

Teichmann, Isabel

**Research Report**

## Technical greenhouse-gas mitigation potentials of biochar soil incorporation in Germany: Data documentation

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# Data Documentation

Deutsches Institut für Wirtschaftsforschung

2014

## Technical Greenhouse-Gas Mitigation Potentials of Biochar Soil Incorporation in Germany: Data Documentation

Isabel Teichmann

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## **Data Documentation 73**

Isabel Teichmann\*

### **Technical Greenhouse-Gas Mitigation Potentials of Biochar Soil Incorporation in Germany: Data Documentation<sup>1</sup>**

Berlin, August 2014

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## Contents

List of Tables .....	ii
List of Abbreviations .....	vi
A.1 Introduction .....	1
A.2 Biomass Potentials .....	1
A.3 Feedstock Characteristics and Biochar Yields and Properties .....	15
A.4 Area of Arable Land .....	38
A.5 GHG Emissions from Manure Management .....	39
A.6 Net GHG Emissions from Transports and Soil Additions .....	44
A.7 Total Net Avoided GHG Emissions per Dry-Feedstock Tonne .....	62
A.8 Revised Biomass Potentials for Biochar Production .....	95
A.9 Revised Transport Distances and Emissions .....	96
A.10 Revised Total Net Avoided GHG Emissions per Dry-Feedstock Tonne .....	109
A.11 Technical GHG Mitigation Potentials of Biochar .....	121
References .....	130

## List of Tables

Table A.1: Biomass Potentials for Bioenergy – Biomass Residues: Solid Residues .....	5
Table A.2: Biomass Potentials for Bioenergy – Biomass Residues: Digestable Residues (Initial Feedstocks) .....	7
Table A.3: Biomass Potentials for Bioenergy – Biomass Residues: Digestable Residues (Digestates) .....	11
Table A.4: Biomass Potentials for Bioenergy – Energy Crops (Initial Feedstocks) .....	13
Table A.5: Biomass Potentials for Bioenergy – Energy Crops (Digestates) .....	13
Table A.6: Maximum Biomass Potentials for Biochar from Biomass Residues in Germany, 2010-2050 .....	14
Table A.7: Feedstock Properties and Associated Slow-Pyrolysis Biochar Yields and Characteristics .....	17
Table A.8: Total Area of Arable Land, Germany, 2010-2050 .....	38
Table A.9: Livestock Population in Germany in 2000 .....	39
Table A.10: Annual CH <sub>4</sub> Emission Factors from Manure Management per Animal .....	40
Table A.11: CH <sub>4</sub> Emissions from Manure Management per Dry Tonne of Feedstock in Germany in 2000 .....	41
Table A.12: Emissions from Cattle Manure Management .....	42
Table A.13: Emissions from Liquid Swine Manure Management .....	42
Table A.14: CO <sub>2</sub> Emissions from Manure Management .....	42
Table A.15: Emission Factors for Direct N <sub>2</sub> O Emissions from Manure Management .....	43
Table A.16: Default Fractions of Manure Nitrogen Volatilizing as NH <sub>3</sub> and NO <sub>x</sub> .....	43
Table A.17: Loss Fractions of Manure Nitrogen from Manure Management .....	43
Table A.18: Mean Transport Distances, Germany, 2015-2050 .....	44
Table A.19: Transport Fuels, Germany, 2010-2050 .....	45
Table A.20: CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units .....	46

Table A.21:	CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms .....	47
Table A.22:	CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Med 1</i> .....	48
Table A.23:	CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Min 1</i> .....	49
Table A.24:	CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Med 2</i> .....	50
Table A.25:	CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Min 2</i> .....	51
Table A.26:	CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Med 1</i> .....	52
Table A.27:	CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Min 1</i> .....	53
Table A.28:	CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Med 2</i> .....	54
Table A.29:	CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Min 2</i> .....	55
Table A.30:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Max 1</i> .....	56
Table A.31:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Med 1</i> .....	57
Table A.32:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Min 1</i> .....	58
Table A.33:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Max 2</i> .....	59
Table A.34:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Med 2</i> .....	60
Table A.35:	Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Min 2</i> .....	61
Table A.36:	Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 1</i> .....	63
Table A.37:	Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 1</i> .....	64
Table A.38:	Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 2</i> .....	65
Table A.39:	Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 2</i> .....	66
Table A.40:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Max 1</i> .....	67
Table A.41:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Med 1</i> .....	68
Table A.42:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Min 1</i> .....	69
Table A.43:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Max 2</i> .....	70
Table A.44:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Med 2</i> .....	71
Table A.45:	Total Net Avoided GHG Emissions, 2015, Scenario <i>Min 2</i> .....	72
Table A.46:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Max 1</i> .....	73
Table A.47:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Med 1</i> .....	74
Table A.48:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Min 1</i> .....	75
Table A.49:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Max 2</i> .....	76
Table A.50:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Med 2</i> .....	77
Table A.51:	Total Net Avoided GHG Emissions, 2050, Scenario <i>Min 2</i> .....	78
Table A.52:	Total Net Avoided GHG Emissions from Sections 4.1 to 4.3 – 68% Biochar Carbon Sequestration for All Feedstocks .....	79

Table A.53: Total Net Avoided GHG Emissions, 2030, Scenario <i>Max 1</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	81
Table A.54: Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 1</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	82
Table A.55: Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 1</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	83
Table A.56: Total Net Avoided GHG Emissions, 2030, Scenario <i>Max 2</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	84
Table A.57: Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 2</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	85
Table A.58: Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 2</i> – 68% Biochar Carbon Sequestration for All Feedstocks .....	86
Table A.59: Total Net Avoided GHG Emissions from Sections 4.1 to 4.3 – Zero Biomass Carbon Sequestration .....	87
Table A.60: Total Net Avoided GHG Emissions, 2030, Scenario <i>Max 1</i> – Zero Biomass Carbon Sequestration .....	89
Table A.61: Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 1</i> – Zero Biomass Carbon Sequestration .....	90
Table A.62: Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 1</i> – Zero Biomass Carbon Sequestration .....	91
Table A.63: Total Net Avoided GHG Emissions, 2030, Scenario <i>Max 2</i> – Zero Biomass Carbon Sequestration .....	92
Table A.64: Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 2</i> – Zero Biomass Carbon Sequestration .....	93
Table A.65: Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 2</i> – Zero Biomass Carbon Sequestration .....	94
Table A.66: Revised Maximum Biomass Potentials for Biochar from Biomass Residues in Germany, 2010-2050 .....	95
Table A.67: Revised Mean Transport Distances, Germany, 2015-2050 .....	96
Table A.68: Revised CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Med 1</i> .....	97
Table A.69: Revised CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Min 1</i> .....	98
Table A.70: Revised CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Med 2</i> .....	99
Table A.71: Revised CO <sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario <i>Min 2</i> .....	99
Table A.72: Revised CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Med 1</i> .....	100
Table A.73: Revised CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Min 1</i> .....	101
Table A.74: Revised CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Med 2</i> .....	102
Table A.75: Revised CO <sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario <i>Min 2</i> .....	102
Table A.76: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Max 1</i> .....	103

Table A.77: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Med 1</i> .....	104
Table A.78: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Min 1</i> .....	105
Table A.79: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Max 2</i> .....	106
Table A.80: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Med 2</i> .....	107
Table A.81: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario <i>Min 2</i> .....	108
Table A.82: Revised Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 1</i> .....	109
Table A.83: Revised Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 1</i> .....	110
Table A.84: Revised Total Net Avoided GHG Emissions, 2030, Scenario <i>Med 2</i> .....	111
Table A.85: Revised Total Net Avoided GHG Emissions, 2030, Scenario <i>Min 2</i> .....	112
Table A.86: Revised Total Net Avoided GHG Emissions, 2015, Scenario <i>Max 1, Med 1, Min 1</i> .....	113
Table A.87: Revised Total Net Avoided GHG Emissions, 2015, Scenario <i>Max 2, Med 2, Min 2</i> .....	114
Table A.88: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Max 1</i> .....	115
Table A.89: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Med 1</i> .....	116
Table A.90: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Min 1</i> .....	117
Table A.91: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Max 2</i> .....	118
Table A.92: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Med 2</i> .....	119
Table A.93: Revised Total Net Avoided GHG Emissions, 2050, Scenario <i>Min 2</i> .....	120
Table A.94: GHG Mitigation Potentials, 2030, Scenario <i>Med 1</i> .....	121
Table A.95: GHG Mitigation Potentials, 2030, Scenario <i>Med 2</i> .....	122
Table A.96: GHG Mitigation Potentials, 2030, Scenario <i>Min 2</i> .....	123
Table A.97: GHG Mitigation Potentials, 2050, Scenario <i>Max 1</i> .....	124
Table A.98: GHG Mitigation Potentials, 2050, Scenario <i>Med 1</i> .....	125
Table A.99: GHG Mitigation Potentials, 2050, Scenario <i>Min 1</i> .....	126
Table A.100: GHG Mitigation Potentials, 2050, Scenario <i>Max 2</i> .....	127
Table A.101: GHG Mitigation Potentials, 2050, Scenario <i>Med 2</i> .....	128
Table A.102: GHG Mitigation Potentials, 2050, Scenario <i>Min 2</i> .....	129



## List of Abbreviations

a	Year	N	Nitrogen
ad	Air dry	n.a.	Not available
ap	As pyrolyzed	N <sub>2</sub> O	Nitrous oxide
B <sub>0</sub>	Maximum methane producing capacity	NH <sub>3</sub>	Ammonia
C	Carbon	Nm <sup>3</sup>	Standard cubic meter
cal	Calorie	NO <sub>x</sub>	Nitric oxides
CH <sub>4</sub>	Methane	oDM	Organic dry mass
CO <sub>2</sub>	Carbon dioxide	P	Phosphorus
CO <sub>2</sub> e	Carbon-dioxide equivalent	Pa	Pascal
d	Day	PJ	Petajoule
D	Digestates	psi	Pound-force per square inch
daf	Dry ash-free basis	RW	Reaction water
db	Dry base	t	Tonne
DDGS	Dry distiller's grains with solubles	TJ	Terajoule
DM	Dry mass	T <sub>max</sub>	Peak temperature
EF	Emission factor	VM	Volatile matter
FM	Fresh mass	VS	Volatile solids
FW	Fresh weight	wt%	Weight percent
g	Gram	°C	Degree centigrade
GHG	Greenhouse gas	-	Not applicable
GWP	Global warming potential		
ha	Hectare		
HHV	Higher heating value		
J	Joule		
K	Kelvin		
K	Potassium		
k	Kilo		
kg	Kilogram		
km	Kilometer		
l	Liter		
LHV	Lower heating value		
m <sup>3</sup>	Cubic meter		
MCF	Methane conversion factor		
min	Minute		
MJ	Megajoule		
mm	Millimeter		

## A.1 Introduction

This data documentation accompanies the study “Technical Greenhouse-Gas Mitigation Potentials of Biochar Soil Incorporation in Germany” (Teichmann 2014), which analyzes the technical greenhouse-gas (GHG) potentials that can be mitigated in Germany in 2015, 2030 and 2050 when slow-pyrolysis biochar produced from biomass residues diverted from conventional feedstock management is used for soil carbon sequestration and when the pyrolysis by-products – pyrolysis oils and gases – are turned into renewable energy.

In addition to background information and detailed calculations, the data documentation contains supplementary results tables referred to but not displayed in Teichmann (2014). Moreover, it provides a discussion of the technical biomass potentials for bioenergy obtained from the literature and used by Teichmann (2014) for the calculation of the technical biomass potentials for biochar production and presents the data from an extensive literature survey that form the basis for the feedstock-specific slow-pyrolysis biochar yields and characteristics along with the associated biomass properties used in the study.

A general conclusion drawn from the assessments of the literature-derived biomass potentials as well as biomass and biochar characteristics is that the comparability across studies would be largely enhanced if the water contents of biomass and biochar would be routinely published and if it would be always clearly indicated whether the results are based on biomass and biochar fresh or dry weights.

The data documentation is organized as follows: Section A.2 derives and discusses the technical biomass potentials used in Teichmann (2014). Section A.3 displays and discusses the biomass and biochar properties and biochar yields used to calculate the corresponding feedstock-specific characteristics applied by Teichmann (2014). In Section A.4, the area of arable land potentially available for biochar deployment in Germany is derived. While Section A.5 provides details for the calculation of GHG emissions from manure management, Section A.6 gives background information and supplementary results for any biomass- and biochar-related emissions from transports and soil additions. Section A.7, in turn, contains supplementary results and sensitivity checks for the total net GHG emissions that are avoided per dry tonne of feedstock turned into biochar. For the reduced set of feedstocks outlined in Teichmann (2014), Section A.8 further presents the derivation of the revised biomass potentials for biochar production, Section A.9 the background data and supplementary results for the revised transport distances and emissions, and Section A.10 the supplementary results for the revised total net avoided GHG emissions per dry tonne of feedstock. Finally, Section A.11 covers supplementary results for the technical GHG mitigation potentials of biochar.

## A.2 Biomass Potentials

As detailed in Section 3.1 of Teichmann (2014)<sup>2</sup> and following the literature (in particular, Shackley et al. 2011), the biomass potentials for biochar production in Germany over the 2015-2050 period used for the calculation of the technical GHG mitigation potentials of biochar have been calculated as a share of the technical biomass potentials for bioenergy production.<sup>3</sup> This accompanying data documentation contains (*i*) the derivation and

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<sup>2</sup> Any section without the leading “A.” refers to Teichmann (2014).

<sup>3</sup> Technical biomass potentials refer to the biomass potentials that are available after accounting for ecological, land-area, agro-technological or topographic constraints, i.e. after deducting land for food, housing or environmental purposes (Slade et al. 2011).

discussion of the technical biomass potentials for bioenergy production and (ii) the calculation of the percentage shares of the technical biomass potentials for bioenergy production that could be available for biochar production.

**Biomass potentials for bioenergy production.** Regarding the technical biomass potentials for bioenergy production, Teichmann (2014) largely focuses on biomass residues, capturing both solid biomass residues and residues that can be anaerobically digested. For the group of digestible feedstocks, Teichmann (2014) gives the biomass potentials for both the initial feedstocks and the corresponding digestates. Additionally, the study by Teichmann (2014) also covers digestates from energy crops used for biogas production, referenced by digestates from corn silage.

**Derivation.** The technical feedstock potentials for bioenergy production of the biomass residues used in Teichmann (2014: Table 1)<sup>4</sup> have been derived from the literature. With some updates for current developments, they refer to the “NaturschutzPlus” (*nature conservation plus*) scenario from Nitsch et al. (2004), which itself is an extended version of the “Umwelt” (*environment*) scenario of Fritsche et al. (2004a). That is, the biomass potentials obtained by Fritsche et al. (2004a, “Umwelt” scenario) form part of Nitsch et al. (2004, “NaturschutzPlus” scenario). While Fritsche et al. (2004a) focus on the time period up to 2030, Nitsch et al. (2004) prolong the potentials until 2050. Both scenarios respect diverse environmental aspects, such as the expansion of organic farming; however, the “NaturschutzPlus” scenario by Nitsch et al. (2004) considers future environmental requirements in greater detail, in particular, concerning nature conservation and soil and water protection. Both studies give priority to the material use of biomass residues and the use of land for food production. Furthermore, they cover quantitatively important feedstocks only.

While the feedstock categories used in Teichmann (2014) largely follow those from Nitsch et al. (2004) and Fritsche et al. (2004a), only the biomass potentials of those feedstocks relevant for biochar production were selected. In particular, Teichmann (2014) does not include the sewage-sludge potential captured as solid fuel in Fritsche et al. (2004a) since this refers to sewage sludge that is highly contaminated and, thus, cannot legally be used as a soil amendment. For this reason, it is not considered suitable for biochar production and attention is restricted to the type of sewage sludge that is allowed to be composted after digestion. The same exclusion holds for scrap wood as it usually refers to treated wood, such as old furniture and demolition wood (Fritsche et al. 2004a).<sup>5</sup> Moreover, thinning material from the formation of forest edges (Nitsch et al. 2004) is not covered since it affects only the period up to 2020 and is, thus, considered negligible. Likewise, carcass meal and animal fat are not included.

Since the biomass potentials in Nitsch et al. (2004) and Fritsche et al. (2004a) were mainly given in the form of (primary) energy contents or acreages, however, they had to be first transformed into dry-mass values. The corresponding calculations for the solid biomass residues are contained in Table A.1; those for the digestible biomass residues in Table A.2. Whenever available, the data necessary for the transformations were taken from Nitsch et al. (2004) and Fritsche et al. (2004a) or the sources cited therein. In the other cases, third sources were used. In addition, the tables contain detailed explanations concerning the modifications made to account for current developments not yet covered by Nitsch et al. (2004) and Fritsche et al. (2004a). Moreover, they provide a detailed description of the underlying feedstocks.

As an alternative to the direct use of the digestible biomass residues for biochar production, Teichmann (2014) also considers the use of the digestates obtained from the anaerobic digestion of the respective biomass residues, assuming that the entire potential of

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<sup>4</sup> All tables numbered without the leading “A.” refer to Teichmann (2014).

<sup>5</sup> Apart from these exclusions, Teichmann (2014) assumes that any possible contaminations of biochar are manageable and that any legal issues for the use of biochar as a soil amendment will be resolved.

digestible biomass residues is first used for biogas production and, then, biochar is derived from the digestates. This alternative pathway is in line with so-called biomass cascading where the same feedstock is used sequentially for material and energetic purposes to increase its resource efficiency (e.g., Arnold et al. 2009). The calculation of the corresponding dry-mass potentials of the digestates entering Table 2 of Teichmann (2014) was performed in Table A.3. It is based on the procedure given in Reinhold (2005).

Likewise, Tables A.4 and A.5 contain the derivation of the dry-mass values for the potential of digestates from energy crops (corn silage) displayed in Table 3 of Teichmann (2014).<sup>6</sup> As outlined in Table A.4, the potential of corn silage is mainly obtained from the acreage devoted to crops for biogas production from FNR (2012a) (current value: 0.9 million ha) and Nitsch et al. (2012) (2050 value: 1.0 million ha), with interpolations for the 2020-2040 period that are based on the total acreage for energy crops as largely derived from Nitsch et al. (2004, “NaturschutzPlus” scenario). The calculation of the digestates from corn silage, in turn, follows the procedure by Reinhold (2005) and is detailed in Table A.5.

**Discussion.** The studies by Nitsch et al. (2004) and Fritsche et al. (2004a) in general and their “NaturschutzPlus” and “Umwelt” scenarios in particular have been chosen as the sources for the German technical biomass potentials for bioenergy for several reasons. First, the studies cover a wide range of feedstocks from agriculture, forestry, landscape management, industry, and the waste sector; and they span until 2030 (Fritsche et al. 2004a) and even 2050 (Nitsch et al. 2004). Comparably comprehensive analyses of the technical biomass potentials for bioenergy generation in Germany can be found in Thrän et al. (2011; 2005) and EEA (2006). However, Thrän et al. (2011; 2005) cover only the period up to 2020; and while the EEA (2006) study ranges until 2030, it has a focus on the European scale and lacks detail on the country level.<sup>7</sup> Other studies deriving biomass potentials, in turn, deal with specific biomass feedstocks only. These include Zeller et al. (2012) for the current prospective bioenergy potential of cereal straw or Zeddies et al. (2012) for the 2015-2050 acreage potentials for energy crops. Second, Nitsch et al. (2004, “NaturschutzPlus” scenario) has been established as one of the bases for the German long-term scenarios for renewable energies (see Nitsch et al. 2012)<sup>8</sup> and the biomass potentials obtained by Fritsche et al. (2004a) are often used in other studies, such as the calculation of optimized recycling of organic wastes by Knappe et al. (2007).<sup>9</sup> Third, the selected “NaturschutzPlus” scenario from Nitsch et al. (2004) and the corresponding “Umwelt” scenario from Fritsche et al. (2004a) belong to the few scenarios that have been considered “realistic” and, thus, “acceptable” by SRU (2007) in their critical review of the biomass-for-bioenergy potentials provided by Fritsche et al. (2004a), Nitsch et al. (2004), Thrän et al. (2005) and EEA (2006).<sup>10</sup>

A critical quantitative assessment of the potentials of the single biomass residues for bioenergy obtained by Nitsch et al. (2004) and Fritsche et al. (2004a) in the specific scenarios, however, is difficult to perform – as would be the case for any other biomass study. This is mainly due to the general complexity of the assumptions necessary for this type of analysis combined with the frequent input of data from various external models, which are often only

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<sup>6</sup> The use of corn as reference crop for energy crops for biogas production follows Nitsch et al. (2012). This choice is in good accordance with current observations that corn accounts for nearly 90% of the acreage used for digestible energy crops (FNR 2012b).

