.989	I2.J4.rail	77.2533014	H3.H1.trailer	93.989
I2.H2.truck	59.43867941	I2.J2.rail	66.34976834	I2.H2.trailer	59.43867941
I2.H3.truck	55.46907818	I2.J1.rail	134.0186374	I2.H3.trailer	55.46907818

I2.J4.truck	71.50802904
I2.J2.truck	60.64931932
I2.J1.truck	80.21307818
J4.J2.truck	90.41734836
J4.I2.truck	71.50802904
J4.H3.truck	95.00295086
J2.J3.truck	81.44300854
J2.J1.truck	111.6426025
J2.I2.truck	60.64931932
J2.J4.truck	90.41734836
J3.K2.truck	109.0916135
J3.K1.truck	95.17059396
J3.J1.truck	89.21959396
J3.J2.truck	81.44300854
M3.C2.truck	191.1598063
C2.M3.truck	191.1598063
D1.E4.truck	151.6208059
E4.D1.truck	151.6208059
D4.D6.truck	74.33619814
D6.D4.truck	74.33619814
D3.E3.truck	79.00380596
E4.E1.truck	86.48519413
E1.E4.truck	86.48519413
E3.F3.truck	101.3245481
F3.E3.truck	101.3245481
E3.D6.truck	102.716
D6.E3.truck	102.716
F3.H2.truck	151.3191493
H2.F3.truck	151.3191493
D6.L1.truck	193.6445811
L1.D6.truck	193.6445811
D6.G3.truck	106.0349254
G3.D6.truck	106.0349254
G3.F2.truck	72.99596618
F2.G3.truck	72.99596618
G3.J1.truck	110.2400746
J1.G3.truck	110.2400746
G3.H2.truck	136.8194734
H2.G3.truck	136.8194734
G3.L2.truck	110.5529254
L2.G3.truck	110.5529254
I2.J3.truck	106.1913279
J3.I2.truck	106.1913279
I2.K1.truck	157.3289218
K1.I2.truck	157.3289218
F1.G3.truck	89.52302273
J4.J2.rail	112.9816208
J4.I2.rail	77.2533014
J2.J3.rail	109.8901962
J2.J1.rail	151.7552177
J2.I2.rail	66.34976834
J2.J4.rail	112.9816208
J3.K2.rail	142.2968611
J3.K1.rail	146.2197612
J3.J1.rail	89.26221817
J3.J2.rail	109.8901962
M3.C2.rail	242.3595056
C2.M3.rail	242.3595056
D1.E4.rail	181.1809284
E4.D1.rail	181.1809284
D4.D6.rail	70.0081997
D6.D4.rail	70.0081997
D3.E3.rail	118.5657575
E4.E1.rail	82.94218634
E1.E4.rail	82.94218634
E3.F3.rail	97.44145974
F3.E3.rail	97.44145974
F3.H2.rail	132.7460863
H2.F3.rail	132.7460863
D6.L1.rail	279.8086755
L1.D6.rail	279.8086755
D6.G3.rail	104.5146618
G3.D6.rail	104.5146618
G3.F2.rail	82.04378067
F2.G3.rail	82.04378067
G3.J1.rail	114.9652892
J1.G3.rail	114.9652892
I2.J3.rail	123.4496001
J3.I2.rail	123.4496001
F1.G3.rail	112.7179432
G3.F1.rail	112.7179432
D3.G3.rail	151.2044823
G3.D3.rail	151.2044823
G2.L1.rail	317.0578437
L1.G2.rail	317.0578437
I2.J4.trailer	71.50802904
I2.J2.trailer	60.64931932
I2.J1.trailer	80.21307818
J4.J2.trailer	90.41734836
J4.I2.trailer	71.50802904
J4.H3.trailer	95.00295086
J2.J3.trailer	81.44300854
J2.J1.trailer	111.6426025
J2.I2.trailer	60.64931932
J2.J4.trailer	90.41734836
J3.K2.trailer	109.0916135
J3.K1.trailer	95.17059396
J3.J1.trailer	89.21959396
J3.J2.trailer	81.44300854
M3.C2.trailer	191.1598063
C2.M3.trailer	191.1598063
D1.E4.trailer	151.6208059
E4.D1.trailer	151.6208059
D4.D6.trailer	74.33619814
D6.D4.trailer	74.33619814
D3.E3.trailer	79.00380596
E4.E1.trailer	86.48519413
E1.E4.trailer	86.48519413
E3.F3.trailer	101.3245481
F3.E3.trailer	101.3245481
E3.D6.trailer	102.716
D6.E3.trailer	102.716
F3.H2.trailer	151.3191493
H2.F3.trailer	151.3191493
D6.L1.trailer	193.6445811
L1.D6.trailer	193.6445811
D6.G3.trailer	106.0349254
G3.D6.trailer	106.0349254
G3.F2.trailer	72.99596618
F2.G3.trailer	72.99596618
G3.J1.trailer	110.2400746
J1.G3.trailer	110.2400746
G3.H2.trailer	136.8194734
H2.G3.trailer	136.8194734
G3.L2.trailer	110.5529254
L2.G3.trailer	110.5529254
I2.J3.trailer	106.1913279
J3.I2.trailer	106.1913279
I2.K1.trailer	157.3289218
K1.I2.trailer	157.3289218
F1.G3.trailer	89.52302273

G3.F1.truck	89.52302273
G2.L1.truck	172.1358947
L1.G2.truck	172.1358947

G3.F1.trailer	89.52302273
G2.L1.trailer	172.1358947
L1.G2.trailer	172.1358947

aIN_{fks} [£m]	
forestry.Int_Gasif.1	0.961711887
waste.Int_Gasif.1	1.32878291
miscanthus.Int_Gasif.1	0.90697273
forestry.Int_Gasif.2	0.501646037
waste.Int_Gasif.2	0.918171665
miscanthus.Int_Gasif.2	0.473093118
forestry.Int_Gasif.3	0.421428655
waste.Int_Gasif.3	0.827001418
miscanthus.Int_Gasif.3	0.397441586
forestry.Int_Gasif.4	0.376390992
waste.Int_Gasif.4	0.772681266
miscanthus.Int_Gasif.4	0.354967398
straw.Int_Gasif.1	0.90191962
straw.Int_Gasif.2	0.470457326
straw.Int_Gasif.3	0.395227279
straw.Int_Gasif.4	0.352989731

bIN_{fks} [£m MW-1]	
forestry.Int_Gasif.1	0
waste.Int_Gasif.1	0
miscanthus.Int_Gasif.1	0
forestry.Int_Gasif.2	90.06494787
waste.Int_Gasif.2	82.66410145
miscanthus.Int_Gasif.2	84.93858993
forestry.Int_Gasif.3	129.3457295
waste.Int_Gasif.3	127.4031594
miscanthus.Int_Gasif.3	121.9835701
forestry.Int_Gasif.4	162.8237815
waste.Int_Gasif.4	167.8173927
miscanthus.Int_Gasif.4	153.556103
straw.Int_Gasif.1	0
straw.Int_Gasif.2	84.46536291
straw.Int_Gasif.3	121.3039506
straw.Int_Gasif.4	152.7005802