<sup>7</sup> For example, detailed data for Germany are only available for the aggregated sectors agriculture, forestry, and waste, but not for specific feedstocks within these sectors (see EEA 2006).

<sup>8</sup> The long-term scenarios are among the studies that form the data base for the German government’s energy reform. The recent version of the long-term scenarios is provided by Nitsch et al. (2012).

<sup>9</sup> However, Knappe et al. (2007) use a different scenario from Fritsche et al. (2004a) than Teichmann (2014).

<sup>10</sup> The endorsement by SRU (2007) is based on the scenarios’ respect of environmental policies and objectives.

generally described.<sup>11</sup> Consequently, the derivation of the resulting biomass potentials can quickly become a black box. Given the challenges in understanding one study, a thorough comparison of the results obtained from different studies is not straightforward. Further difficulties for comparisons across studies arise from the use of different feedstock categories, different measurement units (e.g., dry mass, fresh weight, or energy contents),<sup>12</sup> the frequent lack of data to transform the values from one measurement unit into the other one (such as the feedstocks' water contents), and different understandings about the precise composition of the "technical" biomass potential (such as the degree of inclusion of ecological considerations). At least for the overall potentials of biomass residues for bioenergy, SRU (2007) has provided a comparison of the various scenarios from Fritsche et al. (2004a), Nitsch et al. (2004), Thrän et al. (2005) and EEA (2006). As can be seen from Figure 2-10 in SRU (2007), the total potential of biomass residues in the "NaturschutzPlus" scenario from Nitsch et al. (2004) ranges in between more conservative and more ambitious biomass potentials. This might also indicate that the potentials obtained for the single feedstocks reflect intermediate values.

While also difficult to evaluate, a comparison of the acreages for energy crops is easier to obtain. For example, Nitsch et al. (2004, "NaturschutzPlus" scenario) calculate with a total acreage of arable land for energy crops of 4.2 million ha in 2050. This value is well below the average acreage of about 5.7 million ha obtained when taking the mean over all the scenarios in Zeddies et al. (2012) that account for global food security.<sup>13</sup> Moreover, Thrän et al. (2005: Table 24) assume 4.2-5.6 million ha for energy crops already in 2020. According to the review by SRU (2007: Figure 2-12), Nitsch et al. (2004, "Naturschutzplus" scenario) arrive at the lowest potential acreage of arable land for energy crops also for 2030. Thus, while the acreage for corn used in Teichmann (2014) and derived in Table A.4 follows current trends, its derivation for later periods from the total acreage for energy crops calculated by Nitsch et al. (2004) might support the conclusion that it can be considered as a conservative value.

**Biomass potentials for biochar production.** Constructing a number of biomass scenarios (*Max 1*, *Med 1* and *Min 1* for the case when the digestible biomass residues are used in their undigested form and *Max 2*, *Med 2* and *Min 2* when they are used as digestates), Teichmann (2014: Table 4) presents possible percentage shares of the technical biomass potentials for bioenergy that could be diverted into biochar production.

The common starting point for the derivation of the scenarios for the solid and digestible biomass residues (i.e. not for the digestates) are the differences in (i) the energy potentials of the biomass residues available for bioenergy production in 2010-2050 given in Nitsch et al. (2004, "NaturschutzPlus" scenario) and updated for current developments and (ii) the 2010 amount of 500 PJ/a of biomass already used for bioenergy (Nitsch et al. 2012) and assumed constant over time. Considering these differences as the maximum amounts of biomass residues potentially available for biochar production and assuming further that these maximum potentials are spread evenly across all the respective feedstocks, Table A.6 calculates the upper bounds for the shares of the biomass potentials for bioenergy that might be available for biochar – both for the case when all the solid and digestible biomass residues are used directly for biochar production and for the case when only the solid biomass residues are used directly and the digestible biomass residues enter biochar production as digestates.<sup>14</sup>

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<sup>11</sup> In Fritsche et al. (2004a), for example, the cereal production used to calculate the potential of cereal straw is determined by the so-called HEKTOR model, which quantifies the acreage required for food crops in Germany.

<sup>12</sup> Sometimes, it is even not stated whether the data refer to fresh weights or dry weights.

<sup>13</sup> The respective acreages in Zeddies et al. (2012) range from 0.9-9.4 million ha.

<sup>14</sup> As detailed in Teichmann (2014), these upper bounds result in scenarios *Max 1* and *Max 2*, while the remaining scenarios assume that lower shares of the biomass potentials for bioenergy are used for biochar. For the assumed shares of digestates turned into biochar, see also Teichmann (2014).

**Table A.1: Biomass Potentials for Bioenergy – Biomass Residues: Solid Residues**

Feedstocks	Primary energy content <sup>#</sup>					Dry mass					Yield t <sub>DM</sub> /ha	LHV at (**) water content PJ/t	Water content (**) wt%	FW water content % FW
	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>b</sup>	2050 <sup>b</sup>	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>c</sup>	2050 <sup>c</sup>				
	PJ/a					kt <sub>DM</sub> /a								
<b>Cereal straw<sup>1</sup></b>	52.2	54.2	51.1	53.0	53.0	3,035 <sup>c</sup>	3,151 <sup>c</sup>	2,971 <sup>c</sup>	3,081	3,081	0.57 <sup>e</sup>	0.0000172 <sup>d</sup>	0 <sup>d</sup>	n.a.
<b>Forestry residues<sup>2</sup></b>	149.0 <sup>f</sup>	153.0 <sup>f</sup>	158.0 <sup>f</sup>	164.0	171.0	8,450	8,700	8,950	9,318 <sup>s</sup>	9,716 <sup>s</sup>	n.a.	0.0000186 <sup>a</sup>	0 <sup>a</sup>	30 <sup>a</sup>
<b>Additional forestry residues from historical-forest formation<sup>3</sup></b>		4.0 <sup>b</sup>	11.0 <sup>b</sup>	11.0	11.0		213 <sup>c</sup>	584 <sup>c</sup>	584	584	1.17 <sup>g</sup>	0.000016 <sup>b</sup>	15 <sup>b</sup>	n.a.
<b>Open-country biomass residues<sup>4</sup></b>	22.0 <sup>b</sup>	22.0 <sup>b</sup>	22.0 <sup>b</sup>	22.0	22.0	1,264 <sup>c</sup>	1,264 <sup>c</sup>	1,264 <sup>c</sup>	1,264	1,264	2.50 <sup>h</sup>	0.0000174 <sup>i</sup>	0 <sup>j</sup>	n.a.
<b>Industrial wood waste<sup>5</sup></b>	55.0	55.0	55.0	55.0	55.0	3,098 <sup>n</sup>	3,098 <sup>n</sup>	3,098 <sup>n</sup>	3,098 <sup>j</sup>	3,098 <sup>j</sup>	-	0.0000144 <sup>a</sup>	>15 <sup>a</sup>	n.a.
From sawmills	4.0	4.0	4.0	4.0 <sup>j</sup>	4.0 <sup>j</sup>	250 <sup>f</sup>	250 <sup>f</sup>	250 <sup>f</sup>	250 <sup>j</sup>	250 <sup>j</sup>	-	0.000008 <sup>a</sup>	50 <sup>a</sup>	50 <sup>a</sup>
From wood material industry	5.0	5.0	5.0	5.0 <sup>j</sup>	5.0 <sup>j</sup>	298 <sup>f</sup>	298 <sup>f</sup>	298 <sup>f</sup>	298 <sup>j</sup>	298 <sup>j</sup>	-	0.0000153 <sup>a</sup>	15 <sup>a</sup>	15 <sup>a</sup>
From forest and furniture industry	46.0	46.0	46.0	46.0 <sup>j</sup>	46.0 <sup>j</sup>	2,550 <sup>f</sup>	2,550 <sup>f</sup>	2,550 <sup>f</sup>	2,550 <sup>j</sup>	2,550 <sup>j</sup>	-	0.0000153 <sup>a</sup>	15 <sup>a</sup>	15 <sup>a</sup>
<b>Wood in municipal solid waste<sup>6</sup></b>	20.7	20.3	19.6	20.0	20.0	1,294 <sup>c</sup>	1,269 <sup>c</sup>	1,225 <sup>c</sup>	1,250	1,250	-	0.000008 <sup>i</sup>	50 <sup>u</sup>	n.a.
<b>Green waste: Compensation areas<sup>7</sup></b>	0 <sup>*</sup>	8.0 <sup>b</sup>	8.0 <sup>b</sup>	8.0	8.0	0 <sup>*</sup>	570 <sup>n</sup>	570 <sup>n</sup>	570 <sup>n</sup>	570 <sup>n</sup>	6.00 <sup>b</sup>	0.000014 <sup>b</sup>	0 <sup>d</sup>	n.a.
Arable land	0 <sup>*</sup>	4.3 <sup>m</sup>	4.3 <sup>m</sup>	4.3 <sup>m</sup>	4.3 <sup>m</sup>	0 <sup>*</sup>	306 <sup>k</sup>	306 <sup>k</sup>	306 <sup>k</sup>	306 <sup>k</sup>	6.00 <sup>b</sup>	0.000014 <sup>b</sup>	0 <sup>d</sup>	n.a.
Grassland	0 <sup>*</sup>	3.7 <sup>m</sup>	3.7 <sup>m</sup>	3.7 <sup>m</sup>	3.7 <sup>m</sup>	0 <sup>*</sup>	264 <sup>l</sup>	264 <sup>l</sup>	264 <sup>l</sup>	264 <sup>l</sup>	6.00 <sup>b</sup>	0.000014 <sup>b</sup>	0 <sup>d</sup>	n.a.
<b>Biomass: Habitat-connectivity areas<sup>8</sup></b>	0 <sup>*</sup>	7.3 <sup>*</sup>	18.0 <sup>b</sup>	18.0	18.0	0 <sup>*</sup>	459 <sup>*</sup>	1,100 <sup>n</sup>	1,100 <sup>n</sup>	1,100 <sup>n</sup>	2.00 <sup>b</sup>	0.000016 <sup>b</sup>	0 <sup>b</sup>	n.a.
Woody biomass	0 <sup>*</sup>	2.2 <sup>*</sup>	5.3 <sup>m</sup>	5.3 <sup>m</sup>	5.3 <sup>m</sup>	0 <sup>*</sup>	137 <sup>*</sup>	330 <sup>o</sup>	330 <sup>o</sup>	330 <sup>o</sup>	1.00 <sup>b</sup>	0.000016 <sup>b</sup>	0 <sup>b</sup>	n.a.
Herbaceous biomass	0 <sup>*</sup>	5.1 <sup>*</sup>	12.3 <sup>m</sup>	12.3 <sup>m</sup>	12.3 <sup>m</sup>	0 <sup>*</sup>	322 <sup>*</sup>	770 <sup>o</sup>	770 <sup>o</sup>	770 <sup>o</sup>	3.50 <sup>b</sup>	0.000016 <sup>b</sup>	0 <sup>b</sup>	n.a.
<b>Green waste: Extensive grassland<sup>9</sup></b>	0 <sup>*</sup>	11.6	26.8	26.8	26.8	0 <sup>*</sup>	710	1,630	1,630 <sup>j</sup>	1,630 <sup>j</sup>	3.00 <sup>b</sup>	0.0000165 <sup>b</sup>	0 <sup>b</sup>	n.a.
<b>Short-rotation coppice: Erosion areas<sup>10</sup></b>	0 <sup>*</sup>	0 <sup>*</sup>	94.0 <sup>b</sup>	94.0	94.0	0 <sup>*</sup>	0 <sup>*</sup>	5,500 <sup>p</sup>	5,500 <sup>p</sup>	5,500 <sup>p</sup>	10.00 <sup>b</sup>	0.000017 <sup>b</sup>	0 <sup>q</sup>	n.a.
<b>Solid biomass residues</b>	298.9	335.4	463.5	471.8	478.8	17,141	19,434	26,892	27,395	27,793	-	-	-	-

Values rounded. # = Note that the 2010-2030 values originating from Fritsche et al. (2004a, “Umwelt” scenario) and indicated by a) are part of the “NaturschutzPlus” scenario by Nitsch et al. (2004), who have extended these data to the 2040-2050 period (see b)). That is, for example, the entire 2010-2050 time series for cereal straw in PJ/a is found like this in Nitsch et al. (2004, “NaturschutzPlus” scenario), whereby the 2010-2030 data have been contributed by Fritsche et al. (2004a, “Umwelt” scenario) and the 2040-2050 values by Nitsch et al. (2004, “NaturschutzPlus” scenario). For the ease of illustration, the table gives only the original sources of the data. For an explanation of the time-series patterns of the biomass potentials of the single feedstocks, refer to Fritsche et al. (2004a, “Umwelt” scenario) and Nitsch et al. (2004, “NaturschutzPlus” scenario).

Sources:

- Fritsche et al. (2004a, “Umwelt” scenario).
- Nitsch et al. (2004, “NaturschutzPlus” scenario).
- Own calculation, based on the corresponding primary energy content, LHV and (\*\*) water content.
- Fritsche et al. (2004b).
- Own calculation, based on nearly 6 million ha for cereal production and a primary energy content of 58.8 PJ/a in 2000 (Fritsche et al. 2004a, “Umwelt” scenario) and the corresponding LHV, i.e. the yield refers to the residual straw only.
- Own calculation, based on 500,000 t<sub>FW</sub>/a, 350,000 t<sub>FW</sub>/a and 3,000,000 t<sub>FW</sub>/a for industrial wood waste from sawmills, the wood material industry and the forest and furniture industry, respectively (Fritsche et al. 2004a), and the corresponding FW water content.

- g) Own calculation, based on 500,000 ha historical-forest formation (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the dry-mass values in 2030-2050; due to the initiation phase of the historical forest, there is a lower yield in 2020 (see Nitsch et al. 2004).
- h) Own calculation, based on 500,000 ha open country (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the dry-mass values.
- i) Value for waste from landscape conservation from Hartmann and Kaltschmitt (2002).
- j) Own extrapolation, based on the corresponding 2040 and 2050 (total) primary energy contents.
- k) Own calculation, based on 34,000 ha in 2010 and 51,000 ha in the other years (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the corresponding yield value.
- l) Own calculation, based on 29,000 ha in 2010 and 44,000 ha in the other years (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the corresponding yield value.
- m) Own calculation, based on the corresponding dry mass, LHV and (\*\*) water content.
- n) Own calculation, summing up all dry-mass values of the corresponding subcategories.
- o) Own calculation, based on 330,000 ha (220,000 ha) for woody biomass (herbaceous biomass) (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the corresponding yield value.
- p) Own calculation, based on 550,000 ha (Nitsch et al. 2004, “NaturschutzPlus” scenario) and the corresponding yield value.
- q) Deducted from Hartmann and Kaltschmitt (2002), based on the yield value.
- r) The primary energy content was calculated by Fritsche et al. (2004a) for the LHV of 0.0000176 PJ/t<sub>DM</sub> (at a water content of 30%).
- s) Own calculation, based on the corresponding primary energy content and the LHV of 0.0000176 PJ/t<sub>DM</sub> used by Fritsche et al. (2004a).
- t) Own calculation, based on the primary energy contents and the FW values of 2,610,600 t<sub>FW/a</sub> (2010), 2,569,200 t<sub>FW/a</sub> (2020) and 2,477,400 t<sub>FW/a</sub> (2030) derived from Fritsche et al. (2004a, “Umwelt” scenario); corresponding to the LHV of industrial wood waste from sawmills.
- u) As for industrial wood waste from sawmills.

*Notes:*

- 1) Cereal straw only (wheat, rye, other cereals), i.e. no corn or oil-seed rape straw; approximately 12% of total cereal straw, i.e. after deducting the cereal straw used as soil additive and bedding under the assumption that 80% of the straw remains on the field – either directly as soil additive or in the form of (digested) manure after its use as bedding, whereby only 70% of the straw in the manure is returned to the fields (Fritsche et al. 2004a, “Umwelt” scenario).
- 2) Logging residues (from <100% logging of raw wood) and smallwood from the four main tree types oak, beech, spruce and pine; including only the wood that is excluded from any type of material use (Fritsche et al. 2004a, “Umwelt” scenario).
- 3) Formation of historical forms of forest use (intermediate forest and coppice) on 500,000 ha forest area, based on hardwood (beech) (Nitsch et al. 2004, “NaturschutzPlus” scenario).
- 4) Woody biomass and green waste from the trimming of shrubberies and reeds on 500,000 ha (Nitsch et al. 2004, “NaturschutzPlus” scenario).
- 5) Industrial wood waste from the wood industry (Fritsche et al. 2004a); wood waste from sawmills is considered fresh and including bark (Fritsche et al. 2004a).
- 6) Woody components (60%, e.g. branches) of municipal garden and park waste (Fritsche et al. 2004a, “Umwelt” scenario).
- 7) Green waste from arable land (34,000 ha in 2010 and 51,000 ha in 2020-2050) and biomass from the extensive use of grassland (29,000 ha in 2010 and 44,000 ha in 2020-2050), where the acreages of arable land and extensive grassland are used for compensation measures (Nitsch et al. 2004, “NaturschutzPlus” scenario).
- 8) Development of habitat-connectivity areas (770,000 ha) on arable land with the use of woody biomass and herbaceous biomass (green waste) on 330,000 ha and 220,000 ha, respectively (Nitsch et al. 2004, “NaturschutzPlus” scenario).
- 9) Biomass from the extensive use of 120,000 ha (2010), 240,000 ha (2020) and 540,000 ha (2030-2050) of permanent grassland, including habitat-connectivity areas (330,000 ha in 2030-2050) (Nitsch et al. 2004, “NaturschutzPlus” scenario), i.e. woody and herbaceous biomass.
- 10) Perennial energy crops on 550,000 ha erosion area; values are based on short-rotation coppice (Nitsch et al. 2004, “NaturschutzPlus” scenario), referring to willow and poplar as in Hartmann and Kaltschmitt (2002).

\* Other than in Nitsch et al. (2004, “NaturschutzPlus” scenario) and Fritsche et al. (2004a, “Umwelt” scenario), no or a reduced biomass potential is assumed here. This is due to the 2010 and 2020 differences in the total acreage used for energy crops between Nitsch et al. (2004, “NaturschutzPlus” scenario) (0.15 million ha in 2010 and 1.1 million ha in 2020) and the values used in this study (Table A.4) (2.1 million ha in both 2010 and 2020). The corresponding reductions of 1.95 million ha in 2010 and 1.0 million ha in 2020 were made in the acreage used for nature conservation and compensation areas. Thereby, the elimination of the short-rotation coppice on the erosion areas is in line with the current observations of a tiny production of short-rotation coppice (FNR 2012a), which is, above all, already accounted for in the acreage of energy crops (see Table A.4). Moreover, it should be noted that the total habitat-connectivity area in Nitsch et al. (2004, “NaturschutzPlus” scenario) is 770,000 ha, while only 550,000 ha are used for biomass provision. Thus, the adjustments for this category were based on the 770,000 ha. First deducting the 550,000 ha erosion areas cultivated with short-rotation coppice, leaves 450,000 ha to be deducted from the habitat-connectivity areas in 2020. In other words, 320,000 ha (770,000 ha – 450,000 ha) could stay with the habitat-connectivity areas in 2020. Based on the split of 28.6%, 42.8% and 28.6% (Nitsch et al. 2004, “NaturschutzPlus” scenario) between habitat-connectivity areas not to be used for biomass provision, usable for woody biomass and usable for herbaceous biomass, respectively, about 137,000 ha (92,000 ha) can still be used for woody (herbaceous) biomass in 2020. In 2010, however, the acreage could only be reduced by approximately 1.5 million ha, meaning that the remaining acreage for energy crops has to be taken from the acreage for food production. Finally, note that no adjustments were made for 2030 since Nitsch et al. (2004, “NaturschutzPlus” scenario) assumed 2.0 million ha in 2030, i.e. approximately the acreage of 2.1 million ha used here (Table A.4).

**Table A.2: Biomass Potentials for Bioenergy – Biomass Residues: Digestible Residues (Initial Feedstocks)**

Feedstocks	Energy content of biogas <sup>#</sup>					Initial feedstocks: Dry mass (Initial feedstocks: Organic dry mass)					Biogas yield  m <sup>3</sup> /t <sub>oDM</sub> [m <sup>3</sup> /t <sub>FW</sub> ]	oDM content  % DM	DM content  % FW
	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>b</sup>	2050 <sup>b</sup>	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>c</sup>	2050 <sup>c</sup>			
	PJ/a (at a biogas heating value of 21.6 MJ/m <sup>3</sup> ) <sup>a</sup>					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)							
<b>Sewage sludge</b>	<b>6.1<sup>i</sup></b>	<b>7.1<sup>i</sup></b>	<b>7.6<sup>i</sup></b>	<b>7.6<sup>i</sup></b>	<b>7.6<sup>i</sup></b>	<b>819<sup>i</sup></b> <b>(574<sup>i</sup>)</b>	<b>921<sup>i</sup></b> <b>(646<sup>i</sup>)</b>	<b>965<sup>i</sup></b> <b>(676<sup>i</sup>)</b>	<b>965<sup>i</sup></b> <b>(676<sup>i</sup>)</b>	<b>965<sup>i</sup></b> <b>(676<sup>i</sup>)</b>	400-500 <sup>a</sup>	n.a.	n.a.
Municipal sewage sludge <sup>1</sup>	5.0 <sup>j</sup>	6.0 <sup>j</sup>	6.5 <sup>i</sup>	6.5 <sup>e</sup>	6.5 <sup>e</sup>	663 <sup>d</sup> (464 <sup>f</sup> )	765 <sup>d</sup> (536 <sup>f</sup> )	809 <sup>d</sup> (566 <sup>f</sup> )	809 <sup>e</sup> (566 <sup>f</sup> )	809 <sup>e</sup> (566 <sup>f</sup> )	500 <sup>a</sup>	70 <sup>a</sup>	n.a.
Industrial sewage sludge <sup>2</sup>	1.1	1.1	1.1	1.1 <sup>h</sup>	1.1 <sup>h</sup>	156 <sup>g</sup> (110 <sup>f</sup> )	156 <sup>g</sup> (110 <sup>f</sup> )	156 <sup>g</sup> (110 <sup>f</sup> )	156 <sup>h</sup> (110 <sup>f</sup> )	156 <sup>h</sup> (110 <sup>f</sup> )	400-500 <sup>a</sup>	n.a.	n.a.
<b>Solid manure<sup>3</sup></b>	<b>28.6<sup>i</sup></b>	<b>29.4<sup>i</sup></b>	<b>29.2<sup>i</sup></b>	<b>29.6<sup>o</sup></b>	<b>29.6<sup>o</sup></b>	<b>6,783<sup>i</sup></b> <b>(5,393<sup>i</sup>)</b>	<b>6,931<sup>i</sup></b> <b>(5,507<sup>i</sup>)</b>	<b>6,843<sup>i</sup></b> <b>(5,433<sup>i</sup>)</b>	<b>6,947<sup>i</sup></b> <b>(5,517<sup>i</sup>)</b>	<b>6,947<sup>i</sup></b> <b>(5,517<sup>i</sup>)</b>	n.a.	n.a.	n.a.
Cattle	17.5 <sup>m</sup>	17.8 <sup>m</sup>	17.5 <sup>m</sup>	17.8 <sup>p</sup>	17.8 <sup>p</sup>	4,776 <sup>u</sup> (3,821 <sup>v</sup> )	4,845 <sup>u</sup> (3,876 <sup>v</sup> )	4,753 <sup>u</sup> (3,802 <sup>v</sup> )	4,837 <sup>u</sup> (3,870 <sup>v</sup> )	4,837 <sup>u</sup> (3,870 <sup>v</sup> )	[42.5 <sup>u</sup> ] (dairy)	80 <sup>t</sup>	25 <sup>t</sup>
Swine	6.3 <sup>k</sup>	6.3 <sup>k</sup>	6.1 <sup>k</sup>	6.2 <sup>p</sup>	6.2 <sup>p</sup>	1,322 <sup>u</sup> (1,058 <sup>v</sup> )	1,329 <sup>u</sup> (1,063 <sup>v</sup> )	1,276 <sup>u</sup> (1,021 <sup>v</sup> )	1,296 <sup>u</sup> (1,037 <sup>v</sup> )	1,296 <sup>u</sup> (1,037 <sup>v</sup> )	[55.0 <sup>u</sup> ]	as for cattle	as for cattle
Poultry	4.8	5.3	5.7	5.7 <sup>p</sup>	5.7 <sup>p</sup>	685 <sup>u</sup> (514 <sup>v</sup> )	757 <sup>u</sup> (568 <sup>v</sup> )	814 <sup>u</sup> (610 <sup>v</sup> )	814 <sup>u</sup> (610 <sup>v</sup> )	814 <sup>u</sup> (610 <sup>v</sup> )	[129.7 <sup>u</sup> ]	75 <sup>t</sup>	40 <sup>t</sup>
<b>Liquid manure<sup>4</sup></b>	<b>58.1<sup>i</sup></b>	<b>58.8<sup>i</sup></b>	<b>57.4<sup>i</sup></b>	<b>58.4<sup>o</sup></b>	<b>58.4<sup>o</sup></b>	<b>9,059<sup>i</sup></b> <b>(7,322<sup>i</sup>)</b>	<b>9,175<sup>i</sup></b> <b>(7,416<sup>i</sup>)</b>	<b>8,967<sup>i</sup></b> <b>(7,248<sup>i</sup>)</b>	<b>9,123<sup>i</sup></b> <b>(7,374<sup>i</sup>)</b>	<b>9,123<sup>i</sup></b> <b>(7,374<sup>i</sup>)</b>	n.a.	n.a.	n.a.
Cattle	44.4 <sup>n</sup>	45.0 <sup>n</sup>	44.1 <sup>n</sup>	44.9 <sup>p</sup>	44.9 <sup>p</sup>	7,458 <sup>r</sup> (6,041 <sup>s</sup> )	7,566 <sup>r</sup> (6,129 <sup>s</sup> )	7,422 <sup>r</sup> (6,012 <sup>s</sup> )	7,554 <sup>r</sup> (6,119)	7,554 <sup>r</sup> (6,119)	340 <sup>q</sup>	81 <sup>q</sup>	9 <sup>q</sup>
Swine	13.7 <sup>l</sup>	13.8 <sup>l</sup>	13.2 <sup>l</sup>	13.4 <sup>p</sup>	13.4 <sup>p</sup>	1,601 <sup>u</sup> (1,281 <sup>v</sup> )	1,609 <sup>u</sup> (1,287 <sup>v</sup> )	1,545 <sup>u</sup> (1,236 <sup>v</sup> )	1,569 <sup>u</sup> (1,255 <sup>v</sup> )	1,569 <sup>u</sup> (1,255 <sup>v</sup> )	[23.8 <sup>u</sup> ]	80 <sup>t</sup>	6 <sup>t</sup>
<b>Sugar-beet leaf and potato haulm<sup>5</sup></b>	<b>8.5</b>	<b>8.5</b>	<b>8.3</b>	<b>8.3</b>	<b>8.3</b>	<b>902<sup>i</sup></b> <b>(699<sup>i</sup>)</b>	<b>902<sup>i</sup></b> <b>(699<sup>i</sup>)</b>	<b>884<sup>i</sup></b> <b>(685<sup>i</sup>)</b>	<b>884<sup>i</sup></b> <b>(685<sup>i</sup>)</b>	<b>884<sup>i</sup></b> <b>(685<sup>i</sup>)</b>	n.a.	n.a.	n.a.
Sugar-beet leaf	5.65	5.68	5.60	5.60 <sup>s</sup>	5.60 <sup>s</sup>	711 <sup>r</sup> (551 <sup>s</sup> )	714 <sup>r</sup> (554 <sup>s</sup> )	704 <sup>r</sup> (546 <sup>s</sup> )	704 <sup>r</sup> (546)	704 <sup>r</sup> (546)	475 <sup>a</sup>	77.5 <sup>w</sup>	17.5 <sup>w</sup>
Potato haulm	2.85	2.80	2.68	2.68 <sup>s</sup>	2.68 <sup>s</sup>	191 <sup>r</sup> (148 <sup>s</sup> )	188 <sup>r</sup> (146 <sup>s</sup> )	180 <sup>r</sup> (139 <sup>s</sup> )	180 <sup>r</sup> (139)	180 <sup>r</sup> (139)	890 <sup>a</sup>	77.5 <sup>w</sup>	17.5 <sup>w</sup>

Table will be continued on the next page.



**Table A.2 continued**

Feedstocks	Energy content of biogas <sup>#</sup>					Initial feedstocks: Dry mass (Initial feedstocks: Organic dry mass)					Biogas yield	oDM content	DM content
	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>b</sup>	2050 <sup>b</sup>	2010 <sup>a</sup>	2020 <sup>a</sup>	2030 <sup>a</sup>	2040 <sup>c</sup>	2050 <sup>c</sup>			
	PJ/a (at a biogas heating value of 21.6 MJ/m <sup>3</sup> ) <sup>a</sup>					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)					m <sup>3</sup> /t <sub>oDM</sub>	% DM	% FW
<b>Commercial and industrial waste<sup>6</sup></b>	<b>6.2</b>	<b>6.2</b>	<b>6.2</b>	<b>6.2</b>	<b>6.2</b>	<b>595<sup>i</sup></b> <b>(520)</b>	<b>595<sup>i</sup></b> <b>(520)</b>	<b>595<sup>i</sup></b> <b>(520)</b>	<b>595<sup>i</sup></b> <b>(520<sup>b</sup>)</b>	<b>595<sup>i</sup></b> <b>(520<sup>b</sup>)</b>	n.a.	n.a.	n.a.
Beer production <sup>7</sup>	1.6	1.6	1.6	1.6 <sup>s</sup>	1.6 <sup>s</sup>	125 <sup>t</sup> (100)	125 <sup>t</sup> (100)	125 <sup>t</sup> (100)	125 <sup>t</sup> (100 <sup>b</sup> )	125 <sup>t</sup> (100 <sup>b</sup> )	510 <sup>q</sup> (brewer's grains)	80 <sup>q</sup> (brewer's grains)	21.5 <sup>q</sup> (brewer's grains)
Fruit press houses <sup>8</sup>	1.2	1.2	1.2	1.2 <sup>s</sup>	1.2 <sup>s</sup>	97 <sup>t</sup> (85)	97 <sup>t</sup> (85)	97 <sup>t</sup> (85)	97 <sup>t</sup> (85 <sup>b</sup> )	97 <sup>t</sup> (85 <sup>b</sup> )	n.a.	88 <sup>t</sup> (apple pomace)	35 <sup>t</sup> (apple pomace)
Wine press houses <sup>9</sup>	0.2	0.2	0.2	0.2 <sup>s</sup>	0.2 <sup>s</sup>	14 <sup>t</sup> (12)	14 <sup>t</sup> (12)	14 <sup>t</sup> (12)	14 <sup>t</sup> (12 <sup>b</sup> )	14 <sup>t</sup> (12 <sup>b</sup> )	n.a.	85 <sup>t</sup>	45 <sup>t</sup>
Distilleries <sup>10</sup>	0.5	0.5	0.5	0.5 <sup>s</sup>	0.5 <sup>s</sup>	43 <sup>t</sup> (40)	43 <sup>t</sup> (40)	43 <sup>t</sup> (40)	43 <sup>t</sup> (40 <sup>b</sup> )	43 <sup>t</sup> (40 <sup>b</sup> )	n.a.	94 <sup>t</sup> (distillers grain)	6 <sup>t</sup> (distillers grain)
Dairy-processing industry <sup>11</sup>	0.6	0.6	0.6	0.6 <sup>s</sup>	0.6 <sup>s</sup>	105 <sup>t</sup> (90)	105 <sup>t</sup> (90)	105 <sup>t</sup> (90)	105 <sup>t</sup> (90 <sup>b</sup> )	105 <sup>t</sup> (90 <sup>b</sup> )	570 <sup>q</sup>	86 <sup>q</sup>	5.5 <sup>q</sup>
Sugar manufacture	2.1	2.1	2.1	2.1 <sup>s</sup>	2.1 <sup>s</sup>	211 <sup>i</sup> (195)	211 <sup>i</sup> (195)	211 <sup>i</sup> (195)	211 <sup>i</sup> (195 <sup>b</sup> )	211 <sup>i</sup> (195 <sup>b</sup> )	n.a.	n.a.	n.a.
Beet slices	n.a.	n.a.	n.a.	n.a.	n.a.	126 <sup>t</sup> (120)	126 <sup>t</sup> (120)	126 <sup>t</sup> (120)	126 <sup>t</sup> (120 <sup>b</sup> )	126 <sup>t</sup> (120 <sup>b</sup> )	n.a.	95 <sup>t</sup>	24 <sup>t</sup>
Molasses	n.a.	n.a.	n.a.	n.a.	n.a.	85 <sup>t</sup> (75)	85 <sup>t</sup> (75)	85 <sup>t</sup> (75)	85 <sup>t</sup> (75 <sup>b</sup> )	85 <sup>t</sup> (75 <sup>b</sup> )	n.a.	88 <sup>t</sup>	85 <sup>t</sup>
<b>Organic municipal solid waste</b>	<b>15.5</b>	<b>17.8</b>	<b>18.6</b>	<b>20.0</b>	<b>21.0</b>	<b>1,913<sup>t</sup></b> <b>(1,435<sup>c</sup>)</b>	<b>2,197<sup>t</sup></b> <b>(1,648<sup>c</sup>)</b>	<b>2,296<sup>t</sup></b> <b>(1,723<sup>c</sup>)</b>	<b>2,469<sup>t</sup></b> <b>(1,852)</b>	<b>2,592<sup>t</sup></b> <b>(1,944)</b>	500 <sup>x</sup>	75 <sup>x</sup>	n.a.
Biowaste <sup>12</sup>	11.6 <sup>y</sup>	13.4 <sup>y</sup>	14.0 <sup>y</sup>	15.0 <sup>y</sup>	15.8 <sup>y</sup>	1,435 <sup>t</sup> (1,076 <sup>c</sup> )	1,648 <sup>t</sup> (1,236 <sup>c</sup> )	1,722 <sup>t</sup> (1,292 <sup>c</sup> )	1,852 <sup>t</sup> (1,389)	1,944 <sup>t</sup> (1,458)	500 <sup>x</sup>	75 <sup>x</sup>	n.a.
Municipal garden and park waste <sup>13</sup>	3.9 <sup>y</sup>	4.5 <sup>y</sup>	4.7 <sup>y</sup>	5.0 <sup>y</sup>	5.3 <sup>y</sup>	478 <sup>t</sup> (359 <sup>c</sup> )	549 <sup>t</sup> (412 <sup>c</sup> )	574 <sup>t</sup> (431 <sup>c</sup> )	617 <sup>t</sup> (463)	648 <sup>t</sup> (486)	500 <sup>x</sup>	75 <sup>x</sup>	n.a.
<b>Digestible biomass residues</b>	<b>123.0</b>	<b>127.8</b>	<b>127.3</b>	<b>130.1</b>	<b>131.1</b>	<b>20,071</b>	<b>20,721</b>	<b>20,550</b>	<b>20,983</b>	<b>21,106</b>	-	-	-

Values rounded. # = Note that the 2010-2030 values originating from Fritsche et al. (2004a, "Umwelt" scenario) and indicated by a) are part of the "NaturschutzPlus" scenario by Nitsch et al. (2004), who have extended these data to the 2040-2050 period (see b)). That is, for example, the entire 2010-2050 time series for organic municipal solid waste in PJ/a is found like this in Nitsch et al. (2004, "NaturschutzPlus" scenario), whereby the 2010-2030 data have been contributed by Fritsche et al. (2004a, "Umwelt" scenario) and the 2040-2050 values by Nitsch et al. (2004, "NaturschutzPlus" scenario). For the ease of illustration, the table gives only the original sources of the data. For an explanation of the time-series patterns of the biomass potentials of the single feedstocks, refer to Fritsche et al. (2004a, "Umwelt" scenario) and Nitsch et al. (2004, "NaturschutzPlus" scenario).

*Sources:*

- a) Fritsche et al. (2004a, “Umwelt” scenario).
- b) Nitsch et al. (2004, “NaturschutzPlus” scenario).
- c) Own calculation, based on the corresponding biogas energy potential, biogas heating value and biogas yield.
- d) Own calculation, based on the total available municipal sewage sludge of 2.65 (2.55, 2.45) Mt<sub>DM/a</sub> in 2010 (2020, 2030) (Fritsche et al. 2004a: Figure 32, average value) and the corresponding share of 25% (30%, 33%) in 2010 (2020, 2030) that is digested and composted (Fritsche et al. 2004a: Figure 33).
- e) Extrapolation of the 2030 value, deviating from Nitsch et al. (2004, “NaturschutzPlus” scenario) who assume that a slightly higher share of the municipal sewage sludge is used as a solid fuel after digestion and, thus, a lower share is left for composting after digestion.
- f) Own calculation, based on 70% of organic dry mass in total dry mass (Fritsche et al. 2004a).
- g) Own calculation, based on 2/3 of the 47,000 t<sub>DM/a</sub> of sewage sludge from the food and tobacco industries and 1/3 of the 375,000 t<sub>DM/a</sub> of sewage sludge from the paper, publishing and printing industry (Fritsche et al. 2004a).
- h) Extrapolation of the 2030 value, based on the constancy of the energy contents of both biogas from industrial sewage sludge (Fritsche et al. 2004a) and biogas from total industrial and municipal sewage sludge (Nitsch et al. 2004, “NaturschutzPlus” scenario).
- i) Own calculation, summing up the respective values of the corresponding subcategories.
- j) Fritsche et al. (2004a, reference scenario), i.e. referring to the uncontaminated share of municipal sewage sludge.
- k) 31.42% of the energy content of 20.0 PJ/a (2010), 20.1 PJ/a (2020) and 19.3 PJ/a (2030), respectively (Fritsche et al. 2004a, “Umwelt” scenario), where the 31.42% are derived from the biogas potentials from liquid manure and solid manure in 2000 as given in Fritsche et al. (2004a: Table 46).
- l) 68.58% of the energy content of 20.0 PJ/a (2010), 20.1 PJ/a (2020) and 19.3 PJ/a (2030), respectively (Fritsche et al. 2004a, “Umwelt” scenario), where the 68.58% are derived from the biogas potentials from liquid manure and solid manure in 2000 as given in Fritsche et al. (2004a: Table 46).
- m) 28.33% of the energy content of 20.0 PJ/a (2010), 20.1 PJ/a (2020) and 19.3 PJ/a (2030), respectively (Fritsche et al. 2004a, “Umwelt” scenario), where the 28.33% are derived from the biogas potentials from liquid manure and solid manure in 2000 as given in Fritsche et al. (2004a: Table 46).
- n) 71.67% of the energy content of 20.0 PJ/a (2010), 20.1 PJ/a (2020) and 19.3 PJ/a (2030), respectively (Fritsche et al. 2004a, “Umwelt” scenario), where the 71.67% are derived from the biogas potentials from liquid manure and solid manure in 2000 as given in Fritsche et al. (2004a: Table 46).
- o) Splitting up the total energy potential of 88 PJ/a of biogas from liquid manure and solid manure for 2040 and 2050 (Nitsch et al. 2004, “NaturschutzPlus” scenario), based on the respective contributions of solid manure (34%) and liquid manure (66%) to the total energy potential of 86.5 PJ/a of biogas from liquid manure and solid manure in 2030 as given in Fritsche et al. (2004a, “Umwelt” scenario).
- p) Own calculation, based on the contributions of cattle (61.6 PJ/a or 71.2%), swine (19.3 PJ/a or 22.3%) and poultry (5.7 PJ/a or 6.5%) to the total energy potential of 86.5 PJ/a of biogas from liquid manure and solid manure in 2030 (Fritsche et al. (2004a, “Umwelt” scenario) and the percentage contributions of solid manure and liquid manure for cattle (28.33%, 71.67%) and swine (31.42%, 68.58%) as derived from the biogas potentials from liquid manure and solid manure in 2000 given in Fritsche et al. (2004a: Table 46).
- q) Wilfert et al. (2004: Table 7-8).
- r) Own calculation, based on the corresponding organic dry mass and the oDM content.
- s) Own extrapolation, based on the corresponding 2040 and 2050 (total) biogas energy contents.
- t) FNR (2010: Table 4.9).
- u) Own calculation, based on the corresponding biogas energy potential, biogas heating value, biogas yield, and DM content.
- v) Own calculation, based on the dry-mass value and oDM content.
- w) Koch (2009).
- x) Koch (2009), based on biowaste and food waste.
- y) 75% (25%) of the total energy content for biowaste (municipal garden and park waste), based on the relation of the FW masses of 5,172,000 t/a (2010), 5,656,000 t/a (2020) and 5,531,000 t/a (2030) for biowaste and 1,740,400 t/a (2010), 1,712,800 t/a (2020) and 1,651,600 t/a (2030) for municipal garden and park waste, where the FW values for municipal garden and park waste refer to 40% of 4,351,000 t/a (2010), 4,282,000 t/a (2020) and 4,129,000 t/a (2030) (Fritsche et al. 2004a, “Umwelt” scenario).