$CMin_{ks}$ [MW]	
Int_Gasif.1	0
Int_Gasif.2	250
Int_Gasif.3	500
Int_Gasif.4	750

$CMax_{ks}$ [MW]	
Int_Gasif.1	250
Int_Gasif.2	500
Int_Gasif.3	750
Int_Gasif.4	1000

	Dem_{pzt} GWh year-1			
	20_25	**25_30**	**30_35**	**35_40**
BioSNG.SC	45026	44143	43279	42414
BioSNG.NO	28307	27752	27209	26665
BioSNG.NW	62922	61689	60482	59273
BioSNG.NE	32545	31907	31282	30657
BioSNG.EM	52449	51421	50414	49407
BioSNG.WM	48065	47123	46201	45277
BioSNG.WN	5839	5725	5613	5501
BioSNG.WS	18765	18398	18038	17677
BioSNG.EA	40200	39412	38640	37868
BioSNG.NT	54885	53809	52756	51702
BioSNG.SE	51780	50765	49772	48777
BioSNG.SO	35282	34590	33913	33235
BioSNG.SW	28935	28368	27812	27256
Power.SC	26923	26923	26923	26923
Power.NO	26923	26923	26923	26923
Power.NW	26923	26923	26923	26923
Power.NE	26923	26923	26923	26923
Power.EM	26923	26923	26923	26923
Power.WM	26923	26923	26923	26923
Power.WN	26923	26923	26923	26923
Power.WS	26923	26923	26923	26923

Depreciation factor $DepF_{tt'}$				
	20_25	**25_30**	**30_35**	**35_40**
20_25	0.1575	0.0425	0	0
25_30	0	0.1575	0.0425	0
30_35	0	0	0.1575	0.0425
35_40	0	0	0	0.1575

	$DfCA_t$
20_25	1
25_30	0.620921323
30_35	0.385543289
35_40	0.239392049

	$DfCF_t$
20_25	3.790786769
25_30	2.353780336
30_35	1.461512401
35_40	0.907484213

Power.EA	26923	26923	26923	26923
Power.NT	26923	26923	26923	26923
Power.SE	26923	26923	26923	26923
Power.SO	26923	26923	26923	26923
Power.SW	26923	26923	26923	26923

DW_l [£k h-1]	
trailer	14.10523735

FE_l [Km liters-1]	
trailer	2.3

FP_l [£k liters-1]	
trailer	1.410523735

LUT_l [h]	
trailer	0.25

ME_l [£k Km-1]	
trailer	0.061327119

SP_l [Km h-1]	
trailer	55

$TCap_l$ [Kg]	
trailer	3365

TMA_l^{Loc} [h d-1]	
trailer	15

TMA_l^{Reg} [h d-1]	
trailer	18

TMC_l [£m]	
trailer	0.282104747

GE_l [£k d-1]	
trailer	5.02882375

	$OpCost_{ft}$ [£m ha-1 year-1]			
	20_25	25_30	30_35	35_40
miscanthus	358.0	358.0	358.0	358.0

	$EstCost_{ft}$ [£m ha-1]			
	20_25	25_30	30_35	35_40
miscanthus	1962.9	1962.9	1962.9	1962.9

	$PlanRem_{ft}$ [£m ha-1]			
	20_25	25_30	30_35	35_40
miscanthus	110.2	110.2	110.2	110.2

	$FMax_{fgt}$ [ton year-1]			
	20_25	25_30	30_35	35_40
Forestry.C1	59137.86	52233.01	45328.15	38423.3
Forestry.C2	89596.88	78456.09	67315.31	56174.52
Forestry.D1	70913.72	62082.47	53251.21	44419.96
Forestry.D3	20572.18	18956.74	17341.3	15725.86
Forestry.D4	45798.68	40373.97	34949.26	29524.55
Forestry.D6	60556.74	52578.25	44599.76	36621.27
Forestry.D7	12375.21	11297.53	10219.84	9142.159
Forestry.E1	113057.3	98445.28	83833.24	69221.2
Forestry.E2	146905.5	127276.9	107648.2	88019.53
Forestry.E3	39606.67	35661.14	31715.6	27770.07
Forestry.E4	46631.94	42729.05	38826.16	34923.27
Forestry.F1	106240.8	93960.94	81681.09	69401.25
Forestry.F2	160982.4	140464	119945.6	99427.15
Forestry.F3	186421.9	161033.7	135645.5	110257.3
Forestry.G1	152273.5	131268.2	110262.9	89257.6
Forestry.G2	152229.3	132041.7	111854.1	91666.52
Forestry.G3	11979.32	10943.98	9908.64	8873.3

	$FMax_{fgt}$ [ton year-1]			
	20_25	25_30	30_35	35_40
Straw.H2	72967	72967	72967	72967
Straw.H3	104127	104127	104127	104127
Straw.I2	3225	3225	3225	3225
Straw.J1	123490	123490	123490	123490
Straw.J2	59559	59559	59559	59559
Straw.J3	75021	75021	75021	75021
Straw.J4	74245	74245	74245	74245
Straw.K1	153620	153620	153620	153620
Straw.K2	106900	106900	106900	106900
Straw.K3	71189	71189	71189	71189
Straw.K4	100480	100480	100480	100480
Straw.L1	35721	35721	35721	35721
Straw.L2	50316	50316	50316	50316
Straw.M2	182656	182656	182656	182656
Straw.M3	46160	46160	46160	46160
Straw.M5	82594	82594	82594	82594
Straw.M6	33604	33604	33604	33604

Forestry.H1	336467.4	291036.9	245606.4	200175.9	Waste.C1	390000	314066	242078	173673
Forestry.H2	82664.89	72162.78	61660.67	51158.57	Waste.C2	458181	366443	280585	200025
Forestry.H3	113552.7	98720.01	83887.3	69054.6	Waste.D1	164331	131913	101365	72509
Forestry.I2	41866.1	40718.67	39571.23	38423.79	Waste.D3	866386	700010	541262	389478
Forestry.J1	153489.9	134475.7	115461.4	96447.13	Waste.D4	487485	393286	303667	218218
Forestry.J2	98961.75	88408.71	77855.67	67302.62	Waste.D6	336234	270867	208853	149886
Forestry.J3	92382.46	81741.94	71101.42	60460.9	Waste.D7	427269	338302	256501	181111
Forestry.J4	89860.18	79181.59	68502.99	57824.4	Waste.E1	311153	252459	195984	141555
Forestry.K1	160990.3	139646	118301.8	96957.53	Waste.E2	272883	221852	172549	124848
Forestry.K2	119416.3	103375.7	87335.09	71294.49	Waste.E3	442815	358612	277898	200385
Forestry.K3	67999.39	58698.02	49396.64	40095.26	Waste.E4	779176	639518	501814	366082
Forestry.K4	111575	96427.48	81280	66132.53	Waste.F1	707755	574659	446408	322633
Forestry.L1	146554.8	127601.1	108647.4	89693.74	Waste.F2	584579	478352	374303	272357
Forestry.L2	85788.98	74834	63879.03	52924.06	Waste.F3	246810	202414	158715	115709
Forestry.M2	196517.7	172605.8	148693.9	124782	Waste.G1	429541	347722	269356	194156
Forestry.M3	107208.5	95369.31	83530.16	71691.02	Waste.G2	505488	406367	312704	223988
Forestry.M5	113262.7	98614.2	83965.75	69317.29	Waste.G3	869593	699574	538701	386120
Forestry.M6	79577.33	71204.21	62831.1	54457.99	Waste.H1	820257	671479	525622	382597
Straw.C1	36589	36589	36589	36589	Waste.H2	571686	463532	359610	259582
Straw.C2	58211	58211	58211	58211	Waste.H3	592861	483563	377245	273734
Straw.D1	29623	29623	29623	29623	Waste.I2	2590886	2097570	1624987	1171412
Straw.D3	7429	7429	7429	7429	Waste.J1	751143	609311	472905	341497
Straw.D4	20057	20057	20057	20057	Waste.J2	906066	735077	570586	412084
Straw.D6	38570	38570	38570	38570	Waste.J3	635422	515700	400441	289298
Straw.D7	7694	7694	7694	7694	Waste.J4	571150	464580	361508	261688
Straw.E1	130650	130650	130650	130650	Waste.K1	800859	653939	510688	370917
Straw.E2	136134	136134	136134	136134	Waste.K2	423802	344353	267683	193586
Straw.E3	28023	28023	28023	28023	Waste.K3	189831	155882	122371	89308
Straw.E4	18154	18154	18154	18154	Waste.K4	401506	328717	257340	187334
Straw.F1	90019	90019	90019	90019	Waste.L1	933617	730417	522535	341215
Straw.F2	130498	130498	130498	130498	Waste.L2	545034	428004	307293	201343
Straw.F3	231824	231824	231824	231824	Waste.M2	838297	721752	533857	361266
Straw.G1	143234	143234	143234	143234	Waste.M3	909097	767272	556339	369444
Straw.G2	109415	109415	109415	109415	Waste.M5	188015	161073	118559	79864
Straw.G3	4692	4692	4692	4692	Waste.M6	173786	145732	104972	69261
Straw.H1	403309	403309	403309	403309					

$FxTC_{il}^{Reg}$ [£ Ton-1]	
forestry.truck	1359.745645
waste.truck	1646.803059
miscanthus.truck	1190.460043
straw.truck	1180.539542
Pellets.truck	926.3267206
ForTOP.truck	689.35942
StrTOP.truck	748.546845

$VrTC_{il}^{Reg}$ [£ Ton-1 km-1]	
forestry.truck	30.41680017
waste.truck	36.83812465
miscanthus.truck	32.73765117
straw.truck	32.46483741
Pellets.truck	20.72144512
ForTOP.truck	15.42061032
StrTOP.truck	18.62601808

MisTOP.truck	748.546845
Oil.truck	871.8369135
Slurry.truck	823.4015295
forestry.rail	2722.221703
waste.rail	3296.912951
miscanthus.rail	4254.143976
straw.rail	4218.692776
Pellets.rail	1854.513535
ForTOP.rail	1380.103096
StrTOP.rail	1498.596796
MisTOP.rail	1498.596796
Oil.rail	1745.424504
Slurry.rail	1648.456476

MisTOP.truck	16.74460211
Oil.truck	19.50253658
Slurry.truck	18.41906233
forestry.rail	8.355063602
waste.rail	10.11891036
miscanthus.rail	6.927677139
straw.rail	6.869946496
Pellets.rail	5.691887079
ForTOP.rail	4.235822942
StrTOP.rail	5.116302992
MisTOP.rail	4.59950471
Oil.rail	5.357070192
Slurry.rail	5.059455181

$FxTC_i^{Loc}$ [£ Ton-1]	
forestry	1359.745645
waste	1646.803059
miscanthus	1190.460043
straw	1180.539542
Pellets	926.3267206
ForTOP	689.35942
StrTOP	748.546845
MisTOP	748.546845
Oil	871.8369135
Slurry	823.4015295

$VrTC_i^{Loc}$ [£ Ton-1 km-1]	
forestry	30.41680017
waste	36.83812465
miscanthus	32.73765117
straw	32.46483741
Pellets	20.72144512
ForTOP	15.42061032
StrTOP	18.62601808
MisTOP	16.74460211
Oil	19.50253658
Slurry	18.41906233

	$FxOpIN_{fkt}$ [£m year-1]			
	20_25	**25_30**	**30_35**	**35_40**
forestry.Int_gasif	2.996086653	2.996086653	2.996086653	2.996086653
waste.Int_gasif	2.8	2.8	2.8	2.8
miscanthus.Int_gasif	2.996086653	2.996086653	2.996086653	2.996086653
straw.Int_gasif	2.996086653	2.996086653	2.996086653	2.996086653

	$VrOpIN_{fkt}$ [£m GWh-1]			
	20_25	**25_30**	**30_35**	**35_40**
forestry.Int_gasif	0.003721972	0.003721972	0.003721972	0.003721972
waste.Int_gasif	0.023555845	0.023555845	0.023555845	0.023555845
miscanthus.Int_gasif	0.003409201	0.003409201	0.003409201	0.003409201
straw.Int_gasif	0.003380791	0.003380791	0.003380791	0.003380791

	$Price_{pt}$ [£ kWh-1]			
	20_25	**25_30**	**30_35**	**35_40**
biosng	20.61183833	21.71453823	23.58069856	25.23649117
power	68.70248504	73.39639472	82.28766711	91.29127662

	Inc_{pt} [£ kWh-1]			
	20_25	**25_30**	**30_35**	**35_40**
biosng	73	73	73	73
Power	81	81	81	81

	$Land_{gt}$ [ha]			
	20_25	**25_30**	**30_35**	**35_40**
C1	121871	121871	121871	121871
C2	196635	196635	196635	196635
D1	155872	155872	155872	155872
D3	28512	28512	28512	28512
D4	95746	95746	95746	95746
D6	140820	140820	140820	140820
D7	19021	19021	19021	19021
E1	257902	257902	257902	257902
E2	346446	346446	346446	346446
E3	69639	69639	69639	69639
E4	68886	68886	68886	68886
F1	216739	216739	216739	216739
F2	362150	362150	362150	362150
F3	448101	448101	448101	448101
G1	370744	370744	370744	370744
G2	356311	356311	356311	356311
G3	18274	18274	18274	18274
H1	801848	801848	801848	801848
H2	185362	185362	185362	185362
H3	261797	261797	261797	261797
I2	20252	20252	20252	20252
J1	335602	335602	335602	335602
J2	186261	186261	186261	186261
J3	187805	187805	187805	187805
J4	188477	188477	188477	188477
K1	376726	376726	376726	376726
K2	283116	283116	283116	283116
K3	164169	164169	164169	164169
K4	267353	267353	267353	267353
L1	334532	334532	334532	334532
L2	193355	193355	193355	193355
M2	422044	422044	422044	422044
M3	208961	208961	208961	208961
M5	258545	258545	258545	258545
M6	147785	147785	147785	147785