*Notes:*

- 1) Uncontaminated municipal sewage sludge considered suitable for digestion and subsequent composting (Fritsche et al. 2004a).
- 2) Uncontaminated (biologically treated) industrial sewage sludge from the food and tobacco industries and the paper, publishing and printing industry considered suitable for digestion and subsequent material use, i.e. 2/3 (22,000 t<sub>DM/a</sub>) of the total sewage sludge from the food and tobacco industries (47,000 t<sub>DM/a</sub> or 32,900 t<sub>DM/a</sub>) and 1/3 (87,500 t<sub>DM/a</sub>) of the total sewage sludge from the paper, publishing and printing industry (375,000 t<sub>DM/a</sub> or 262,500 t<sub>DM/a</sub>) (Fritsche et al. 2004a).
- 3) Solid manure from large livestock populations kept in stables (cattle, swine, fattened chicken and turkeys as well as laying hens) (Fritsche et al. 2004a, “Umwelt” scenario).
- 4) Liquid manure from large livestock populations kept in stables (cattle, swine, fattened chicken and turkeys as well as laying hens) (Fritsche et al. 2004a, “Umwelt” scenario).
- 5) Sugar-beet leaf from 25% of the acreage used for sugar beet and potato haulm from 33% of the acreage used for potatoes (Fritsche et al. 2004a, “Umwelt” scenario).

- 6) Other than Fritsche et al. (2004a) without slaughterhouse waste and waste from meat processing due to the lack of data to calculate the dry-mass values; the deletion has only a minor impact since the contribution of slaughterhouse waste and waste from meat processing is only 20 kt<sub>oDM</sub>/a (Fritsche et al. 2004a, "Umwelt" scenario).
- 7) 75% brewer's grains and 25% yeast, tank bottoms and lees (Fritsche et al. 2004a, "Umwelt" scenario).
- 8) Leftovers from cleaning and pomace (Fritsche et al. 2004a, "Umwelt" scenario).
- 9) Marc (Fritsche et al. 2004a, "Umwelt" scenario).
- 10) Distillers grain (Fritsche et al. 2004a, "Umwelt" scenario).
- 11) Whey (Fritsche et al. 2004a, "Umwelt" scenario).
- 12) Separately collected biowaste (organic-waste collection bin) and bio- and green waste (50% kitchen waste, 50% garden waste) in remaining household waste, bulky waste and commercial waste similar to household waste, whereby the bio- and green waste is assumed to be separately collected in the future; excluding biomass for composting by households or direct mulching (Fritsche et al. 2004a, "Umwelt" scenario).
- 13) Herbaceous components (40%) of municipal garden and park waste, including foliage, green waste and waste from landscape conservation (Fritsche et al. 2004a, "Umwelt" scenario).

**Table A.3: Biomass Potentials for Bioenergy – Biomass Residues: Digestible Residues (Digestates)**

Feedstocks*	Biogas <sup>a</sup>					Digestates: Dry mass <sup>b</sup> (Digestates: Organic dry mass) <sup>c</sup>				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
	t <sub>DM</sub> /a					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)				
<b>Sewage sludge</b>	<b>296,528</b>	<b>345,139</b>	<b>369,444</b>	<b>369,444</b>	<b>369,444</b>	<b>522</b> <b>(277)</b>	<b>576</b> <b>(300)</b>	<b>595</b> <b>(306)</b>	<b>595</b> <b>(306)</b>	<b>595</b> <b>(306)</b>
Municipal sewage sludge	243,056	291,667	315,972	315,972	315,972	419 (221)	473 (244)	493 (250)	493 (250)	493 (250)
Industrial sewage sludge	53,472	53,472	53,472	53,472	53,472	103 (56)	103 (56)	103 (56)	103 (56)	103 (56)
<b>Solid manure</b>	<b>1,391,263</b>	<b>1,429,490</b>	<b>1,420,190</b>	<b>1,439,921</b>	<b>1,439,921</b>	<b>5,392</b> <b>(4,001)</b>	<b>5,501</b> <b>(4,077)</b>	<b>5,422</b> <b>(4,013)</b>	<b>5,507</b> <b>(4,077)</b>	<b>5,507</b> <b>(4,077)</b>
Cattle	852,458	864,852	848,326	863,475	863,475	3,923 (2,968)	3,980 (3,011)	3,904 (2,954)	3,974 (3,006)	3,974 (3,006)
Swine	305,472	307,000	294,781	299,363	299,363	1,017 (752)	1,022 (756)	981 (726)	997 (737)	997 (737)
Poultry	233,333	257,639	277,083	277,083	277,083	452 (281)	499 (310)	537 (333)	537 (333)	537 (333)
<b>Liquid manure</b>	<b>2,823,320</b>	<b>2,858,010</b>	<b>2,789,532</b>	<b>2,837,857</b>	<b>2,837,857</b>	<b>6,235</b> <b>(4,498)</b>	<b>6,317</b> <b>(4,558)</b>	<b>6,177</b> <b>(4,458)</b>	<b>6,285</b> <b>(4,536)</b>	<b>6,285</b> <b>(4,536)</b>
Cattle	2,156,570	2,187,926	2,146,118	2,184,442	2,184,442	5,301 (3,884)	5,378 (3,941)	5,276 (3,866)	5,370 (3,934)	5,370 (3,934)
Swine	666,750	670,084	643,414	653,415	653,415	934 (614)	939 (617)	901 (592)	915 (602)	915 (602)
<b>Sugar-beet leaf and potato haulm</b>	<b>413,194</b>	<b>412,222</b>	<b>402,500</b>	<b>402,500</b>	<b>402,500</b>	<b>489</b> <b>(286)</b>	<b>490</b> <b>(287)</b>	<b>482</b> <b>(283)</b>	<b>482</b> <b>(283)</b>	<b>482</b> <b>(283)</b>
Sugar-beet leaf	274,653	276,111	272,222	272,222	272,222	436 (276)	438 (277)	432 (274)	432 (274)	432 (274)
Potato haulm	138,542	136,111	130,278	130,278	130,278	53 (10)	52 (10)	50 (9)	50 (9)	50 (9)

Table will be continued on the next page.

**Table A.3 continued**

Feedstocks*	Biogas <sup>a</sup>					Digestates: Dry mass <sup>b</sup> (Digestates: Organic dry mass) <sup>c</sup>				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
	t <sub>DM</sub> /a					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)				
<b>Commercial and industrial waste</b>	<b>301,389</b>	<b>301,389</b>	<b>301,389</b>	<b>301,389</b>	<b>301,389</b>	<b>293</b> <b>(219)</b>	<b>293</b> <b>(219)</b>	<b>293</b> <b>(219)</b>	<b>293</b> <b>(219)</b>	<b>293</b> <b>(219)</b>
Beer production	77,778	77,778	77,778	77,778	77,778	47 (22)	47 (22)	47 (22)	47 (22)	47 (22)
Fruit press house	58,333	58,333	58,333	58,333	58,333	38 (27)	38 (27)	38 (27)	38 (27)	38 (27)
Wine press houses	9,722	9,722	9,722	9,722	9,722	4 (2)	4 (2)	4 (2)	4 (2)	4 (2)
Distilleries	24,306	24,306	24,306	24,306	24,306	18 (16)	18 (16)	18 (16)	18 (16)	18 (16)
Dairy-processing industry	29,167	29,167	29,167	29,167	29,167	75 (61)	75 (61)	75 (61)	75 (61)	75 (61)
Sugar manufacture	102,083	102,083	102,083	102,083	102,083	109 (93)	109 (93)	109 (93)	109 (93)	109 (93)
<b>Organic municipal solid waste</b>	<b>753,472</b>	<b>865,278</b>	<b>904,167</b>	<b>972,222</b>	<b>1,020,833</b>	<b>1,160</b> <b>(682)</b>	<b>1,332</b> <b>(783)</b>	<b>1,392</b> <b>(818)</b>	<b>1,497</b> <b>(880)</b>	<b>1,572</b> <b>(924)</b>
Biowaste	565,104	648,958	678,125	729,167	765,625	870 (511)	999 (587)	1,044 (614)	1,123 (660)	1,179 (693)
Municipal garden and park waste	188,368	216,319	226,042	243,056	255,208	290 (170)	333 (196)	348 (205)	374 (220)	393 (231)
<b>Digestates</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>14,091</b>	<b>14,509</b>	<b>14,361</b>	<b>14,660</b>	<b>14,735</b>

Values rounded.

Sources:

- a) Own calculation, based on the energy contents from Table A.2, the biogas heating value of 21.6 MJ/m<sup>3</sup> (Fritsche et al. 2004a) and the average dry mass captured in biogas of 1.05 kg/m<sup>3</sup> (Reinhold 2005).
- b) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in t<sub>DM</sub>/a from the respective dry-mass values given in Table A.2.
- c) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in t<sub>DM</sub>/a from the respective organic-dry-mass values given in Table A.2.

\* For the feedstock descriptions, see Table A.2.

**Table A.4: Biomass Potentials for Bioenergy – Energy Crops (Initial Feedstocks)**

Feedstocks*	Energy content					Acreage					Initial feedstocks: Dry mass (Initial feedstocks: Organic dry mass)					Yield	oDM content	DM content
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050			
	PJ/a					Million ha					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)					t <sub>DM</sub> /ha (m <sup>3</sup> /t <sub>oDM</sub> )	% DM	% FW
<b>Total</b>	-	-	-	-	-	2.1 <sup>c</sup>	2.1 <sup>d</sup>	2.1 <sup>d</sup>	3.1 <sup>b</sup>	4.2 <sup>a, b</sup>	-	-	-	-	-	-	-	-
Corn silage for biogas**	113 <sup>h</sup>	113 <sup>h</sup>	113 <sup>h</sup>	125 <sup>h</sup>	125 <sup>a</sup>	0.9 <sup>c</sup>	0.9 <sup>e</sup>	0.9 <sup>e</sup>	1.0 <sup>f</sup>	1.0 <sup>a</sup>	9,082 <sup>k</sup> (8,174 <sup>i</sup> )	9,082 <sup>k</sup> (8,174 <sup>i</sup> )	9,082 <sup>k</sup> (8,174 <sup>i</sup> )	10,047 <sup>k</sup> (9,042 <sup>j</sup> )	10,047 <sup>k</sup> (9,042 <sup>j</sup> )	(640 <sup>j</sup> )	90 <sup>i</sup>	32.5 <sup>i</sup>
Short-rotation coppice	n.a.	n.a.	n.a.	n.a.	175 <sup>a</sup>	0.006 <sup>c</sup>	n.a.	n.a.	n.a.	0.9 <sup>a</sup>	60 <sup>g</sup>	n.a.	n.a.	n.a.	9,000 <sup>g</sup>	10 <sup>b</sup>	n.a.	n.a.
(Mainly) Rape-seed for biofuels	n.a.	n.a.	n.a.	n.a.	300 <sup>a</sup>	1.15 <sup>c</sup>	n.a.	n.a.	n.a.	2.3 <sup>a</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Sources: Values rounded.

- a) Nitsch et al. (2012), based on the total 2050 acreage for energy crops of 4.2 million ha from Nitsch et al. (2004, “NaturschutzPlus” scenario).
- b) Nitsch et al. (2004, “NaturschutzPlus” scenario).
- c) FNR (2012a) (values refer to 2011).
- d) Own assumption, based on the total acreage of 1.1 million ha (2020) and 2.0 million ha (2030) assumed in Nitsch et al. (2004, “NaturschutzPlus” scenario) and the 2010 value of already 2.1 million ha (FNR 2012a).
- e) Own assumption, based on the corresponding total acreage and the 2010 total and corn acreage values.
- f) Own assumption.
- g) Own calculation, based on the corresponding acreage and yield value.
- h) Own calculation, based on the corresponding acreage and the 2050 energy content and acreage.
- i) Value for corn silage from Wilfert et al. (2004: Table 7-8).
- j) Own calculation, based on the corresponding energy content, the biogas heating value of 21.6 MJ/m<sup>3</sup> (Fritsche et al. 2004a) and the corresponding biogas yield.
- k) Own calculation, based on the corresponding organic dry mass and oDM content.

\* The feedstock choice follows Nitsch et al. (2012).

\*\* Following Nitsch et al. (2012), it is assumed that biogas is entirely produced from corn silage; this assumption is justified since corn in 2012 was grown on 0.8 million ha (FNR 2012b) out of the 0.9 million ha used for digestible energy crops.

**Table A.5: Biomass Potentials for Bioenergy – Energy Crops (Digestates)**

Feedstock	Biogas <sup>a</sup>					Digestates: Dry mass <sup>b</sup> (Digestates: Organic dry mass) <sup>c</sup>				
	2010	2020	2030	2040	2050	2010	2020	2030	2040	2050
	t <sub>DM</sub> /a					kt <sub>DM</sub> /a (kt <sub>oDM</sub> /a)				
Corn silage	5,493,056	5,493,056	5,493,056	6,076,389	6,076,389	3,589 (2,681)	3,589 (2,681)	3,589 (2,681)	3,971 (2,966)	3,971 (2,966)

Sources: Values rounded.

- a) Own calculation, based on the energy contents from Table A.4, the biogas heating value of 21.6 MJ/m<sup>3</sup> (Fritsche et al. 2004a) and the average dry mass captured in biogas of 1.05 kg/m<sup>3</sup> (Reinhold 2005).
- b) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in t<sub>DM</sub>/a from the respective dry-mass values given in Table A.4.
- c) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in t<sub>DM</sub>/a from the respective organic-dry-mass values given in Table A.4.

**Table A.6: Maximum Biomass Potentials for Biochar from Biomass Residues\* in Germany, 2010-2050**

		Energy potential					Remaining biomass residues (C) as a percentage of (D) and (F), respectively				
		2010**	2020	2030	2040	2050	2010**	2020	2030	2040	2050
		PJ/a					%				
<i>Nitsch et al. (2004, "NaturschutzPlus" scenario)</i>											
Total biomass residues <sup>1</sup>		677	696	705	715	724	→ Assumed maximum biomass potentials for biochar				
Total biomass residues, adjusted <sup>2</sup>	(A)	554	591.3	705	715	724					
Actual 2010 energy provision <sup>3</sup>	(B)	500	500	500	500	500					
Remaining biomass residues, i.e. (C) = (A) – (B)	(C)	<b>54</b>	<b>91.3</b>	<b>205</b>	<b>215</b>	<b>224</b>					
<i>Teichmann (2014)</i>											
Solid biomass residues <sup>4</sup>	(D)	298.9	335.4	463.5	471.8	478.8	<b>18.07</b>	<b>27.22</b>	<b>44.23</b>	<b>45.57</b>	<b>46.78</b>
Digestible biomass residues <sup>5</sup>	(E)	123.0	127.8	127.3	130.1	131.1					
Total biomass residues, i.e. (F) = (D) + (E)	(F)	421.9	463.2	590.8	601.9	609.9	<b>12.80</b>	<b>19.71</b>	<b>34.70</b>	<b>35.72</b>	<b>36.73</b>

Values rounded.

*Sources:*

- 1) Nitsch et al. (2004, "NaturschutzPlus" scenario); without energy crops.
- 2) Adjusting the 2010 and 2020 energy potentials from biomass residues from Nitsch et al. (2004, "NaturschutzPlus" scenario) for the higher acreage used for energy crops analogously to the adjustments undertaken in Table A.1, comment (\*).
- 3) Nitsch et al. (2012); assumed to be constant over 2020-2050.
- 4) See Table A.1.
- 5) See Table A.2.

\* Note that the biomass residues considered here do not include digestates.

\*\* The 2010 values will be used for 2015.

### A.3 Feedstock Characteristics and Biochar Yields and Properties

The analysis by Teichmann (2014) focuses on slow-pyrolysis biochar and relies on feedstock-specific biochar yields, feedstock characteristics and biochar properties for all the biomass types used in the study. Thereby, the feedstock-specific properties – summarized in Table 8 of Teichmann (2014) – are calculated as averages of the respective characteristics of suitable reference feedstocks obtained from an extended literature survey, where the feedstock reference materials include species relevant for Germany, at least Europe. Both the original values from the literature and the corresponding feedstock-specific averages are presented in Table A.7.

The data collection in Table A.7 covers typical slow-pyrolysis processes ranging from peak temperatures of 350-700°C. This temperature range was chosen to obtain a critical mass of data. The selection of a single temperature only, such as 400°C or 500°C, would not have resulted in sufficient information for all feedstock categories and/or biochar yields and biomass and biochar characteristics. For the same reason, the table includes results from both laboratory and pilot-scale pyrolysis plants, capturing diverse pyrolysis technologies. Furthermore, the survey focuses on slow-pyrolysis processes conducted at atmospheric pressure,<sup>15</sup> without ash removal from the initial biomass and without activation of the biochars.<sup>16</sup> For any other set of assumptions, not enough studies would have been available to draw a coherent picture across all feedstock categories. Moreover, also for consistency reasons, biochar yields from thermogravimetric analyses are excluded since they tend to differ systematically from pyrolysis results (Das et al. 2008).

Despite a high degree of coherence and, thus, comparability of the data from the different studies listed in Table A.7, however, the following should be noted. First, the means for a given feedstock category do not always reflect the same underlying feedstocks. That is, due to missing data, the type and number of original feedstocks entering the calculation of the means of a given feedstock category might differ across the single biomass, biochar and process characteristics.<sup>17</sup> For some feedstock categories, information for certain characteristics is even completely missing. Second, all char, liquid and gas yields in Table A.7 have been reported as based on feedstock dry weights. However, it was not always entirely clear from the literature whether this was indeed the case. If the char yields were truly given on the basis of feedstock fresh weights, misreporting them as based on feedstock dry weights would lead to an underestimation of the char yields. Therefore, the char yields should generally be interpreted as conservative measures. Finally, it could not always be deduced from the literature whether the biochar yields and characteristics were based on biochar fresh weights or biochar dry weights. Since the water contents of biochar tend to be below 4% (e.g., Kern et al. 2012; Inguanzo et al. 2002; Hossain et al. 2011; Spokas et al. 2011),<sup>18</sup> however, any differences in the data referring to biochar dry weights and biochar fresh weights are considered to be negligible. For this reason, Table A.7 does not differentiate between biochar fresh weight and biochar dry weight and assigns all biochar yields and characteristics to biochar fresh weight and dry weight alike.

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<sup>15</sup> With some exceptions when elevated pressures did not have apparent impacts on the results (cp. Table A.7).