	LD_g [km]
C1	20.97563
C2	32.02929
D1	33.47832
D3	15.40082
D4	22.3244
D6	19.73715
D7	12.98744
E1	25.61247
E2	36.20669
E3	16.07004
E4	17.96281
F1	28.68834
F2	31.01345
F3	32.85619
G1	38.99117
G2	31.89074
G3	14.29796
H1	46.8615
H2	23.00079
H3	25.52145
I2	20.79124
J1	31.23915
J2	32.54812
J3	28.20494
J4	27.47456
K1	36.9369
K2	35.02714
K3	35.91481
K4	35.66877
L1	74.21243
L2	66.35262
M2	54.20107
M3	52.24912
M5	32.06278
M6	109.2639

$MaxLand_t$ [ha]	
20_25	1234500
25_30	1467500
30_35	1584000
35_40	1584000

LHV_i [GJ ton-1]	
forestry	10.9
waste	9
miscanthus	11.9
straw	12
biosng	49.855

	$Rent_{gt}$ [£m ha-1 year-1]			
	20_25	**25_30**	**30_35**	**35_40**
C1	1520.4	1520.4	1520.4	1520.4
C2	1520.4	1520.4	1520.4	1520.4
D1	1873.2	1873.2	1873.2	1873.2
D3	1873.2	1873.2	1873.2	1873.2
D4	1873.2	1873.2	1873.2	1873.2
D6	1873.2	1873.2	1873.2	1873.2
D7	1873.2	1873.2	1873.2	1873.2
E1	1834.8	1834.8	1834.8	1834.8
E2	1834.8	1834.8	1834.8	1834.8
E3	1834.8	1834.8	1834.8	1834.8
E4	1834.8	1834.8	1834.8	1834.8
F1	2233.2	2233.2	2233.2	2233.2
F2	2233.2	2233.2	2233.2	2233.2
F3	2233.2	2233.2	2233.2	2233.2
G1	2655.6	2655.6	2655.6	2655.6
G2	2655.6	2655.6	2655.6	2655.6
G3	2655.6	2655.6	2655.6	2655.6
H1	2552.4	2552.4	2552.4	2552.4
H2	2552.4	2552.4	2552.4	2552.4
H3	2552.4	2552.4	2552.4	2552.4
I2	1977.6	1977.6	1977.6	1977.6
J1	1977.6	1977.6	1977.6	1977.6
J2	1977.6	1977.6	1977.6	1977.6
J3	1977.6	1977.6	1977.6	1977.6
J4	1977.6	1977.6	1977.6	1977.6
K1	1842.0	1842.0	1842.0	1842.0
K2	1842.0	1842.0	1842.0	1842.0
K3	1842.0	1842.0	1842.0	1842.0
K4	1842.0	1842.0	1842.0	1842.0
L1	1476.0	1476.0	1476.0	1476.0
L2	1476.0	1476.0	1476.0	1476.0
M2	1297.2	1297.2	1297.2	1297.2
M3	940.8	940.8	940.8	940.8
M5	1148.4	1148.4	1148.4	1148.4
M6	332.4	332.4	332.4	332.4

	$Yield_{fgt}$ [ton year-1 ha-1]			
	20_25	**25_30**	**30_35**	**35_40**
Miscanthus.C1	10.18	10.70	10.93	10.84
Miscanthus.C2	10.29	10.89	11.13	11.03
Miscanthus.D1	12.55	13.04	13.47	13.83
Miscanthus.D3	14.25	14.64	14.96	15.22
Miscanthus.D4	13.33	13.77	14.13	14.41
Miscanthus.D6	11.86	12.29	12.54	12.61
Miscanthus.D7	12.18	12.52	12.70	12.72
Miscanthus.E1	10.32	10.80	11.04	11.06
Miscanthus.E2	10.45	11.05	11.32	11.25
Miscanthus.E3	9.49	9.92	10.14	10.15
Miscanthus.E4	11.24	11.75	12.07	12.21
Miscanthus.F1	9.74	10.17	10.39	10.40
Miscanthus.F2	8.63	8.94	9.15	9.25
Miscanthus.F3	8.58	8.94	9.15	9.21
Miscanthus.G1	9.99	10.43	10.72	10.86
Miscanthus.G2	10.07	10.60	10.93	11.07
Miscanthus.G3	9.51	9.86	10.11	10.26
Miscanthus.H1	8.53	8.86	9.05	9.10
Miscanthus.H2	8.62	8.96	9.16	9.20
Miscanthus.H3	7.42	7.74	7.94	8.02
Miscanthus.I2	8.87	9.20	9.42	9.53
Miscanthus.J1	10.36	10.72	10.97	11.10
Miscanthus.J2	12.91	13.15	13.35	13.52
Miscanthus.J3	14.91	15.31	15.64	15.91
Miscanthus.J4	10.94	11.12	11.30	11.45
Miscanthus.K1	13.05	13.47	13.78	14.00
Miscanthus.K2	13.88	14.10	14.31	14.50
Miscanthus.K3	16.79	17.37	17.84	18.19
Miscanthus.K4	15.94	16.39	16.76	17.07
Miscanthus.L1	14.63	15.04	15.44	15.82
Miscanthus.L2	13.34	13.92	14.34	14.61
Miscanthus.M2	9.89	10.51	10.85	10.93
Miscanthus.M3	12.05	12.49	12.89	13.25
Miscanthus.M5	9.46	10.01	10.32	10.39
Miscanthus.M6	8.53	8.97	9.27	9.44

	UFC_{fgt} [£ Ton-1]					UFC_{fgt} [£ Ton-1]			
	20_25	25_30	30_35	35_40		20_25	25_30	30_35	35_40
Forestry.C1	65	65	65	65	Straw.H2	60	60	60	60
Forestry.C2	65	65	65	65	Straw.H3	60	60	60	60
Forestry.D1	65	65	65	65	Straw.I2	60	60	60	60
Forestry.D3	65	65	65	65	Straw.J1	60	60	60	60
Forestry.D4	65	65	65	65	Straw.J2	60	60	60	60
Forestry.D6	65	65	65	65	Straw.J3	60	60	60	60
Forestry.D7	65	65	65	65	Straw.J4	60	60	60	60
Forestry.E1	65	65	65	65	Straw.K1	60	60	60	60
Forestry.E2	65	65	65	65	Straw.K2	60	60	60	60
Forestry.E3	65	65	65	65	Straw.K3	60	60	60	60
Forestry.E4	65	65	65	65	Straw.K4	60	60	60	60
Forestry.F1	65	65	65	65	Straw.L1	60	60	60	60
Forestry.F2	65	65	65	65	Straw.L2	60	60	60	60
Forestry.F3	65	65	65	65	Straw.M2	60	60	60	60
Forestry.G1	65	65	65	65	Straw.M3	60	60	60	60
Forestry.G2	65	65	65	65	Straw.M5	60	60	60	60
Forestry.G3	65	65	65	65	Straw.M6	60	60	60	60
Forestry.H1	65	65	65	65	Waste.C1	-35	-20	-10	0
Forestry.H2	65	65	65	65	Waste.C2	-35	-20	-10	0
Forestry.H3	65	65	65	65	Waste.D1	-35	-20	-10	0
Forestry.I2	65	65	65	65	Waste.D3	-35	-20	-10	0
Forestry.J1	65	65	65	65	Waste.D4	-35	-20	-10	0
Forestry.J2	65	65	65	65	Waste.D6	-35	-20	-10	0
Forestry.J3	65	65	65	65	Waste.D7	-35	-20	-10	0
Forestry.J4	65	65	65	65	Waste.E1	-35	-20	-10	0
Forestry.K1	65	65	65	65	Waste.E2	-35	-20	-10	0
Forestry.K2	65	65	65	65	Waste.E3	-35	-20	-10	0
Forestry.K3	65	65	65	65	Waste.E4	-35	-20	-10	0
Forestry.K4	65	65	65	65	Waste.F1	-35	-20	-10	0
Forestry.L1	65	65	65	65	Waste.F2	-35	-20	-10	0
Forestry.L2	65	65	65	65	Waste.F3	-35	-20	-10	0
Forestry.M2	65	65	65	65	Waste.G1	-35	-20	-10	0
Forestry.M3	65	65	65	65	Waste.G2	-35	-20	-10	0
Forestry.M5	65	65	65	65	Waste.G3	-35	-20	-10	0
Forestry.M6	65	65	65	65	Waste.H1	-35	-20	-10	0
Straw.C1	60	60	60	60	Waste.H2	-35	-20	-10	0
Straw.C2	60	60	60	60	Waste.H3	-35	-20	-10	0
Straw.D1	60	60	60	60	Waste.I2	-35	-20	-10	0
Straw.D3	60	60	60	60	Waste.J1	-35	-20	-10	0
Straw.D4	60	60	60	60	Waste.J2	-35	-20	-10	0
Straw.D6	60	60	60	60	Waste.J3	-35	-20	-10	0
Straw.D7	60	60	60	60	Waste.J4	-35	-20	-10	0
Straw.E1	60	60	60	60	Waste.K1	-35	-20	-10	0
Straw.E2	60	60	60	60	Waste.K2	-35	-20	-10	0

Straw.E3	60	60	60	60	Waste.K3	-35	-20	-10	0
Straw.E4	60	60	60	60	Waste.K4	-35	-20	-10	0
Straw.F1	60	60	60	60	Waste.L1	-35	-20	-10	0
Straw.F2	60	60	60	60	Waste.L2	-35	-20	-10	0
Straw.F3	60	60	60	60	Waste.M2	-35	-20	-10	0
Straw.G1	60	60	60	60	Waste.M3	-35	-20	-10	0
Straw.G2	60	60	60	60	Waste.M5	-35	-20	-10	0
Straw.G3	60	60	60	60	Waste.M6	-35	-20	-10	0
Straw.H1	60	60	60	60					

βIN_{fkt}	
forestry.Int_gasif.biosng	0.627912
waste.Int_gasif.biosng	0.52
miscanthus.Int_gasif.biosng	0.644436
straw.Int_gasif.biosng	0.66096
forestry.Int_gasif.heat	0.222
waste.Int_gasif.heat	0.1
miscanthus.Int_gasif.heat	0.222
straw.Int_gasif.heat	0.222

A.2. UK NUTS classification

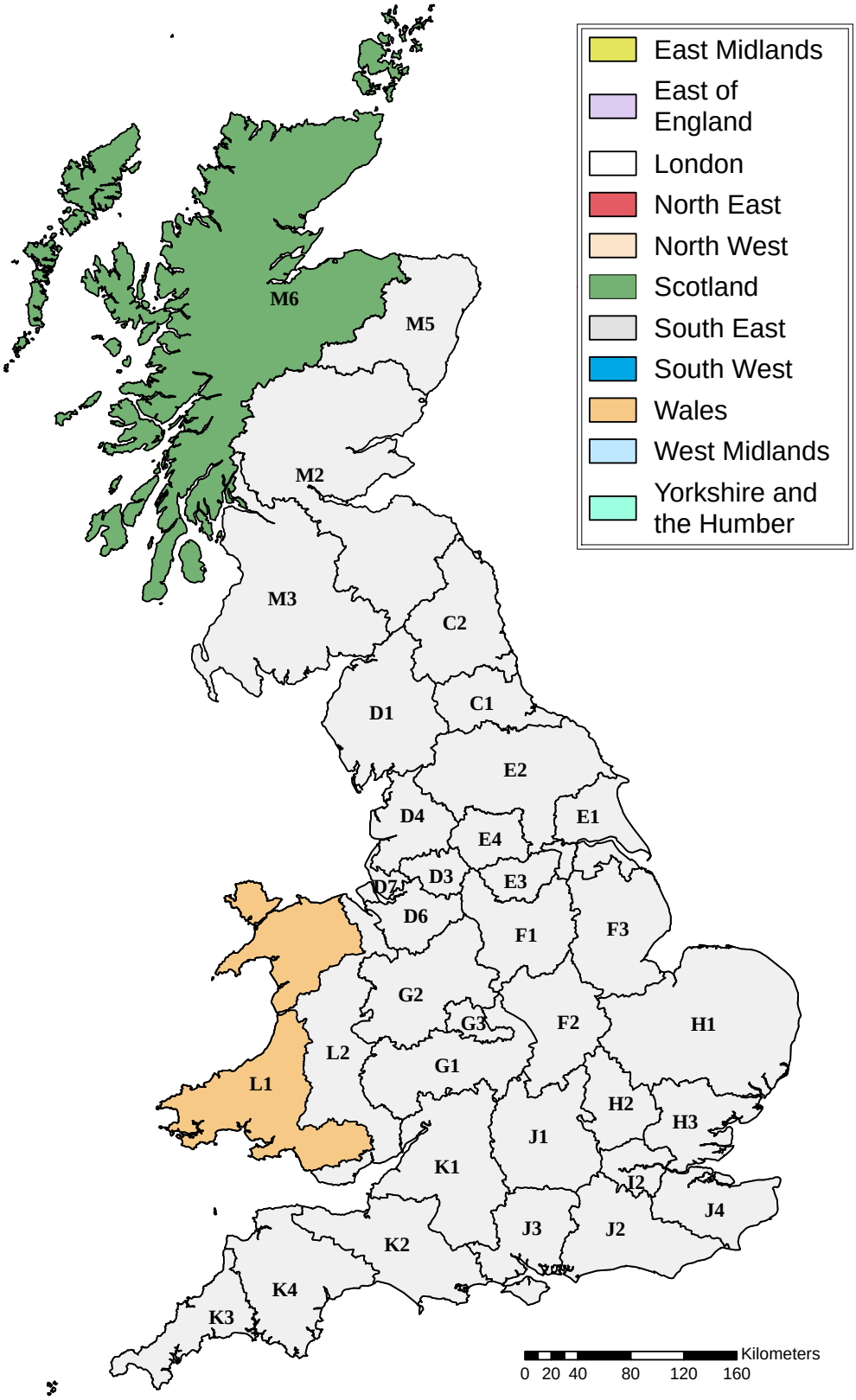

Figure A.1-1. UK statistical regions classified by NUTS 1 (colour) and NUTS 2 (labels)