<sup>16</sup> Activation aims at increasing the internal surface areas and porosity of chars and can be performed during or after biochar production (Downie et al. 2009).

<sup>17</sup> As a result, for example, the average char, liquid and gas yields do not generally add up to 100%. However, depending on the type of measurement procedure chosen, the char, liquid and gas yields often do not add up to 100% even in the single studies underlying the means (see Table A.7).

<sup>18</sup> Beyond these four studies, biochar water contents were not reported in the surveyed literature.



To summarize, any remaining shortcomings in the consistency of the data given in Table A.7 tend to be associated with missing information in some studies whether the results are reported on a dry base or whether they are based on fresh weights of biomass and/or biochar. Moreover, the frequent lack of biochar water contents often hinders the transformation of the biochar yields and characteristics to a common measurement unit. Thus, the comparability across studies would be largely enhanced if the water contents of biochar (and biomass) would be routinely published and if it would be always clearly reported whether the data are based on biomass and biochar fresh or dry weights. Furthermore, the literature review has revealed that there is a general lack of studies that provide complete and, thus, coherent information for the entire spectrum of data ranging from the properties of the biomass that is turned into biochar to the associated biochar yields and characteristics, let alone the properties of the corresponding pyrolysis oils and gases. This does not only hold for feedstocks that are covered by very few studies, such as digestates, but also for feedstocks that are well-researched, such as cereal straw or woody biomass.

**Table A.7: Feedstock Properties and Associated Slow-Pyrolysis Biochar Yields and Characteristics**

Feedstock	Feedstock characteristics				Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.							
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery		Energy content	HHV					
	C	N												C	N	P	K										
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg									
(3)							(1)						(2)				(1)*(2)/(3)										
<b>CEREAL STRAW</b>																											
Cereal straw	48.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a					
Wheat straw	47.7	0.46	4.17	8.92	17.26 MJ/kg <sub>daf</sub> (LHV)	450	n.a.	n.a.	~35	~15	~50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	14.44 MJ/Nm <sup>3</sup> (LHV)	n.a.				
						500			~34	~13.5	~52.5											16.17		75.08	0.81	2.17	n.a.
						550			~32	~5.5	~62.5																n.a.
						600			~32.5	~5.0	~62.5											n.a.		n.a.	n.a.	n.a.	n.a.
Wheat straw ( <i>Triticum aestivum</i> )	44.2	0.66	3.6	9	n.a.	400	300	8 K/min	~34	n.a.	n.a.	n.a.	9.7	65.7	1.05	n.a.	n.a.	n.a.	n.a.	n.a.	50.5	n.a.					
						460			n.a.	n.a.	12.0												72.4	1.07	n.a.		
						525			n.a.	n.a.	12.7												74.4	1.04	n.a.		
Wheat straw	n.a.	n.a.	n.a.	10	18	n.a.	n.a.	n.a.	38	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	d				
Wheat straw (Danish)	43.6	0.3	5.25	6.54 <sup>6</sup> 7% <sub>DM</sub>	n.a.	~400	n.a.	n.a.	~41	~38	~18	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.				
						~500			~31	~44	~21													64.27	0.48	41.3	
						~575			~28	~44	~24																n.a.
						~665			~26	~40	~28													n.a.	n.a.	n.a.	
Wheat straw (Danish)	45.9	1.1	6.82	6.27	18.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.				
	45.4	0.33	7.1	9.4	18.5																						
Wheat straw	56.2 <sup>z</sup> 52.9 <sub>FW</sub>	0.43 <sup>z</sup> 0.4 <sub>FW</sub>	7.3 <sup>z</sup> 6.9 <sub>FW</sub>	5.9	19.7 <sub>FW</sub>	400	≥30	7	n.a.	Oil: ~14.8 <sup>8</sup> ~16.0 <sub>daf</sub>	~31.1 <sup>8</sup> ~33.5 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	30.88				
						500			n.a.	Oil: 17.7 <sup>8</sup> 19.1 <sub>daf</sub>	~28.7 <sup>8</sup> ~31 <sub>daf</sub>													32.69			
						600			n.a.	Oil: ~16.7 <sup>8</sup> ~18.0 <sub>daf</sub>	~30.1 <sup>8</sup> ~32.5 <sub>daf</sub>													32.74			
						700			n.a.	Oil: ~13.9 <sup>8</sup> ~15.0 <sub>daf</sub>	~36.2 <sup>8</sup> ~39.0 <sub>daf</sub>													33.19			
						~23.0 <sub>daf</sub>			~28.5 <sub>daf</sub>	~26.5 <sub>daf</sub>	~25.0 <sub>daf</sub>													~23.0 <sub>daf</sub>			

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.				
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV					
	C	N												C	N	P	K									
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg								
(3)							(1)						(2)				(1)*(2)/(3)									
Wheat straw	40.8	0.178	n.a.	n.a.	16.24	500	~125	12	32 <sup>#</sup>	11 <sup>#</sup>	57 <sup>#</sup>	n.a.	n.a.	71.18 <sup>#</sup>	0.250 <sup>#</sup>	n.a.	n.a.	24.67 <sup>#</sup>	55.8 <sup>#</sup>	n.a.	n.a.	g				
Wheat straw	45.6	0.48	5.7	n.a.	18.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp				
(Winter) Wheat straw	42.2	0.23	7.46	~8	16.743	Stages 1: 260 2: 310	Stages 1: 30 2: 30	n.a.	42.2	34.1	7.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h				
Rye straw	46.6	0.55	4.8	n.a.	18.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp				
Oat straw	52.0 <sup>‡</sup> 48.5 <sub>FW</sub>	0.43 <sup>‡</sup> 0.4 <sub>FW</sub>	18.5 <sup>‡</sup> 17.3 <sub>FW</sub>	6.7	17.0 <sub>FW</sub>	400	≥30	7	n.a.	Oil: ~12.6 <sup>§</sup> ~15.5 <sub>daf</sub>	~24.5 <sup>§</sup> ~30 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	26.13	i				
						500			n.a.	Oil: ~25.3 <sup>§</sup> ~15.5 <sup>§</sup> ~19.0 <sub>daf</sub>	~25.3 <sup>§</sup> ~31 <sub>daf</sub>												26.94			
						600			n.a.	Oil: ~26.1 <sup>§</sup> 16.5 <sup>§</sup> 20.3 <sub>daf</sub>	~26.1 <sup>§</sup> ~32 <sub>daf</sub>														27.09	
						700			n.a.	Oil: ~28.5 <sup>§</sup> ~13.9 <sup>§</sup> ~17.0 <sub>daf</sub>	~28.5 <sup>§</sup> ~35 <sub>daf</sub>															26.89
Barley straw	47.5	0.46	4.8	n.a.	18.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp				
Barley straw	n.a.	n.a.	n.a.	n.a.	n.a.	300	120	n.a.	n.a.	n.a.	n.a.	n.a.	10.3	68.3	0.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	j				
<b>Mean****,1</b>	<b>46.6</b>	<b>0.47</b>	<b>6.9</b>	<b>7.9</b>	<b>17.92</b>	<b>520</b>	<b>-</b>	<b>-</b>	<b>33.8</b>	<b>20.8</b>	<b>38.9</b>	<b>n.a.</b>	<b>13.8</b>	<b>70.3</b>	<b>0.65</b>	<b>n.a.</b>	<b>2.17</b>	<b>24.67</b>	<b>49.5</b>	<b>n.a.</b>	<b>29.57</b>	<b>-</b>				
<b>FORESTRY RESIDUES</b>																										
Forestry residues	49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a				
Oak wood ( <i>Quercus spec</i> )	50.1	0.08	0.19	n.a.	n.a.	450	60	~1.8	31.2	n.a.	n.a.	76.9	1.42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k				
Oak wood ( <i>Quercus robur</i> )	46.1	n.a.	n.a.	n.a.	n.a.	400	30 - 240	n.a.	27.8	n.a.	n.a.	n.a.	n.a.	76.7	n.a.	n.a.	n.a.	n.a.	n.a.	46.3	n.a.	n.a.	l			
						600			17.6					90.0						34.4						
Oak wood ( <i>Quercus spp</i> )	n.a.	n.a.	n.a.	<10 (ap)	n.a.	350	15-20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	75.9	0.10	n.a.	0.11	n.a.	n.a.	n.a.	n.a.	n.a.	uu			
						600																		88.4	0.12	0.22

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV	
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)						(2)				(1)*(2)/(3)					
Oak wood	47.1	0.1	2.0	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	38.1	1.1	74.9	0.2	0.001	0.11	n.a.	n.a.	n.a.	n.a.	ss
						400						58.3	0.8	78.8	0.2	0.001	0.15					
						450						55.0	0.6	85.1	0.2	0.004	0.17					
						500						65.6	3.7	85.3	0.2	0.001	0.12					
						550						60.9	0.6	87.9	0.2	0.003	0.13					
						600						71.2	1.3	87.6	0.2	n.a.	0.21					
Beech wood	49.5	0.4	0.4	n.a.	n.a.	~377	n.a.	10 K/s	29.7	48.0	22.3	n.a.	2.4	76.0	0.3	n.a.	n.a.	29.26	45.6	n.a.	n.a.	m
						~477			26.2	48.4	25.4		2.5	81.5	0.2			30.76	43.1			
						~577			24.7	48.0	37.3		2.6	85.2	0.2			31.29	42.5			
						~677			23.6	17.3	59.1		2.7	88.0	0.2			31.39	42.0			
Beech wood ( <i>Fagus sylvatica</i> )	46.1	0.00	0.72	~10	18.42	350	32	n.a.	36.3 <sup>†</sup>	40.3 <sup>†</sup>	11.9 <sup>†</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h
						350	n.a.	n.a.	29.1 <sup>**</sup>	53.3 <sup>**</sup>	12.1 <sup>**</sup>											
						Stages 1: 280 2: 350	Stages 1: 32 2: 32	n.a.	47.5 <sup>†</sup>	36.4 <sup>†</sup>	15.2 <sup>†</sup>											
						Stages 1: 200 2: 280 3: 350	Stages 1: 60 2: 60 3: 30	Stages 1: - 2: 4 3: 2	30.6 <sup>**</sup>	49.6 <sup>**</sup>	12.2 <sup>**</sup>											
Beech wood and bark	47.9	0.22	0.5	n.a.	19.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Spruce wood ( <i>Picea abies</i> )	48.9	0.12	0.3	n.a.	n.a.	450	10	~4.8	33.0	n.a.	n.a.	69.1	0.65	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k
						450	60	~1.8	32.2			74.7	0.41									
						450	240	~1.8	31.7			78.7	0.79									
Spruce wood	51.9	0.3	0.5	n.a.	n.a.	~377	n.a.	10 K/s	32.6	47.2	20.2	n.a.	2.6	77.0	0.2	n.a.	n.a.	29.34	48.4	n.a.	n.a.	m
						~477			29.4	45.7	24.9		2.7	83.2	0.2			31.13	47.1			
						~577			27.8	36.4	35.8		2.9	87.4	0.1			31.38	46.8			
						~677			26.1	17.4	56.5		3.0	89.1	0.1			31.56	44.8			

Table will be continued on the next page.

Table A.7 continued

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.			
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV				
	C	N												C	N	P	K								
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg							
(3)							(1)						(2)				(1)*(2)/(3)								
Spruce wood ( <i>Picea abies</i> )	47.2	<0.05	0.17	~7	19.157	Stages 1: 290 2: 345	Stages 1: 30 2: 30	n.a.	36.2	27.5	8.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h			
Spruce wood and bark	49.8	0.13	0.6	n.a.	20.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp			
Spruce wood and needles ( <i>Picea abies</i> )	48.4	0.75	1.8	33	n.a.	400	600	8 K/min	36	n.a.	n.a.	n.a.	1.9	63.5	1.02	n.a.	n.a.	n.a.	n.a.	47.2	n.a.	n.a.	c		
						460			n.a.	3.0	79.6			1.24	n.a.										
						525				4.7	78.3			1.17											
Pine wood ( <i>Pinus silvestrus</i> )	49.4	0.11	0.3	n.a.	n.a.	450	10	~4.8	28.9	n.a.	n.a.	69.6	0.90	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k		
						450	60	~1.8	32.1	74.6	0.37														
						450	240	~1.8	31.8	78.6	0.93														
						550	60	~1.8	28.8	86.6	0.88														
Pine wood	47.8 <sup>§</sup> 48.2 <sub>daf</sub>	0.1 <sup>§</sup> 0.1 <sub>daf</sub>	0.86 <sup>‡</sup> 0.8 <sub>FW</sub>	7	n.a.	420	~120	5 K/min	29.7	48.3 Oil: 12.4	21.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	~32	n.a.	n.a.	~23	tt
						600			24.4	49.0 Oil: 12.4	26.4														
						420		20 K/min	27.2	49.6 Oil: 12.2	23.0														
						600			22.6	50.4 Oil: 12.8	27.0														
						420		40 K/min	26.4	46.0 Oil: 11.8	27.6														
						600			20.4	50.8 Oil: 13.2	28.8														
						420		80 K/min	25.2	48.8 Oil: 11.9	26.0														
						600			18.7	52.4 Oil: 14.6	29.1														

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.				
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV					
	C	N												C	N	P	K									
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg								
(3)							(1)						(2)					(1)*(2)/(3)								
Pine wood <i>(Pinus ponderosa)</i>	50.9 <sup>§</sup>	n.a.	0.54	n.a.	n.a.	350	60	n.a.	26.8	n.a.	n.a.	n.a.	n.a.	76.2 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	o
	51.2 <sub>daf</sub>						480		21.1					69.8 <sub>daf</sub>												
						400	60		22.5					77.4 <sub>daf</sub>												
							480		13.9					79.4 <sub>daf</sub>												
						500	60		11.2					84.0 <sub>daf</sub>												
Pine wood	49.5	0.06	0.5	3.0	n.a.	500	n.a.	n.a.	31.2	50.4	18.4	n.a.	1.60	83.5	0.1	n.a.	n.a.	n.a.	n.a.	52.6	n.a.	n.a.	n.a.	n.a.	n.a.	p
	48.0	0.05	1.2	7.7		n.a.	5.91	n.a.	30.0	57.9	12.1	n.a.	5.00	79.1	0.2	n.a.	n.a.	n.a.	n.a.	49.4	n.a.	n.a.	n.a.	n.a.	n.a.	
Pine wood	n.a.	n.a.	0.2	n.a.	19.2	350	120	n.a.	n.a.	n.a.	n.a.	65.8	1.7	n.a.	n.a.	n.a.	n.a.	n.a.	25.9	n.a.	n.a.	n.a.	n.a.	n.a.	n	
						400						67.5	2.0						26.5							
						450						70.4	2.6						27.6							
						500						73.8	3.1						28.6							
						550						76.0	4.1						28.7							
						600						78.1	4.7						28.8							
Pine wood	47.0	0.0	1.8	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	43.2	0.6	70.7	0.1	0.005	0.039	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ss	
						400						53.5	1.1	76.3	0.1	0.004	0.037									
						450						49.7	1.5	80.5	0.1	n.a.	0.100									
						500						62.0	1.0	83.4	0.1	0.000	0.068									
						550						59.0	0.8	86.8	0.1	n.a.	0.073									
						600						71.2	1.1	91.1	0.1	0.001	0.078									
Pine needles	n.a.	n.a.	n.a.	n.a.	n.a.	400	360	n.a.	30.0	n.a.	n.a.	n.a.	2.32	76.0 <sup>§</sup>	1.13 <sup>§</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	q
						500			26.1				2.80	79.4 <sup>§</sup>	1.08 <sup>§</sup>											
						600			20.4				2.76	83.0 <sup>§</sup>	0.95 <sup>§</sup>											
						700			14.0				2.20	84.6 <sup>§</sup>	1.1 <sup>§</sup>											

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.						
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV							
	C	N												C	N	P	K											
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg										
(3)							(1)						(2)				(1)*(2)/(3)											
Pine needles ( <i>Pinus ponderosa</i> )	n.a.	n.a.	n.a.	n.a.	21.54 <sup>s</sup>	400	10	200	37.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	27.58 <sup>s</sup>	n.a.	17.99 <sup>s</sup>	n.a.	r						
Pine bark ( <i>Pinus ponderosa</i> )	49.6 <sup>s</sup> 51.3 <sub>daf</sub>	n.a.	3.23	n.a.	n.a.	350	60	n.a.	44.5	n.a.	n.a.	n.a.	n.a.	68.3 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	o					
						480	33.3		68.5 <sub>daf</sub>																			
						400	28.7		80.8 <sub>daf</sub>																			
<b>Mean</b> <sup>*****,2</sup>	<b>48.6</b>	<b>0.16</b>	<b>0.9</b>	<b>10.9</b>	<b>19.70</b>	<b>465</b>	-	-	<b>29.6</b>	<b>46.6</b>	<b>23.3</b>	<b>69.2</b>	<b>2.2</b>	<b>81.4</b>	<b>0.37</b>	<b>0.002</b>	<b>0.13</b>	<b>29.76</b>	<b>46.6</b>	<b>n.a.</b>	<b>23.00</b>	-						
<b>ADDITIONAL FORESTRY RESIDUES FROM HISTORICAL-FOREST FORMATION</b>																												
Oak wood ( <i>Quercus spec</i> )	50.1	0.08	0.19	n.a.	n.a.	450	60	~1.8	31.2	n.a.	n.a.	76.9	1.42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k					
Oak wood ( <i>Quercus robur</i> )	46.1	n.a.	n.a.	n.a.	n.a.	400	30 - 240	n.a.	27.8	n.a.	n.a.	n.a.	n.a.	76.7	n.a.	n.a.	n.a.	n.a.	46.3	n.a.	n.a.	n.a.	l					
						600			17.6					90.0				34.4										
Oak wood ( <i>Quercus spp</i> )	n.a.	n.a.	n.a.	<10 (ap)	n.a.	350	15-20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	75.9	0.10	n.a.	0.11	n.a.	n.a.	n.a.	n.a.	n.a.	uu					
						600								88.4			0.12							0.22				
Oak wood	47.1	0.1	2.0	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	n.a.	n.a.	38.1	1.1	74.9	0.2	0.001	0.11	n.a.	n.a.	n.a.	n.a.	ss				
						400								58.3				0.8							78.8	0.2	0.001	0.15
						450								55.0				0.6							85.1	0.2	0.004	0.17
						500								65.6				3.7							85.3	0.2	0.001	0.12
						550								60.9				0.6							87.9	0.2	0.003	0.13
						600								71.2				1.3							87.6	0.2	n.a.	0.21
Beech wood	49.5	0.4	0.4	n.a.	n.a.	~377	n.a.	10 K/s	29.7	48.0	22.3	n.a.	2.4	76.0	0.3	n.a.	n.a.	29.26	45.6	n.a.	n.a.	n.a.	m					
						~477			26.2		25.4							2.5						81.5	0.2	30.76	43.1	
						~577			24.7		48.0							37.3						2.6	85.2	0.2	31.29	42.5
						~677			23.6		17.3							59.1						2.7	88.0	0.2	31.39	42.0

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV	
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)								(1)					(2)				(1)*(2)/(3)					
Beech wood ( <i>Fagus sylvatica</i> )	46.1	0.00	0.72	~10	18.42	350	32	n.a.	36.3 <sup>f</sup>	40.3 <sup>f</sup>	11.9 <sup>f</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h
						350	n.a.	n.a.	29.1 <sup>ff</sup>	53.3 <sup>ff</sup>	12.1 <sup>ff</sup>											
						Stages 1: 280 2: 350	Stages 1: 32 2: 32	n.a.	47.5 <sup>f</sup>	36.4 <sup>f</sup>	15.2 <sup>f</sup>											
						Stages 1: 200 2: 280 3: 350	Stages 1: 60 2: 60 3: 30	Stages 1: - 2: 4 3: 2	30.6 <sup>ff</sup>	49.6 <sup>ff</sup>	12.2 <sup>ff</sup>											
Beech wood and bark	47.9	0.22	0.5	n.a.	19.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Alder wood ( <i>Alnus incana</i> )	48.3	0.30	0.3	n.a.	n.a.	450	10	~4.8	30.2	n.a.	n.a.	71.7	1.10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k
						450	60	~1.8	30.5			76.2	1.10									
						450	240	~1.8	29.8			78.4	1.18									
Birch wood ( <i>Betula pubescens</i> )	48.1	0.17	0.2	n.a.	n.a.	450	10	~4.8	29.5	n.a.	n.a.	72.5	1.15	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k
						450	60	~1.8	28.8			77.2	1.23									
						450	240	~1.8	28.8			79.1	1.04									
<b>Mean****,3</b>	<b>47.9</b>	<b>0.18</b>	<b>0.6</b>	<b>10</b>	<b>19.06</b>	<b>460</b>	-	-	<b>29.2</b>	<b>42.7</b>	<b>24.4</b>	<b>71.7</b>	<b>1.5</b>	<b>82.9</b>	<b>0.18</b>	<b>0.002</b>	<b>0.16</b>	<b>30.68</b>	<b>41.8</b>	<b>n.a.</b>	<b>n.a.</b>	-
<b>OPEN-COUNTRY BIOMASS RESIDUES</b>																						
<i>Herbaceous biomass</i> <sup>4</sup>	45.4	1.03	6.5	6.3	18.24	475	-	-	32.4	n.a.	n.a.	65.1	17.5	63.3	0.83	n.a.	n.a.	n.a.	45.0	n.a.	n.a.	-
<i>Woody biomass</i> <sup>5</sup>	48.6	0.16	0.9	10.9	19.70	465	-	-	29.6	46.6	23.3	69.2	2.2	81.4	0.37	0.002	0.13	29.76	46.6	n.a.	23.00	-
<b>Mean</b> <sup>6</sup>	<b>46.5</b>	<b>0.74</b>	<b>4.6</b>	<b>7.8</b>	<b>18.73</b>	<b>472</b>	-	-	<b>31.5</b>	<b>46.6</b>	<b>23.3</b>	<b>66.5</b>	<b>12.4</b>	<b>69.3</b>	<b>0.68</b>	<b>0.002</b>	<b>0.13</b>	<b>29.76</b>	<b>45.5</b>	<b>n.a.</b>	<b>23.00</b>	-
<b>INDUSTRIAL WOOD WASTE</b>																						
Sawmill by-products	49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a
Bark	49	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a

Table will be continued on the next page.