Table A.1. UK NUTS1 and NUTS2 classification

UK NUTS 1	UK NUTS 2	REGIONS
East Midlands	F1	Derbyshire and Nottinghamshire
	F2	Leicestershire, Rutland and Northamptonshire
	F3	Lincolnshire
East of England	H1	East Anglia
	H2	Bedfordshire and Hertfordshire
	H3	Essex
Greater London	I2	Inner and outer London
North East England	C1	Tees Valley and Durham
	C2	Northumberland and Tyne and Wear
North West England	D1	Cumbria
	D3	Manchester
	D4	Lancashire
	D6	Cheshire
	D7	Merseyside
South East England	J1	Berkshire, Buckinghamshire and Oxfordshire
	J2	Surrey, East and West Sussex
	J3	Hampshire and Isle of Wight
	J4	Kent
South West England	K1	Gloucestershire, Wiltshire and Bristol/Bath area
	K2	Dorset and Somerset
	K3	Cornwall and Isles of Scilly
	K4	Devon
West Midlands	G1	Herefordshire, Worcestershire and Warwickshire
	G2	Shropshire and Staffordshire
	G3	West Midlands
Yorkshire and the Humber	E1	East Yorkshire and Northern Lincolnshire
	E2	North Yorkshire
	E3	South Yorkshire
	E4	West Yorkshire
Wales	L1	West Wales and The Valleys
	L2	East Wales
Scotland	M2	Eastern Scotland
	M3	South Western Scotland
	M5	North Eastern Scotland
	M6	Highlands and Islands

A.3. Resources

The estimation of available feedstocks is discussed in detail in the following sections.

Woody biomass

Currently, woody biomass is regarded as the most likely feedstock to be used in first commercial plants for production of BioSNG [1]. In this study, the potential of woody biomass available for renewable energy generation is estimated based on 4 sources:

Forestry residues and Stemwood

Forestry residues are mainly composed by tips and branches (56%), which are considered as waste products of removal operations, followed by poor quality stemwood (30%) and finally by foliage (14%) [2]. Stemwood is the most valuable part of a tree. Its quality is classified according to the top diameter. The forestry commission suggests that only stemwood with a diameter less than 14 cm will be available for the energy market. Moreover, the forestry commission reported species such as pines, spruces, other conifers, and broadleaves as adequate sources of stemwood. Forestry residues have several relevant environmental functions such as source of nutrients, prevention of erosion, habitat provider, etc. This imposes limitations on the usage of forestry residues for renewable energy generation. Accordingly, the European Environmental Agency (EEA) estimated the amount of forestry residues and stemwood that can be used taking into account several environmental factors. In the UK, the total potential that can be used without impacting the environment was reported to be 3450 kTon/yr for 2020 and it decreases to 2532 kTon/yr in 2030 [3]. Some environmental factors included by the EEA can explain the reduction of resources in almost 27% between 2020 and 2030. For example, the analysis considers a potential future increase in protected areas and an increment share of deadwood left on site. This decreasing trend was used to extrapolate forestry residues and stemwood resources until 2040. As the information is reported at national level, a map for the geographic distribution of forestry lands across UK (see section A.4 in supporting information) is used as proxy for the calculation of available forestry residues at NUTS2 level.

Arboricultural arisings

This category includes stemwood, branches, wood chips, and foliage from harvesting, pruning and safety operations in urban and semi-rural areas. Arboricultural arisings are usually chipped and left onsite or used for composting. Arboricultural arisings are gaining importance as a low-price source of timber. In 2003, the total availability of arboricultural arisings was reported to be 481 kTon/yr [4], including total arboricultural contractor arisings and utility work arisings. Almost all the arisings are located in England (92.6%) followed by Scotland

(4.5%), and Wales (2.9%). It is not expected a considerable increase of arboricultural arisings in the future and their availability is estimated to be 68% of the initial potential if competing markets are taken into account [4]. The final contribution of arboricultural arisings for energy generation is 332 kTon/yr. In order to distribute this potential into the 35 regions (NUTS2), a Land Cover Map of Great Britain published in 2007 (LCM2007) was used. This map is derived from satellite images and digital cartography and gives land cover information for the entire UK by classifying the land into 23 different categories (see section A.4 in supporting information). The category of Urban and Suburban areas in UK was used to allocate the arboricultural resources at the NUTS2 level. The availability was kept constant along the planning horizon.

Sawmill coproducts

The total production of sawmill coproducts in the UK in 2003 was 864 kTon/y [2]. 66% of this resource is in the form of chips (peeled and unpeeled), 20% is sawdust and 11% is bark. Scotland has 47% of the total sawmill production followed by England with 33% and finally wales with a share of 20%. Within England, 35% of the English production comes from West Midlands. North East and North West are also important regions with a contribution of 17% and 13%, respectively. The fraction available for energy generation is estimated to be 10% of the total sawmill coproducts since most of the production is sold to wood processing industries [4]. It was possible to establish a correlation between the production of sawmill coproducts and the corresponding sawn softwood production in 2003, as shown in Figure . The data correspond to the 11 NUTS1 regions in which UK is divided. This correlation was used to estimate the sawmill coproducts availability in 2013, based on the sawn softwood production in the same year. Finally, the sawmill coproducts potential at NUTS2 level was estimated based on a map of active sawmills in the UK (see section A.4 in supporting information). Finally, data regarding estimation of future sawn softwood production are not available, therefore, the availability of sawmill coproducts was kept constant along the planning horizon.

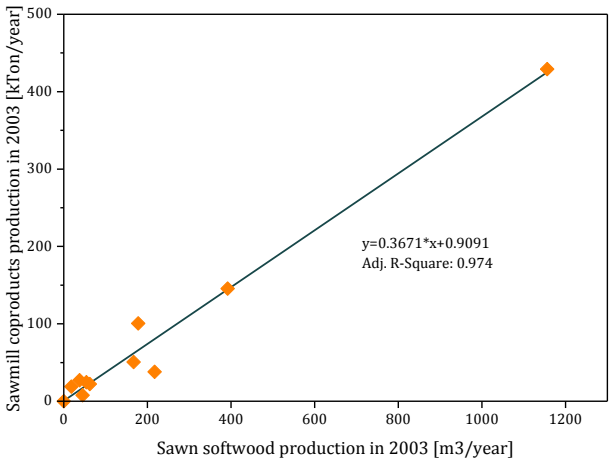

Figure A.3-1. Correlation used to forecast sawmill coproducts production from 2003 to 2013, based on sawn softwood production

As the woody resources are composed by different types of biomass, an average cost of 65 £/Ton was used for all the regions [5]. This cost was kept constant for all the planning periods.