Table A.7 continued

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.								
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li- quid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content		HHV							
	C	N												C	N	P	K												
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg											
(3)							(1)					(2)					(1)*(2)/(3)												
Oak wood ( <i>Quercus spec</i> )	50.1	0.08	0.19	n.a.	n.a.	450	60	~1.8	31.2	n.a.	n.a.	76.9	1.42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k							
Oak wood ( <i>Quercus robur</i> )	46.1	n.a.	n.a.	n.a.	n.a.	400	30 - 240	n.a.	27.8	n.a.	n.a.	n.a.	n.a.	76.7	n.a.	n.a.	n.a.	n.a.	46.3	n.a.	n.a.	n.a.							
						600			17.6					90.0					34.4										
Oak wood ( <i>Quercus spp</i> )	n.a.	n.a.	n.a.	<10 (ap)	n.a.	350	15-20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	75.9	0.10	n.a.	0.11	n.a.	n.a.	n.a.	n.a.	n.a.	uu						
						600								n.a.										88.4	0.12	0.22			
Oak wood	47.1	0.1	2.0	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	n.a.	38.1	1.1	74.9	0.2	0.001	0.11	n.a.	n.a.	n.a.	n.a.	n.a.	ss					
						400									58.3										0.8	78.8	0.2	0.001	0.15
						450									55.0										0.6	85.1	0.2	0.004	0.17
						500									65.6										3.7	85.3	0.2	0.001	0.12
						550									60.9										0.6	87.9	0.2	0.003	0.13
						600									71.2										1.3	87.6	0.2	n.a.	0.21
Beech wood sawdust	45.7 <sup>s</sup> 45.9 <sub>daf</sub>	0.2 <sup>s</sup> 0.2 <sub>daf</sub>	0.34	n.a.	n.a.	450	95	Stages ≤16.5	30.6	44.3	25.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	s						
Beech wood	49.5	0.4	0.4	n.a.	n.a.	~377	n.a.	10 K/s	29.7	48.0	22.3	n.a.	2.4	76.0	0.3	n.a.	n.a.	n.a.	29.26	45.6	n.a.	n.a.	m						
						~477			26.2	48.4	25.4													2.5	81.5	0.2	30.76	43.1	
						~577			24.7	48.0	37.3													2.6	85.2	0.2	31.29	42.5	
						~677			23.6	17.3	59.1													2.7	88.0	0.2	31.39	42.0	
Beech wood ( <i>Fagus sylvatica</i> )	46.1	0.00	0.72	~10	18.42	350	32	n.a.	36.3 <sup>f</sup>	40.3 <sup>f</sup>	11.9 <sup>f</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h						
						350	n.a.	n.a.	29.1 <sup>ff</sup>	53.3 <sup>ff</sup>	12.1 <sup>ff</sup>																		
						Stages 1: 280 2: 350	Stages 1: 32 2: 32	n.a.	47.5 <sup>f</sup>	36.4 <sup>f</sup>	15.2 <sup>f</sup>																		
						Stages 1: 200 2: 280 3: 350	Stages 1: 60 2: 60 3: 30	Stages 1: - 2: 4 3: 2	30.6 <sup>ff</sup>	49.6 <sup>ff</sup>	12.2 <sup>ff</sup>																		

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li- quid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV	
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)						(2)				(1)*(2)/(3)					
Beech wood and bark	47.9	0.22	0.5	n.a.	19.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Spruce wood ( <i>Picea abies</i> )	48.9	0.12	0.3	n.a.	n.a.	450	10	~4.8	33.0	n.a.	n.a.	69.1	0.65	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k
						450	60	~1.8	32.2	74.7	0.41											
						450	240	~1.8	31.7	78.7	0.79											
Spruce wood	51.9	0.3	0.5	n.a.	n.a.	~377	n.a.	10 K/s	32.6	47.2	20.2	n.a.	2.6	77.0	0.2	n.a.	n.a.	29.34	48.4	n.a.	n.a.	m
						~477			29.4	45.7	24.9	2.7	83.2	0.2	31.13	47.1						
						~577			27.8	36.4	35.8	2.9	87.4	0.1	31.38	46.8						
						~677			26.1	17.4	56.5	3.0	89.1	0.1	31.56	44.8						
Spruce wood ( <i>Picea abies</i> )	47.2	<0.05	0.17	~7	19.157	Stages 1: 290 2: 345	Stages 1: 30 2: 30	n.a.	36.2	27.5	8.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h
Spruce wood and bark	49.8	0.13	0.6	n.a.	20.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Pine wood	n.a.	n.a.	0.2	n.a.	19.2	350	120	n.a.	n.a.	n.a.	n.a.	65.8	1.7	n.a.	n.a.	n.a.	n.a.	25.9	n.a.	n.a.	n.a.	n
						400			67.5	2.0	26.5											
						450			70.4	2.6	27.6											
						500			73.8	3.1	28.6											
						550			76.0	4.1	28.7											
						600			78.1	4.7	28.8											
Pine wood ( <i>Pinus ponderosa</i> )	50.9 <sup>§</sup> 51.2 <sub>daf</sub>	n.a.	0.54	n.a.	n.a.	350	60	n.a.	26.8	n.a.	n.a.	n.a.	n.a.	76.2 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	o
						480			21.1	69.8 <sub>daf</sub>												
						400	60		22.5	77.4 <sub>daf</sub>												
						480			13.9	79.4 <sub>daf</sub>												
						500	60		11.2	84.0 <sub>daf</sub>												
Pine wood	49.5	0.06	0.5	3.0	n.a.	500	n.a.	n.a.	31.2	50.4	18.4	n.a.	1.60	83.5	0.1	n.a.	n.a.	n.a.	52.6	n.a.	n.a.	p
	48.0	0.05	1.2	7.7	n.a.	n.a.	5.91	n.a.	30.0	57.9	12.1	n.a.	5.00	79.1	0.2	n.a.	n.a.	n.a.	49.4	n.a.	n.a.	

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.	
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV		
	C	N												C	N	P	K						
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg					
(3)							(1)						(2)				(1)*(2)/(3)						
Pine wood ( <i>Pinus silvestrus</i> )	49.4	0.11	0.3	n.a.	n.a.	450	10	~4.8	28.9	n.a.	n.a.	69.6	0.90	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	k	
						450	60	~1.8	32.1			74.6	0.37										
						450	240	~1.8	31.8			78.6	0.93										
						550	60	~1.8	28.8			86.6	0.88										
Pine wood	47.8 <sup>s</sup> 48.2 <sub>daf</sub>	0.1 <sup>s</sup> 0.1 <sub>daf</sub>	0.86 <sup>t</sup> 0.8 <sub>FW</sub>	7	n.a.	420	~120	5 K/min	29.7	48.3 Oil: 12.4	21.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	~32	n.a.	n.a.	~23	tt	
						600			24.4	49.0 Oil: 12.4	26.4												
						420		20 K/min	27.2	49.6 Oil: 12.2	23.0												
						600			22.6	50.4 Oil: 12.8	27.0												
						420		40 K/min	26.4	46.0 Oil: 11.8	27.6												
						600			20.4	50.8 Oil: 13.2	28.8												
						420		80 K/min	25.2	48.8 Oil: 11.9	26.0												
						600			18.7	52.4 Oil: 14.6	29.1												
Pine wood	47.0	0.0	1.8	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	43.2	0.6	70.7	0.1	0.005	0.039	n.a.	n.a.	n.a.	n.a.	ss	
						400						53.5	1.1	76.3	0.1	0.004	0.037						
						450						49.7	1.5	80.5	0.1	n.a.	0.100						
						500						62.0	1.0	83.4	0.1	0.000	0.068						
						550						59.0	0.8	86.8	0.1	n.a.	0.073						
						600						71.2	1.1	91.1	0.1	0.001	0.078						

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li- quid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV	
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)						(2)				(1)*(2)/(3)					
Pine bark ( <i>Pinus ponderosa</i> )	49.6 <sup>§</sup> 51.3 <sub>daf</sub>	n.a.	3.23	n.a.	n.a.	350	60	n.a.	44.5	n.a.	n.a.	n.a.	n.a.	68.3 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	o
							480		33.3					68.5 <sub>daf</sub>								
						400	480		28.7					80.8 <sub>daf</sub>								
<b>Mean****,7</b>	<b>48.5</b>	<b>0.13</b>	<b>0.8</b>	<b>8.1</b>	<b>19.34</b>	<b>463</b>	-	-	<b>29.1</b>	<b>46.3</b>	<b>23.6</b>	<b>69.2</b>	<b>2.0</b>	<b>82.5</b>	<b>0.16</b>	<b>0.002</b>	<b>0.13</b>	<b>30.30</b>	<b>46.5</b>	<b>n.a.</b>	<b>23.00</b>	-
<b>WOOD IN MUNICIPAL SOLID WASTE</b>																						
<b>Mean<sup>5</sup></b>	<b>48.6</b>	<b>0.16</b>	<b>0.9</b>	<b>10.9</b>	<b>19.70</b>	<b>465</b>	-	-	<b>29.6</b>	<b>46.6</b>	<b>23.3</b>	<b>69.2</b>	<b>2.2</b>	<b>81.4</b>	<b>0.37</b>	<b>0.002</b>	<b>0.13</b>	<b>29.76</b>	<b>46.6</b>	<b>n.a.</b>	<b>23.00</b>	-
<b>GREEN WASTE: COMPENSATION AREAS</b>																						
Hay	48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a
Hay	45.5	1.14	5.7	n.a.	18.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Ryegrass	46.1	1.34	8.8	n.a.	18.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Ryegrass shoot litter ( <i>Lolium perenne</i> )	n.a.	n.a.	n.a.	n.a.	n.a.	400	780	~1.4	33	n.a.	n.a.	n.a.	n.a.	56	n.a.	n.a.	n.a.	n.a.	45	n.a.	n.a.	t
Ryegrass	49.8	0.41	3.2	6.2	18.6	620	120	13	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	u
Ryegrass and fescue grass stems and leaves <sup>8</sup>	41.7 <sup>§</sup> 44.5 <sub>daf</sub>	1.4 <sup>§</sup> 1.54 <sub>daf</sub>	~6.2	6.3	17.9	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	v
Fescue grass	41.4	0.87	8.5	n.a.	17.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp
Fescue grass ( <i>Festuca arundinacea</i> )	n.a.	n.a.	n.a.	n.a.	n.a.	400	60	n.a.	37.2	n.a.	n.a.	56.9	16.3	64.7 <sup>§</sup> 77.3 <sub>daf</sub>	1.04 <sup>§</sup> 1.24 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	w
						500			31.4			64.3	15.4	69.5 <sup>§</sup> 82.2 <sub>daf</sub>	0.92 <sup>§</sup> 1.09 <sub>daf</sub>							
						600			29.8			67.6	18.9	72.2 <sup>§</sup> 89.0 <sub>daf</sub>	0.80 <sup>§</sup> 0.99 <sub>daf</sub>							
						700			28.8			71.6	19.3	76.0 <sup>§</sup> 94.2 <sub>daf</sub>	0.56 <sup>§</sup> 0.70 <sub>daf</sub>							
<b>Mean****,9</b>	<b>45.4</b>	<b>1.03</b>	<b>6.5</b>	<b>6.3</b>	<b>18.24</b>	<b>475</b>	-	-	<b>32.4</b>	<b>n.a.</b>	<b>n.a.</b>	<b>65.1<sup>#</sup></b>	<b>17.5</b>	<b>63.3<sup>#</sup></b>	<b>0.83</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>45.0</b>	<b>n.a.</b>	<b>n.a.</b>	-

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.		
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV			
	C	N												C	N	P	K							
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg						
(3)							(1)						(2)				(1)*(2)/(3)							
<b>BIOMASS: HABITAT-CONNECTIVITY AREAS</b>																								
Woody <sup>5</sup>	48.6	0.16	0.9	10.9	19.70	465	-	-	29.6	46.6	23.3	69.2	2.2	81.4	0.37	0.002	0.13	29.76	46.6	n.a.	23.00	-		
Herbaceous <sup>4</sup>	45.4	1.03	6.5	6.3	18.24	475	-	-	32.4	n.a.	n.a.	65.1	17.5	63.3	0.83	n.a.	n.a.	n.a.	45.0	n.a.	n.a.	-		
<b>Mean<sup>10</sup></b>	<b>46.5</b>	<b>0.74</b>	<b>4.6</b>	<b>7.8</b>	<b>18.73</b>	<b>472</b>	-	-	<b>31.5</b>	<b>46.6</b>	<b>23.3</b>	<b>66.5</b>	<b>12.4</b>	<b>69.3</b>	<b>0.68</b>	<b>0.002</b>	<b>0.13</b>	<b>29.76</b>	<b>45.5</b>	<b>n.a.</b>	<b>23.00</b>	-		
<b>GREEN WASTE: EXTENSIVE GRASSLAND</b>																								
<b>Mean<sup>11</sup></b>	<b>46.5</b>	<b>0.74</b>	<b>4.6</b>	<b>7.8</b>	<b>18.73</b>	<b>472</b>	-	-	<b>31.5</b>	<b>46.6</b>	<b>23.3</b>	<b>66.5</b>	<b>12.4</b>	<b>69.3</b>	<b>0.68</b>	<b>0.002</b>	<b>0.13</b>	<b>29.76</b>	<b>45.5</b>	<b>n.a.</b>	<b>23.00</b>	-		
<b>SHORT-ROTATION COPPICE: EROSION AREAS</b>																								
Willow wood	47.1	0.54	2.0	n.a.	19.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp		
Willow chips	47.2 <sup>s</sup> 47.8 <sub>daf</sub>	0.30 <sup>s</sup> 0.30 <sub>daf</sub>	1.34	7.76	18.861	-	-	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	v		
Poplar wood	47.5	0.42	1.8	n.a.	19.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp		
Poplar wood ( <i>Populus tremula</i> )	46.1	0.64	1.1	28	n.a.	400	600	8 K/min	32	n.a.	n.a.	n.a.	n.a.	3.5	67.3	0.78	n.a.	n.a.	n.a.	46.7	n.a.	n.a.	c	
						460			n.a.						5.7	70.0								0.95
						525			n.a.						6.8	77.9								1.07
Poplar wood ( <i>Populus ssp</i> )	n.a.	n.a.	n.a.	n.a.	19.33 <sup>s</sup>	400	10	200	21.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	29.83 <sup>s</sup>	n.a.	16.42 <sup>s</sup> MJ/kg	r		
Poplar wood	49.6 <sup>s</sup> 49.9 <sub>daf</sub>	n.a.	0.53	n.a.	n.a.	350	60	n.a.	27.1	n.a.	n.a.	n.a.	n.a.	n.a.	76.2 <sub>daf</sub>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	x	
							480		20.4						75.6 <sub>daf</sub>									
							400		60						79.1 <sub>daf</sub>									
							500		60						86.6 <sub>daf</sub>									
Poplar wood ( <i>Populus alba</i> )	47.4	0.00	1.05	~54 (fresh)	18.815	Stages 1: 280 2: 335	Stages 1: 30 2: 30	n.a.	30.6	37.9	11.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	h		
<b>Mean<sup>****, 12</sup></b>	<b>47.5</b>	<b>0.38</b>	<b>1.3</b>	<b>17.9</b>	<b>19.30</b>	<b>421</b>	-	-	<b>25.1</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>5.3</b>	<b>71.7</b>	<b>0.93</b>	<b>n.a.</b>	<b>n.a.</b>	<b>29.83</b>	<b>46.7</b>	<b>16.42</b>		-		

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics				Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.											
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery		Energy content	HHV									
	C	N												C	N	P	K														
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg													
(3)							(1)						(2)				(1)*(2)/(3)														
<b>DIGESTATES</b>																															
Digestates	41	7.3	n.a.	93.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	y									
Sewage sludge (anaerobically stabilized)	21.5	2.3	n.a.	<20 (dried)	n.a.	505	60	2-26 deg/min	~68	~26	~6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	aa									
Sewage sludge (municipal) (anaerobically digested)	37.9	6.2	25.9	84.5	n.a.	300	30	17	62.5	n.a.	n.a.	n.a.	n.a.	39.7	7.1	n.a.	n.a.	n.a.	65.5	n.a.	n.a.	n.a.	cc								
						400			28.5															n.a.	n.a.	n.a.					
						500			27.3															9.8	2.1	7.1					
						400	60	25.5	27.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.				
						500																						27.5	n.a.	n.a.	n.a.
						400																						90	27.5	n.a.	n.a.
500	90	27.0	27.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.									
400																							27.5	n.a.	n.a.	n.a.					
500																							31.0	n.a.	n.a.	n.a.					
Sewage sludge (urban) (anaerobically digested)	35.7	3.5	29.5	5.2 (dried)	16.558	450	n.a.	5	~53	~37 (organic fraction: ~2/3)	~10	26.2 <sup>F</sup> VM <sub>db</sub> : 23.1	50.7	36.0	3.8	n.a.	n.a.	12.429	53.4	~26	22.446 (organic fraction)	dd									
						n.a.			60	~46.5	~40.5 (organic fraction: ~2/3)	~13											23.6 <sup>F</sup> VM <sub>db</sub> : 18.4	58.0	29.9	3.2	n.a.	n.a.	11.533	38.9	~17.5
						650	n.a.	5	~45	~40.5 (organic fraction: ~2/3)	~14.5	27.8 <sup>F</sup> VM <sub>db</sub> : 11.9	60.3	30.8	3.0	n.a.	n.a.	11.904	38.8	~19 (at 600°C)	27.004 (organic fraction)										
						n.a.	60	~44	~41.5 (organic fraction: ~2/3)	~14.5	26.8 <sup>F</sup> VM <sub>db</sub> : 11.0	62.2	29.2	2.7	n.a.	n.a.	11.058	36.0	~22 (at 600°C)	23.271 (organic fraction)											
Sewage sludge (digested)	n.a.	n.a.	22.1	77.7 (dewatered)	n.a.	500	60	n.a.	37.5	n.a.	n.a.	23.0	56.4	32.5	3.8	n.a.	0.34	13.071	n.a.	n.a.	n.a.	vv									
Sewage sludge (municipal) (anaerobically digested)	n.a.	n.a.	n.a.	70 (dewatered)	17	500	n.a.	n.a.	53	Oil: 26	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	10	n.a.	n.a.	38-39	ww									

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li- quid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV	
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)				(2)						(1)*(2)/(3)					
Sewage sludge (urban) (anaerobically digested)	35.0 <sup>£</sup> 32.3 <sub>ad</sub>	3.54 <sup>£</sup> 3.27 <sub>ad</sub>	36.8 <sup>£</sup> 34 <sub>ad</sub>	7.6 (ad)	n.a.	400	n.a.	10	68.9 <sup>£</sup> 63.7 <sub>ad</sub>	n.a.	n.a.	7.1 <sup>¥</sup> 6.8 <sub>FM</sub>	66.1 <sup>¥</sup> 63.3 <sub>FM</sub>	21.1 <sup>¥</sup> 20.2 <sub>FM</sub>	2.51 <sup>¥</sup> 2.40 <sub>FM</sub>	n.a.	n.a.	n.a.	41.5	n.a.	n.a.	ee
						500			62.7 <sup>£</sup> 57.9 <sub>ad</sub>			7.9 <sup>¥</sup> 7.6 <sub>FM</sub>	70.7 <sup>¥</sup> 68.2 <sub>FM</sub>	21.0 <sup>¥</sup> 20.3 <sub>FM</sub>	2.21 <sup>¥</sup> 2.13 <sub>FM</sub>				37.6			
						700			56.7 <sup>£</sup> 52.4 <sub>ad</sub>			8.6 <sup>¥</sup> 8.3 <sub>FM</sub>	75.1 <sup>¥</sup> 72.5 <sub>FM</sub>	21.1 <sup>¥</sup> 20.4 <sub>FM</sub>	1.24 <sup>¥</sup> 1.20 <sub>FM</sub>				34.2			
Dairy manure (anaerobically digested)	n.a.	n.a.	n.a.	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	31.7	12.7	57.7	2.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ss
						400						26.9	14.5	63.8	2.4	0.64	1.66					
						450						40.8	17.8	60.4	2.5	n.a.	n.a.					
						500						42.6	14.7	59.4	2.6	0.56	1.49					
						550						41.0	17.3	60.9	2.2	n.a.	n.a.					
						600						41.7	18.8	62.8	2.2	0.83	2.09					
<b>Mean****,13</b>	<b>36.8</b>	<b>5.59</b>	<b>28.6</b>	<b>85.3</b>	<b>16.78</b>	<b>491</b>	-	-	<b>49.4</b>	<b>32.9</b>	<b>9.5</b>	<b>28.2</b>	<b>38.8</b>	<b>42.3</b>	<b>2.57</b>	<b>0.68</b>	<b>1.04</b>	<b>11.60</b>	<b>28.9</b>	<b>21.13</b>	<b>31.85</b>	-
<b>SEWAGE SLUDGE</b>																						
Sewage sludge	43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a
Sewage sludge	27	3.2	50	20 (dried)	11.455	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	oo
Sewage sludge (municipal) (excess sludge from final clarification)	28.1	3.5	42.6	n.a.	10.778 (LHV)	500	n.a.	Fed in hot reactor	52	28	≥9	n.a.	n.a.	20	~2.1	n.a.	n.a.	n.a.	37.0	n.a.	n.a.	z
Sewage sludge (raw)	30	3.1	n.a.	<20 (dried)	n.a.	505	60	2-26 deg/min	~68	~26	~6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	aa
Sewage sludge (municipal) (primary)	n.a.	n.a.	n.a.	75 (dewatered)	23	500	n.a.	n.a.	33	Oil: 42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17	n.a.	n.a.	36-38	ww
Sludge pellets	44	5.3	15	5 (dried)	n.a.	Stages 1: 450 <sup>†</sup> 2: 450	n.a.	n.a.	43	43 Oil: 29 RW: 14	14	n.a.	35	47	6.7	5.6	n.a.	18	45.9	15 MJ/kg	Oil: 30 RW: 6	bb
Sludge cakes (urban) (stabilized by polyacrylamide)	41.7	3.22	39.8	84	16.61	250-700	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ff

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.	
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content		HHV
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)					(2)					(1)*(2)/(3)					
Sewage sludge (municipal) (activated)	~35	~5.5	~21	<=10 (dried)	n.a.	400	120	2	~59	n.a.	n.a.	~19	~40	~40	~5.0	n.a.	n.a.	n.a.	67.4	n.a.	n.a.	gg
						500			~48			~24	~46	~38	~4.4				52.1			
						600			~44			~30	~51	~35	~3.8				44.0			
<b>Mean****, 14</b>	<b>35.5</b>	<b>3.97</b>	<b>33.7</b>	<b>79.5</b>	<b>17.02</b>	<b>491</b>	-	-	<b>49.3</b>	<b>32.3</b>	<b>9.7</b>	<b>24.3</b>	<b>40.3</b>	<b>34.9</b>	<b>4.40</b>	<b>5.60</b>	<b>n.a.</b>	<b>17.50</b>	<b>45.8</b>	<b>n.a.</b>	<b>33.50</b>	-
<b>SOLID CATTLE MANURE</b>																						
Cattle manure	n.a.	4.0	n.a.	75	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq
Cow biosolids (dewatered and stabilized)	~32	~2.7	~30	<=10 (dried)	n.a.	400	120	2	~61	n.a.	n.a.	~20	~53	~36	~2.0	n.a.	n.a.	n.a.	68.6	n.a.	n.a.	gg
						500			~57			~21	~58	~35	~1.7				62.3			
						600			~51			~22	~63	~34	~1.4				54.2			
Cattle stall manure	n.a.	n.a.	n.a.	38	17	n.a.	n.a.	n.a.	42	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	d
Cattle feedlot	n.a.	n.a.	n.a.	n.a.	n.a.	450	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	44	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	hh
Paved-feedlot manure	45.1	2.37	15.4	77.9	17.66	350	120	2.5 200-350°C	51.1	n.a.	n.a.	23.5	28.7	53.32	3.64	1.14	3.20	20.39	60.5	n.a.	n.a.	ii
						700		8.33 200-700°C	32.2			36.3	44.0	52.41	1.70	1.76	4.91	17.23	37.5			
Bull manure with sawdust	43.8	0.6	5.3	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	33.0	8.3	66.3	1.3	0.26	2.44	n.a.	n.a.	n.a.	n.a.	ss
						400						53.7	9.4	68.5	1.2	0.31	2.89					
						450						44.5	9.3	71.5	1.1	0.25	3.04					
						500						59.2	10.4	74.1	1.1	0.31	3.35					
						550						50.1	10.9	74.3	1.1	0.31	3.28					
					600						59.4	10.6	76.0	0.8	0.30	3.58						
<b>Mean****, 15</b>	<b>40.3</b>	<b>2.42</b>	<b>16.9</b>	<b>63.6</b>	<b>17.33</b>	<b>488</b>	-	-	<b>46.7</b>	<b>n.a.</b>	<b>n.a.</b>	<b>33.6</b>	<b>34.7</b>	<b>50.9</b>	<b>1.82</b>	<b>0.87</b>	<b>3.58</b>	<b>18.81</b>	<b>55.4</b>	<b>n.a.</b>	<b>n.a.</b>	-
<b>SOLID SWINE MANURE</b>																						
Separated swine solids	47.4	4.11	20.9	78.5	19.39	350	120	2.5 200-350°C	62.3	n.a.	n.a.	17.7	32.5	51.51	3.54	3.89	1.78	21.12	67.7	n.a.	n.a.	ii
						700		8.33 200-700°C	36.4			33.8	52.9	44.06	2.61	5.90	2.57	15.07	33.8			

Table will be continued on the next page.



**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.			
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li- quid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV				
	C	N												C	N	P	K								
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg							
(3)							(1)				(2)					(1)*(2)/(3)									
Separated swine solids	47.3	4.58	18.5	12.8 (dried)	19.5	620	120	13	~45 <sup>†</sup>	n.a.	n.a.	41.2	44.7	50.7	3.26	7.15	2.56	18.3	~48	29.5 MJ/S m <sup>3</sup>	n.a.	u			
<b>Mean****, 15</b>	<b>47.4</b>	<b>4.35</b>	<b>19.7</b>	<b>78.5</b>	<b>19.45</b>	<b>573</b>	-	-	<b>47.2</b>	<b>n.a.</b>	<b>n.a.</b>	<b>33.5</b>	<b>43.7</b>	<b>49.2</b>	<b>3.17</b>	<b>6.02</b>	<b>2.37</b>	<b>18.20</b>	<b>49.4</b>	<b>29.50</b>	<b>n.a.</b>	<b>-</b>			
<b>SOLID POULTRY MANURE</b>																									
Chicken litter	34.4	3.27	30.6	10.2	13.0	620	120	13	~46 <sup>†</sup>	n.a.	n.a.	30.8	53.2	41.5	2.77	1.72	6.77	13.5	~56	15.0 MJ/S m <sup>3</sup>	n.a.	u			
Pelletized poultry litter ( <i>Gallus domesticus</i> )	36.2	4.1	24.4	n.a.	n.a.	350	60-180	n.a.	57	n.a.	n.a.	27.4 <sup>†</sup>	35.9	46.1	4.9	2.94	n.a.	n.a.	n.a.	72.6	n.a.	n.a.	jj		
						700			36			33.5 <sup>†</sup>												52.4	44.0
Poultry litter ( <i>Gallus domesticus</i> )	32.6	4.51	n.a.	n.a.	n.a.	400	n.a.	n.a.	~37	n.a.	n.a.	n.a.	n.a.	39.2	3.47	3.01	5.11	n.a.	44.5	n.a.	n.a.	n.a.	kk		
						500			~29															39.2	3.09
Poultry litter (fine: <0.85mm)	35.6	5.9	13.7	10.6	n.a.	500	n.a.	n.a.	45.0	35.0	20.0	n.a.	34.6	53.6	5.0	n.a.	n.a.	n.a.	n.a.	67.8	n.a.	n.a.	p		
Poultry litter (middle: 0.85-3.35 mm)	37.6	2.91	13.3	8.5	500	40.0			45.0	15.0	27.1		61.6	3.1	65.5										
Poultry litter (coarse: >3.35 mm)	36.4	2.92	13.4	10.2	500	42.8			35.7	21.5	35.2		51.6	3.0	60.7										
Poultry litter	n.a.	n.a.	n.a.	n.a.	n.a.	400			>15	n.a.	n.a.		n.a.	n.a.	n.a.					42.3				4.2	n.a.
Poultry litter	n.a.	3.07	28.5	7.7	n.a.	350	~20	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	51.29	n.a.	3.22	2.40	7.46	n.a.	n.a.	n.a.	n.a.	rr		
						400								~218 <sup>e</sup>		51.52	56.62	2.63						2.63	8.12
						450								~190 <sup>e</sup>		48.69	58.66	2.23						2.66	8.57
						500								~163 <sup>e</sup>		47.57	60.58	1.21						2.79	8.79
						550								~135 <sup>e</sup>		46.62	60.65	0.31						2.98	8.97
						600								~113 <sup>e</sup>		45.71	60.78	0.12						3.05	9.15
Poultry litter	42.2	3.67	16.9	23.7	15.11	350	120	2.5 200-350°C	54.3	n.a.	n.a.	27.0	30.7	51.07	4.45	2.08	4.85	19.03	65.9	n.a.	n.a.	ii			
						700			8.33 200-700°C			36.7											35.5	46.2	45.91

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.	
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content		HHV
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)					(2)					(1)*(2)/(3)					
Poultry manure with sawdust	25.3	2.1	36.3	~10 (ap)	n.a.	350	15-20	<10	n.a.	n.a.	n.a.	1.6	51.2	30.6	2.0	2.13	3.18	n.a.	n.a.	n.a.	n.a.	ss
						400						4.5	51.7	32.1	1.2	1.80	2.81					
						450						0.2	53.6	35.4	1.2	1.73	2.74					
						500						4.2	52.6	27.8	1.1	3.06	4.86					
						550						0.6	54.9	28.1	1.1	2.01	3.21					
						600						-0.2	55.8	28.7	0.9	2.36	3.68					
Turkey litter	40.5	3.43	20.3	26.1	15.48	350	120	2.5 200-350°C	58.1	n.a.	n.a.	23.1	34.8	49.28	4.07	2.62	4.01	17.28	70.8	n.a.	n.a.	ii
						700		8.33 200-700°C	39.9			29.2	49.9	44.77	1.94	3.66	5.59	14.45	44.2			
<b>Mean****, 15</b>	<b>35.6</b>	<b>3.59</b>	<b>21.9</b>	<b>13.4</b>	<b>14.53</b>	<b>500</b>	<b>-</b>	<b>-</b>	<b>44.1</b>	<b>38.6</b>	<b>18.8</b>	<b>24.2</b>	<b>42.9</b>	<b>46.1</b>	<b>3.12</b>	<b>2.76</b>	<b>5.85</b>	<b>15.42</b>	<b>57.3</b>	<b>15.0</b>	<b>n.a.</b>	<b>-</b>
<b>LIQUID CATTLE AND SWINE MANURE</b>																						
Liquid manure	45	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a
Cattle manure	n.a.	3.5	n.a.	90	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq
Dairy manure	46.5	2.29	14.8	86.5	17.62	350	120	2.5 200-350°C	54.9	n.a.	n.a.	23.2	24.2	55.80	2.60	1.00	1.43	20.90	65.7	n.a.	n.a.	ii
						700		8.33 200-700°C	35.0			34.7	39.5	56.67	1.51	1.69	2.31	18.97	42.7			
Raw dairy manure	n.a.	n.a.	n.a.	~10 (ap)	n.a.	500	15-20	<10	n.a.	n.a.	n.a.	35.0	32.0	51.2	2.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ss
Cow manure	n.a.	n.a.	n.a.	n.a.	n.a.	400	40	5-10	n.a.	n.a.	n.a.	n.a.	70.4	17.50	1.35	0.44	2.64	n.a.	n.a.	n.a.	n.a.	mm
Swine manure	n.a.	3.6	n.a.	94	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq
Swine manure	n.a.	n.a.	n.a.	n.a.	n.a.	350	>15	n.a.	n.a.	n.a.	n.a.	21.5 <sup>F</sup> VM <sub>db</sub> : 46.2	32.3	50.8	3.74	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ll
<b>Mean****, 16</b>	<b>45.8</b>	<b>3.13</b>	<b>14.8</b>	<b>90.2</b>	<b>17.62</b>	<b>444</b>	<b>-</b>	<b>-</b>	<b>45.0</b>	<b>n.a.</b>	<b>n.a.</b>	<b>28.5</b>	<b>41.6</b>	<b>43.9</b>	<b>2.31</b>	<b>0.89</b>	<b>2.26</b>	<b>19.94</b>	<b>54.2</b>	<b>n.a.</b>	<b>n.a.</b>	<b>-</b>
<b>SUGAR-BEET LEAF AND POTATO HAULM</b>																						
Sugar-beet leaf + potato haulm	48	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics					Process conditions			Product distribution			Biochar characteristics								Gas	Bio-oil	Ref.		
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Li-liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery	Energy content	HHV			
	C	N												C	N	P	K							
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg						
(3)							(1)						(2)				(1)*(2)/(3)							
Sugar-beet leaf + potato haulm	n.a.	n.a.	n.a.	82.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	xx		
Sugar-beet leaf	n.a.	n.a.	~25	85.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	yy		
Sugar-beet leaf	41	2.10	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	zz		
Potato haulm	40	0.55	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	zz		
<b>Mean****</b>	<b>43.0</b>	<b>1.33</b>	<b>25.0</b>	<b>84.0</b>	<b>n.a.</b>	<b>n.a.</b>	-	-	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	-		
<b>COMMERCIAL AND INDUSTRIAL WASTE</b>																								
Brewer's grain	50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a		
Brewer's grain	n.a.	4.5	n.a.	77.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq		
Apple pomace	50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a		
Apple pomace	n.a.	1.1	n.a.	65	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq		
Grape marc	n.a.	2.3	n.a.	55	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq		
Distillers grain	n.a.	8	n.a.	94	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq		
Distillers grain	n.a.	n.a.	n.a.	n.a.	n.a.	350	>15	n.a.	n.a.	n.a.	n.a.	44.8 VM <sub>db</sub> : 43.9	11.3	67.4	7.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	ll	
						400																		51.4 VM <sub>db</sub> : 36.9
DDGS (from bioethanol production, from wheat, corn and triticale, pelletized)	49.0	1.00	6.28	6.5	22.84 MJ/kg <sub>daf</sub> (LHV)	450	n.a.	n.a.	~40	~22.5	~17.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.66 MJ/Nm <sup>3</sup> (LHV)	n.a.	b
						500			~40	~21.5	~18.5											n.a.		
						550			~31	~17	~52											23.6		
Molasses	50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a	
Molasses	n.a.	1.5	n.a.	15	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq	
<b>Mean****,17</b>	<b>49.8</b>	<b>3.07</b>	<b>6.28</b>	<b>61.3</b>	<b>n.a.</b>	<b>438</b>	-	-	<b>37.0</b>	<b>20.3</b>	<b>29.3</b>	<b>48.1</b>	<b>17.6</b>	<b>66.1</b>	<b>4.18</b>	<b>n.a.</b>	<b>2.05</b>	<b>n.a.</b>	<b>40.7</b>	<b>n.a.</b>	<b>n.a.</b>	-		

Table will be continued on the next page.

**Table A.7 continued**

Feedstock	Feedstock characteristics				Process conditions			Product distribution			Biochar characteristics							Gas	Bio-oil	Ref.		
	Elements		Ash	Water	HHV	T <sub>max</sub>	Residence time**	Heating rate	Char	Liquid	Gas	Fixed C	Ash	Elements				HHV	C recovery		Energy content	HHV
	C	N												C	N	P	K					
	wt% <sub>db</sub>		wt%*	MJ/kg <sub>db</sub>	°C	min	°C/min	wt% <sub>db</sub> ***,****			wt%****				MJ/kg****	% <sub>db</sub> ****	MJ/m <sup>3</sup>	MJ/kg				
(3)							(1)						(2)				(1)*(2)/(3)					
<b>ORGANIC MUNICIPAL SOLID WASTE</b>																						
Organic waste	n.a.	~1.5 <sup>c</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	nn	
Organic waste	n.a.	n.a.	n.a.	43	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	aaa	
Municipal biowaste	25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	a	
Food waste	n.a.	n.a.	n.a.	72.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	aaa	
Food waste	n.a.	n.a.	n.a.	~80	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	nn	
Food waste	n.a.	n.a.	n.a.	~10 (ap)	n.a.	400	15-20	<10	n.a.	n.a.	n.a.	18.3	46.0	52.4	3.4	0.50	1.46	n.a.	n.a.	n.a.	n.a.	ss
						500						13.6	52.7	42.0	2.8	0.75	2.13					
						600						13.6	52.0	32.0	1.2	0.82	2.79					
Municipal greenwaste	n.a.	n.a.	n.a.	n.a.	n.a.	450	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	76	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	hh	
Greenwaste	n.a.	~1.2 <sup>c</sup>	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	nn	
Greenwaste	n.a.	2.5	n.a.	88	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	qq	
Street greenwaste	37.1	1.49	23.1	n.a.	15.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	pp	
Summer yard waste (mainly grass)	n.a.	n.a.	n.a.	~10 (ap)	n.a.	500	15-20	<10	n.a.	n.a.	n.a.	59.8	25.5	53.5	4.9	1.20	6.13	n.a.	n.a.	n.a.	ss	
Fall yard waste (mainly leaves)	n.a.	n.a.	n.a.	~10 (ap)	n.a.	500	15-20	<10	n.a.	n.a.	n.a.	45.2	14.5	60.7	1.1	0.21	1.08	n.a.	n.a.	n.a.	ss	
Winter yard waste (mainly brush)	n.a.	n.a.	n.a.	~10 (ap)	n.a.	500	15-20	<10	n.a.	n.a.	n.a.	58.2	1.8	84.0	0.1	0.013	0.087	n.a.	n.a.	n.a.	ss	
<b>Mean****, 17</b>	<b>31.1</b>	<b>1.67</b>	<b>23.1</b>	<b>70.9</b>	<b>15.2</b>	<b>490</b>	-	-	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>44.6</b>	<b>23.0</b>	<b>63.3</b>	<b>2.14</b>	<b>0.53</b>	<b>2.36</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>n.a.</b>	<b>-</b>

Values rounded. If not otherwise indicated, process conditions and, thus, product distributions and biochar characteristics refer to atmospheric pressure. Values with the leading “~” refer to data obtained from graphical illustrations. \* = Based on as-received FW. \*\* = Solid residence time at T<sub>max</sub>. \*\*\* = Based on feedstock dry weight. Note that it was not always entirely clear from the literature whether the char, liquid and gas yields were indeed based on the feedstock dry weights. Still, the values have been assigned to this measurement unit. The reason is that, if the char yields were truly given on the basis of feedstock fresh weights, the direction of bias would be an underestimation of the char yields, leading to conservative measures, not overstating the impact of biochar. \*\*\*\* = Note that many values refer to biochar dry weight; however, this table does not differentiate between biochar fresh weight and biochar dry weight since it could not always be deducted from the literature whether the biochar yields and characteristics were based on biochar fresh weight or biochar dry weight. This procedure is justified since the water contents of biochar tend to be below 4% (e.g., Kern et al. 2012; Inguanzo et al. 2002; Hossain et al. 2011; Spokas et al. 2011) and are, thus, considered to be negligible. Beyond the just-mentioned studies, biochar water contents were not given in the literature cited in this table. \*\*\*\*\* = Weighted average over the values in normal font size in the colored fields in each

column, i.e., first, the mean across each study was taken and, then, the overall mean was calculated. Note that, due to missing data, the type and number of the specific feedstocks entering the calculation of the means of a given feedstock category might differ across the single characteristics.