Cereal Straw

Agricultural residues are an additional source of biomass for renewable energy generation. For this case study, cereal straw, from wheat and barley, is considered to be a suitable feedstock for future projects in BioSNG production. The Department for Environment Food and Rural Affairs (Defra) estimated that the total straw production in the UK in 2007 ranged between 9 and 10 million tonnes per year. Nonetheless, a significant fraction of these resources are recycled for activities such as animal bedding (56%), animal feed (19%), and used as fertilizers and organic matter supplements [6]. After considering these figures, Defra estimated the total production of cereal straw available for bioenergy production to be 3000 KTon/yr [7]. The discretisation of the total cereal straw potential at NUTS2 level was done based on the arable and horticultural land categories included in LCM2007 (see section A.4 in supporting information). The data shows that England has the higher cereal straw production with 86%, followed by Scotland with 11% and Wales with only 3%. Due to lack of information with forecasted straw production in the UK, the availability of straw was kept constant along the planning horizon. Regarding prices, Defra reports periodically average prices for different agricultural products. The price of cereal straw was fixed at 60 £/Ton which is the average of the monthly price reported for pickup baled wheat straw in 2014 [8]. This value was also kept constant for all the planning periods.

Residual Waste

Economic growth is usually attached to increment in waste generation [9]. Energy generation from waste streams, e.g. municipal solid waste (MSW), is an interesting application

that can have an important role in the waste management strategy of a country while contributing in reducing dependency of fossil fuels. The waste management hierarchy places waste prevention at the top, followed by reuse, recycle/compost, then energy recovery, and finally disposal as the last option [10]. The UK has adopted policies and targets consistent with this classification aiming towards a future zero waste economy. This policy framework gives priority to increase the share of disposal and recycling, whereas limits are imposed not only on the amount of waste for disposal, but also on the percentage that can be treated in waste-to-energy applications. Some of the relevant policies are summarised for each country as follows:

The plan in Scotland includes the following targets for 2025 (http://www.recoup.org/p/189/scotland):

- Developing of adequate infrastructure to collect, recycle and compost 70% of total waste. This will include recycling centres, transfer stations, Material Recovery Facilities (MRFs, to process dry recyclates), composting facilities and anaerobic digestion facilities.
- Treating no more than 25% of waste in waste-to-energy facilities.
- Landfilling no more than 5% of its waste

The plan in Wales includes the following targets for 2025 [11–13]:

- 70% of the generated waste must be sent for recycling or composting
- No more than 30% of waste can be used in energy from waste facilities
- Landfilling no more than 5% of waste.

Additionally, Welsh government has also set a target for 2050 of zero waste, which means that all waste produced should be reuse or recycled [14]. The plan in England includes the following targets for 2020:

- Recycling and composting 50% of the total household waste [10].
- Reuse and/or recycle of 75% of MSW [10].
- Reuse and/or recycle of 70% of waste produced in construction and demolition sector [15].

The maximum percentage allowable for energy production is not specified. Three categories were included for the estimation of available waste for energy production: MSW, commercial sector, and industrial sector.

The potential of MSW recovery in Wales in 2009 was estimated in 1,700 kTon/year [16]. Based on the targets previously discussed, MSW availability for 2020 is 1475 kTon/year and 1067 kTon/year for 2040. Furthermore, the fraction available for energy generation from MSW in Wales goes from 36% in 2020 down to 12% in 2040 [14], which corresponds to 531 kTon/year and 128 kTon/year available for 2020 and 2040, respectively. The commercial and industrial sector generated 1,665 kTon/year and 2,035 kTon/year in 2012, respectively [12]. It is expected a yearly reduction of waste generation of 1.2% for the commercial sector and 1.4% for the industrial sector, in addition, the fraction of waste available for energy generation is 33% and 30% for both sectors for 2020 and 2040, respectively [17]. Finally, the available resources from commercial and industry sectors for energy generation are 497 kTon/year and 596 kTon/year in 2020, and decrease to 132 kTon/year and 148 kTon/year in 2040, respectively, which represents an average reduction of 75%.

In 2010 the waste arising in Scotland from MSW, commercial, and industrial sectors were 3,141 kTon/year, 4,701 kTon/year, and 1,799 kTon/year, respectively (https://www.sepa.org.uk). Moreover, some initiatives are in evaluation in order to promote resource efficiency, which could result in a reduction of 5% in the total waste production in 2015 and 15% in 2025 (http://www.recoup.org/p/189/scotland). Finally, the available fraction for energy generation is set at 25% for all the sectors along the planning horizon [18]. The available resources for energy generation in Scotland from MSW, commercial, and industrial sectors are 706 kTon/year, 1058 kTon/year, and 405 kTon/year, respectively. The resource availability decreases around 69% by 2040.

In England, the total production of MSW in 2015 was 22,227 kTon/year [19]. In the case of commercial and industrial sectors, a total of 23,844 kTon/year and 24,083 kTon/year was generated in 2009, respectively [20]. A average yearly reduction of 1.2% from the total waste generation is used along with fraction available for energy generation of 35% for MSW and 30% for commercial and industrial sectors in 2020 [21,22]. For 2040, these values are set to 10% and 15%, respectively. Finally, the total available resources in England are: 7,344 kTon/year coming from MWS, 5911 kTon/year generated in the commercial sector, and 5971 kTon/year from industrial sector. In total, available residual waste for energy generation the UK is around 23,020 kTon/yr in 2020 and decreases to 7,544 kTon/yr by 2040, around 67% less availability than at the beginning of the planning horizon. Most of the residual waste is produced in England (83.5%), followed by Scotland (9.4%), and Wales (7.1%).

A.4. Supporting maps

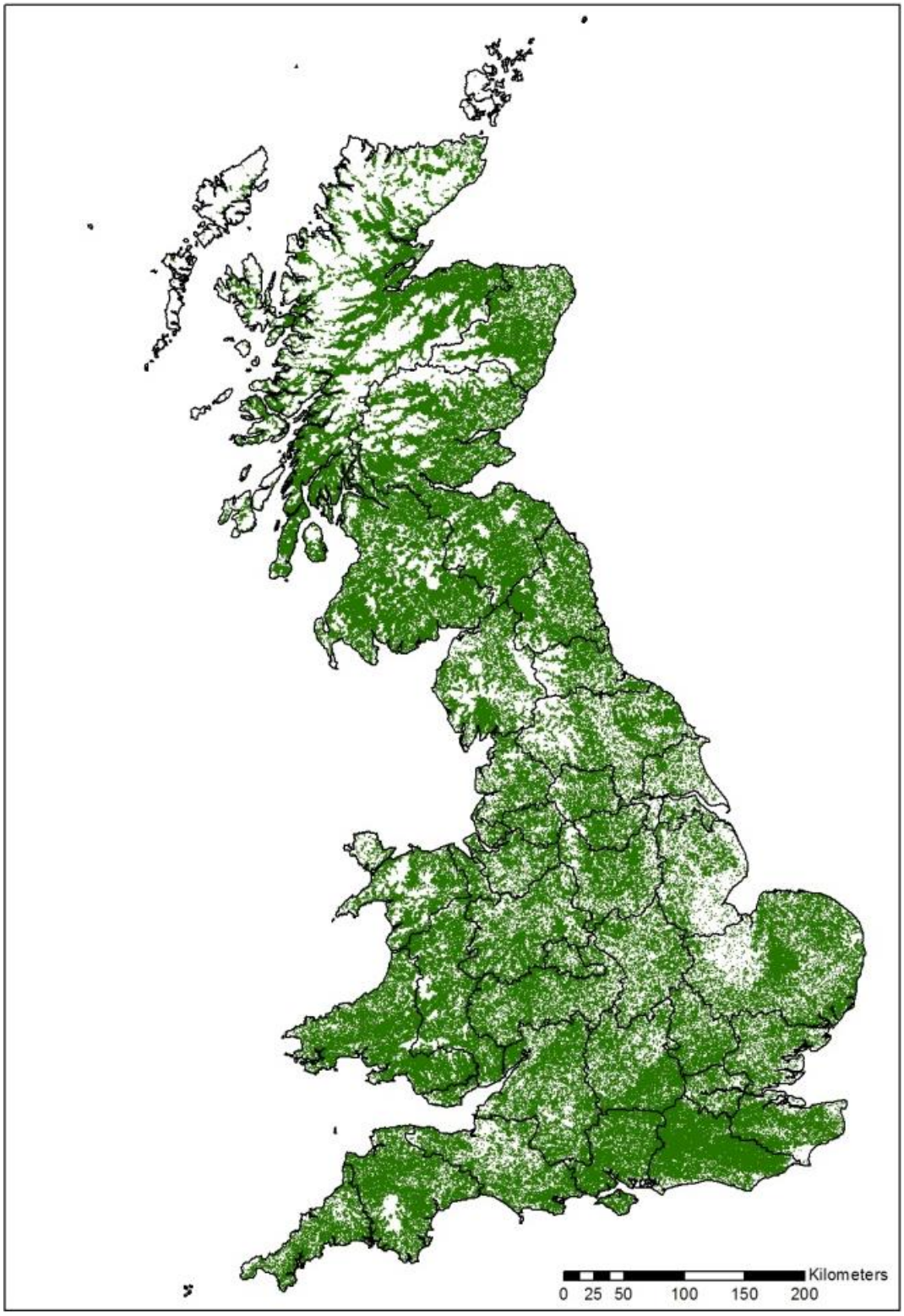

Figure A.4-1. Forestry land distribution across the UK [23]

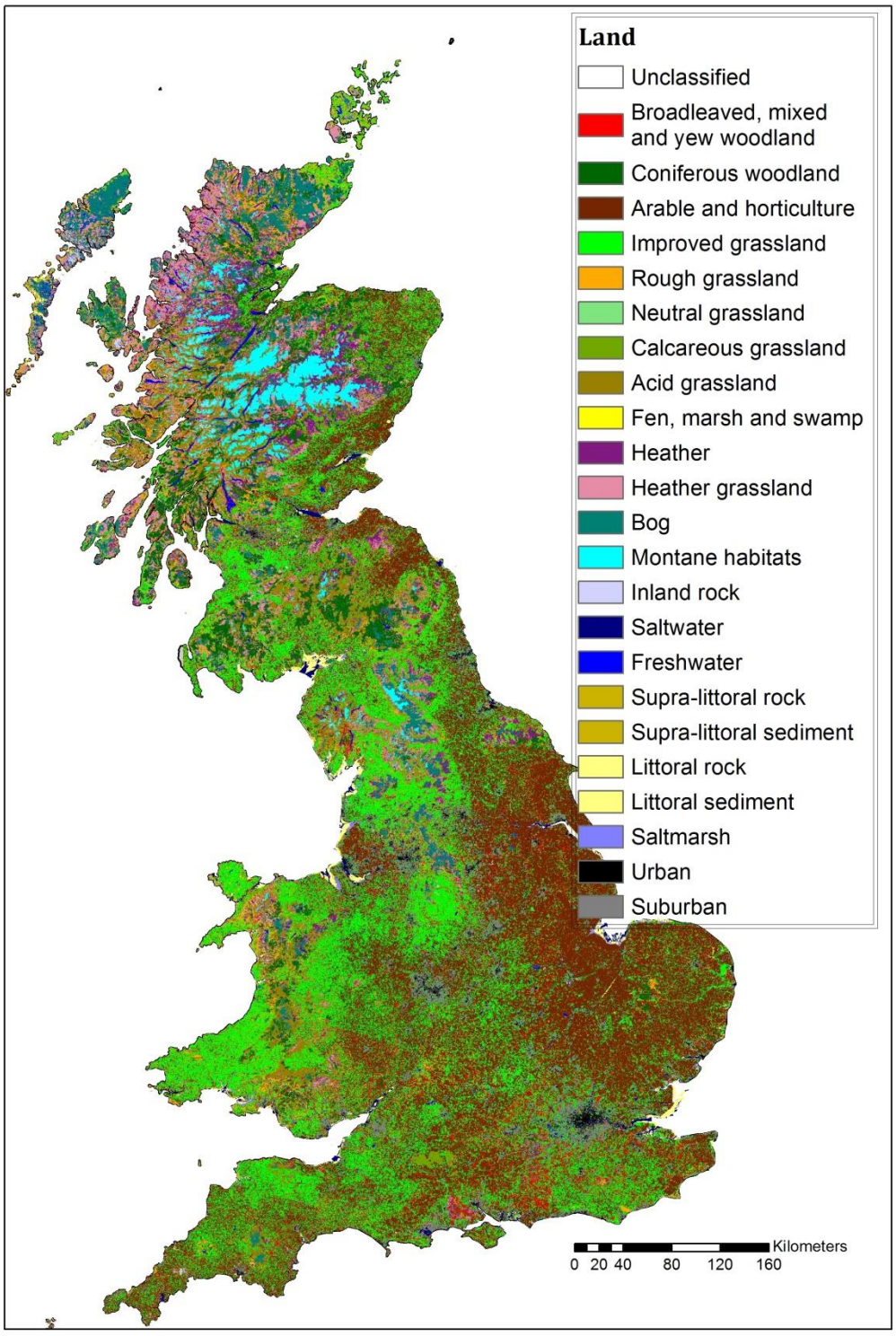

Figure A.4-2. UK Land Cover Area [24]

Figure A.4-3. UK map of active sawmills [25]

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