*Sources:*

a) Schuchardt and Vorlop (2010)	s) Bajus (2010)	kk) Gaskin et al. (2008)
b) Kern et al. (2012)	t) Kuzyakov et al. (2009)	ll) Spokas et al. (2011)
c) Kloss et al. (2012)	u) Ro et al. (2010)	mm) Singh et al. (2010)
d) Gaunt and Cowie (2009)	v) Fahmi et al. (2007)	nn) Kern et al. (2010)
e) Di Blasi et al. (2000)	w) Keiluweit et al. (2010)	oo) Rentz et al. (1999), cited in Fritsche et al. (2004b)
f) Knudsen et al. (2004)	x) Rutherford et al. (2005)	pp) Hartmann and Kaltschmitt (2002)
g) Mahinpey et al. (2009)	y) Kluge et al. (2008)	qq) FNR (2010)
h) de Wild et al. (2009)	z) Rumphorst and Ringel (1994)	rr) Song and Guo (2012)
i) Ateş and Işıklıdağ (2008)	aa) Kistler et al. (1987)	ss) Enders et al. (2012a, 2012b)
j) Haumaier and Zech (1995)	bb) Bridle and Pritchard (2004)	tt) Williams and Besler (1996)
k) Antal et al. (2000)	cc) Agrafioti et al. (2013)	uu) Nguyen and Lehmann (2009)
l) Turney et al. (2006)	dd) Inguanzo et al. (2002)	vv) Hwang et al. (2007)
m) Demirbaş (2001)	ee) Hossain et al. (2011)	ww) Kim and Parker (2008)
n) Yang and Sheng (2012)	ff) He et al. (2010)	xx) Koch (2009)
o) Rutherford et al. (2005, 2008)	gg) Shinogi and Kanri (2003)	yy) IfZ (2013)
p) Das et al. (2008)	hh) Sinclair et al. (2009)	zz) Gutser and Vilsmeier (1985)
q) Chen et al. (2008)	ii) Cantrell et al. (2012)	aaa) Wilfert et al. (2004)
r) Susott et al. (1975), cited in Shafizadeh (1984)	jj) Novak et al. (2009)	

*Notes:*

§ Own calculation, based on the respective daf value and ash content of biomass (biochar)	‡ At a pressure of 1.5 kPa in the first stage
# At a pyrolysis pressure of 20 psi, where the char yield is roughly constant over 10-40 psi	£ Own calculation, based on the volatile-matter and ash contents (Fixed C = 100-ash-VM)
## See comment ***** for why the value for biochar fixed carbon exceeds the total biochar carbon	¥ Own calculation, based on the air-dry/fresh-weight value and water content
¶ Auger reactor	¥ Own calculation, based on the water content of biochar of 4.2% <sub>FW</sub> at 400°C, 3.5% <sub>FW</sub> at 500°C and 3.4% <sub>FW</sub> at 700°C
¶¶ Fluidized-bed reactor	¢ Own calculation, based on the heating rate and reaction time as given in Song and Guo (2012)
\$ Transformed from cal/g into MJ/kg using 1 cal/g = 4.1868/1,000 MJ/kg	& Average of values cited in Kern et al. (2010: Table 6)
† Deducted from the C recovery	
‡ Derived from the moisture content, i.e. 6.54% = 0.07/(1+0.07) (cp. FNR 2005: 85)	

- 1) Although cereal straw consists of ~45% wheat, ~9% rye and ~46% other cereals in FM (Fritsche et al. 2004a), the mean is largely based on wheat straw due to the lack of sufficient data for the other straw types.
- 2) Due to the lack of sufficient data for all the wood types, no weighting of beech, oak, spruce and pine wood was undertaken. Except for oak, the distribution was nearly even, with beech, oak, spruce and pine accounting for 29%, 10%, 33% and 29% in 2010, 30%, 11%, 31% and 27% in 2020, and 31%, 11%, 31% and 27% in 2030 (Fritsche et al. 2004a). Moreover, the shares of foliage in forestry residues are negligible: The shares of foliage are 5.46% in 2010, 4.13% in 2020 and 2.77% in 2030, based on a foliage share of 7.6% in smallwood and 18.4% in logging residues, the assumption that the entire foliage remains in the forest on 60% (2010), 70% (2020), 80% (2030) of the forest area, and the share of logging residues of 56% (2010), 57% (2020), 58% (2030) in total forestry residues (Fritsche et al. 2004a).
- 3) Based on hardwood, as in Nitsch et al. (2004).
- 4) As for *Green waste: Compensation areas*.
- 5) As for *Forestry residues*.
- 6) Weighted average (2/3 herbaceous biomass, 1/3 woody biomass) since the major part of open-country biomass residues consists of herbaceous biomass according to Nitsch et al. (2004).
- 7) Largely based on the same values as *Forestry residues*, however, without foliage and with some additional items; according to Fritsche et al. (2004a), including bark.
- 8) Including *Lolium multiflorum-2x* (stem), *Lolium multiflorum-2xi* (stem), *Festuca pratensis-2x* (stem), *Lolium multiflorum-6x* (leaves), *Festuca arundinacea-6x* (leaves), *Festuca pratensis-2x* (leaves), *Lolium perenne-2x* (leaves), *Lolium multiflorum-4x* (leaves), and *Lolium multiflorum-2x* (leaves).
- 9) Due to the lack of data, no further differentiation was possible between green waste from arable land and grassland.
- 10) Weighted average (2/3 herbaceous biomass, 1/3 woody biomass), based on the relation of woody and herbaceous biomass in habitat-connectivity areas obtained from the dry-mass values given in Table A.1.
- 11) As for *Biomass: Habitat-connectivity areas* since extensive grassland also covers habitat-connectivity areas and the heating values of both categories compare well (Table A.1).
- 12) Short-rotation coppice refers to poplar and willow as in Hartmann and Kaltschmitt (2002).

- 13) In order to reduce the dominating effect of digested sewage sludge, first, the mean for digested sewage sludge was calculated and, then, the overall average was taken for digestates. Due to the lack of data, however, digestates are still largely driven by digested sewage sludge.
- 14) Due to the lack of data, it was not possible to differentiate between municipal and industrial sewage sludge.
- 15) Feedstocks that (seem to) include bedding.
- 16) Feedstocks that do not (seem to) include bedding.
- 17) Due to the lack of data, it was not possible to weight the different items belonging to this category.

## A.4 Area of Arable Land

The study by Teichmann (2014) assumes that biochar is added to arable land in Germany. The area of arable land potentially available up to 2050 and referred to in Section 3.4 of Teichmann (2014) has been derived from Nitsch et al. (2004) and Fritsche et al. (2004a),<sup>19</sup> with some updates from Statistisches Bundesamt (2013). The acreage is consistent with the assumptions underlying the derivation of the technical biomass potentials for biochar production. The detailed calculations can be found in Table A.8.

**Table A.8: Total Area of Arable Land, Germany, 2010-2050**

		2000	2010*	2020	2030	2040	2050
		Million ha					
Arable land for food crops (in 2000) <sup>a</sup>	(A)	11.03	11.03	11.03	11.03	11.03	11.03
Acreage balances <sup>a</sup>	(B)	-	0.52	1.57	2.39	3.39 <sup>l</sup>	4.49 <sup>l</sup>
Set-aside land	(C)	-	0.25 <sup>b</sup>	0.25 <sup>c</sup>	0.25 <sup>c</sup>	0.25 <sup>c</sup>	0.25 <sup>c</sup>
Correction <sup>d</sup>	(D)	-	0.51	-	-	-	-
<b>Arable land for food crops<sup>e</sup></b>	(E)	-	<b>9.5<sup>f</sup></b>	<b>9.21</b>	<b>8.39</b>	<b>7.39<sup>f</sup></b>	<b>6.29<sup>f</sup></b>
<b>Arable land for energy crops<sup>g</sup></b>	(F)	-	<b>2.1</b>	<b>2.1</b>	<b>2.1</b>	<b>3.1</b>	<b>4.2</b>
<b>Set-aside land</b>	(G)	-	<b>0.25<sup>b</sup></b>	<b>0.25<sup>c</sup></b>	<b>0.25<sup>c</sup></b>	<b>0.25<sup>c</sup></b>	<b>0.25<sup>c</sup></b>
<b>Erosion areas (short-rotation coppice)<sup>h</sup></b>	(H)	-	<b>0<sup>i</sup></b>	<b>0<sup>i</sup></b>	<b>0.55</b>	<b>0.55</b>	<b>0.55</b>
<b>TOTAL<sup>j</sup></b>	(I)	-	<b>11.85<sup>b</sup></b>	<b>11.56</b>	<b>11.29</b>	<b>11.29<sup>k</sup></b>	<b>11.29<sup>k</sup></b>

Values rounded.

Sources:

- Fritsche et al. (2004a, "Umwelt" scenario). The acreage balances (Fritsche et al. 2004a: Table 121) indicate the area of arable land that is set free in each year compared to the base year (2000) due to a lower acreage demand for food production in Germany.
  - Statistisches Bundesamt (2013).
  - Own assumption, based on the 2010 value.
  - Own calculation, reconciling the values obtained from Fritsche et al. (2004a, "Umwelt" scenario) with the updated data from Statistisches Bundesamt (2013), i.e. (D) = (A) – (B) – (C) – (E). The value corresponds well with the reduction in the acreage for food production (approximately 0.45 million ha) necessary to accommodate the larger acreage for energy crops in 2010, see Table A.1, comment (\*).
  - Own calculation, (E) = (A) – (B) – (C) – (D).
  - Own calculation, (E) = (I) – (H) – (G) – (F).
  - See Table A.4.
  - Nitsch et al. (2004, "NaturschutzPlus" scenario). Since biochar is applied once on a given soil, it is assumed that it can be incorporated into land for perennial crops.
  - Own assumption, see Table A.1, comment (\*).
  - Own calculation, (I) = (E) + (F) + (G) + (H).
  - Own assumption, based on the 2030 value.
  - Own calculation, (B) = (A) – (C) – (D) – (E).
- \* The 2010 values will be used for 2015.

<sup>19</sup> The data from Nitsch et al. (2004) and Fritsche et al. (2004a) can be combined despite their different assumptions concerning the land area under environmental protection since any differences are accounted for in the area available for energy crops, leaving the area of arable land for food production unchanged.

## A.5 GHG Emissions from Manure Management

Compared to conventional feedstock management, the conversion of biomass into biochar is associated with a change in GHG emissions. For solid cattle, swine and poultry manure under conventional manure management, Teichmann (2014: Table 12) assumes solid storage and subsequent land spread, while liquid storage plus land spread is assumed for liquid cattle and swine manure. The decomposition of the manures during conventional manure management and after their soil addition often causes CH<sub>4</sub> and N<sub>2</sub>O emissions that can be avoided with biochar production, while the soil incorporation of these feedstocks also leads to some carbon sequestration via SOC formation, which needs to be accounted for in the net GHG mitigation potential of biochar. This section provides the background information and calculations for the derivation of the respective GHG emissions and carbon sequestration from conventional manure management displayed in Tables 14-16 of Teichmann (2014).

Starting with CH<sub>4</sub> emissions from manure management, Tables A.9-A.11 contain the data and calculations for the transformation of the CH<sub>4</sub> emissions per animal and year deductible from Dong et al. (2006) and UBA (2013) (Table A.10, column 6) into the CH<sub>4</sub> emissions per tonne of dry-matter feedstock used by Teichmann (2014: Table 14, column 1) (Table A.11, column 9).

To obtain the carbon sequestration potential of the manures when they are spread on land (Teichmann 2014: Table 15), Tables A.12-A.14 derive the CO<sub>2</sub> emissions from manure management necessary to calculate the carbon contents of the manures prior to soil addition.

Turning to the N<sub>2</sub>O emissions from manure management displayed in Teichmann (2014: Table 16), Table A.15 outlines the derivation of the emission factors for the direct N<sub>2</sub>O emissions and Table A.16 the derivation of the default fractions of manure N volatilizing as NH<sub>3</sub> and NO<sub>x</sub> required to calculate the indirect N<sub>2</sub>O emissions from manure management.

Finally, to derive the N<sub>2</sub>O emissions from the soil addition of the manures (Teichmann 2014: Table 16), Table A.17 contains the feedstock-specific fractions of manure N lost due to N<sub>2</sub>O emissions from manure management that are necessary to obtain the N contents of the manures prior to land spread.

**Table A.9: Livestock Population in Germany in 2000**

	Total population <sup>a</sup>	Population share for energy production <sup>b</sup>	Population for energy production <sup>c</sup>
	Million animals	% of (1)	Million animals
<b>Livestock</b>	(1)	(2)	(3)
Cattle	3.1	83	2.6
Dairy cows	4.8		4.0
<b>Cattle</b>	-	-	<b>6.6</b>
Swine	42.3	94	39.8
<b>Swine</b>	-	-	<b>39.8</b>
Fattened chicken	471.4	98	462.0
Fattened turkeys	23.7		23.2
Laying hens	50.7		42.1
<b>Poultry</b>	-	-	<b>527.3</b>

Values rounded.

Sources:

- Fritsche et al. (2004b: Table 20).
- Fritsche et al. (2004a: Table 43).
- Own calculation, based on columns 1 and 2.



**Table A.10: Annual CH<sub>4</sub> Emission Factors from Manure Management per Animal**

Feedstocks	Conventional feedstock management (see Teichmann 2014: Table 12)	Daily VS excretions <sup>a</sup>		B <sub>0</sub> <sup>c</sup>	MCF		Annual EF per animal <sup>h</sup>
		kg VS <sub>oDM</sub> animal <sup>-1</sup> d <sup>-1</sup>		m <sup>3</sup> CH <sub>4</sub> /kg VS <sub>oDM</sub>	% of B <sub>0</sub>		kg CH <sub>4</sub> animal <sup>-1</sup> a <sup>-1</sup>
		(1)	(2)	(3)	(4)	(5)	(6)
Solid cattle manure	Solid storage, land spread	Dairy cattle: 3.99 Other cattle: 1.47	3.01 <sup>b</sup>	0.23	Dairy cattle: 2.0 <sup>e</sup> Other cattle: 7.7 <sup>e</sup>	4.2 <sup>b</sup>	<b>7.11</b>
Solid swine manure	Solid storage, land spread	0.26		0.30	8.0 <sup>e</sup>		<b>1.53</b>
Solid poultry manure	Solid storage, land spread	0.026		0.368 <sup>d</sup>	1.5 <sup>f</sup>		<b>0.04</b>
Liquid cattle manure	Liquid storage, land spread	Dairy cattle: 3.99 Other cattle: 1.47	3.01 <sup>b</sup>	0.23	Dairy cattle: 14.4 <sup>g</sup> Other cattle: 13.6 <sup>g</sup>	14.1 <sup>b</sup>	<b>23.87</b>
Liquid swine manure	Liquid storage, land spread	0.26		0.30	21.7 <sup>g</sup>		<b>4.14</b>

Values rounded. VS = volatile solids (animal-specific). B<sub>0</sub> = maximum methane producing capacity (animal-specific). MCF = methane conversion factor (storage-specific). EF = emission factor. For more detailed definitions, see Dong et al. (2006).

*Sources:*

- a) 2009-2011 averages from UBA (2013: Table 155).
- b) Weighted average of the values in (1), respectively (4), where the weights are based on the distribution of dairy cows and other cattle in Germany in 2000 from Table A.9 (column 3) and, thus, amount to 0.39 = 2.6/6.6 for other cattle and 0.61 = 4.0/6.6 for dairy cattle.
- c) UBA (2013: Table 161).
- d) 2009-2011 average from UBA (2013: Table 162).
- e) 2009-2011 averages from UBA (2013: Table 167), i.e. based on mean MCF for all straw-based systems.
- f) UBA (2013: p. 417).
- g) 2009-2011 averages from UBA (2013: Table 166), i.e. based on mean MCF for all slurry-based systems.
- h) Own calculation, based on the formula  $EF = (VS \cdot 365 \text{ d/a}) (B_0 \cdot 0.67 \text{ kg/m}^3 \cdot \text{MCF}/100)$  adapted from Equation 10.23 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Dong et al. 2006).

Note that bedding material, such as straw, is not counted as an emission source in the Tier 2 method (Dong et al. 2006) followed here and used by UBA (2013). Moreover, note that the annual CH<sub>4</sub> emission factors per animal are based on current data and, thus, do not reflect future changes in animal diets, storage systems, etc.

**Table A.11: CH<sub>4</sub> Emissions from Manure Management per Dry Tonne of Feedstock in Germany in 2000**

	Energy content of biogas <sup>a</sup>	Feedstock dry mass <sup>a</sup>	Total livestock population for energy production <sup>b</sup>	Manure per animal <sup>c</sup>	Total livestock population for energy production (split) <sup>d</sup>	Annual average livestock population for energy production <sup>e</sup>	Annual CH <sub>4</sub> emission factor per animal <sup>f</sup>	Total annual CH <sub>4</sub> emissions <sup>g</sup>	CH <sub>4</sub> emissions per t <sub>DM</sub> of feedstock <sup>h</sup>
	PJ/a	kt <sub>DM</sub> /a	Million animals/a	t <sub>DM</sub> /animal	Million animals/a	Million animals/a	kg CH <sub>4</sub> animal <sup>-1</sup> a <sup>-1</sup>	t CH <sub>4</sub> /a	t CH <sub>4</sub> /t <sub>DM</sub> feedstock
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Solid cattle manure	17.6	4,791	6.6	0.726	2.6	2.6	7.11	18,486	<b>0.004</b>
Solid swine manure	5.9	1,243	39.8	0.031	17.9	17.9	1.53	27,387	<b>0.022</b>
Solid poultry manure	7.2	1,028	527.3	0.002	527.3	96.6	0.04	3,864	<b>0.004</b>
Liquid cattle manure	44.5	7,482	6.6	1.134	4.0	4.0	23.87	95,480	<b>0.013</b>
Liquid swine manure	12.9	1,505	39.8	0.038	21.9	21.9	4.14	90,666	<b>0.060</b>

Values rounded. Note that the CH<sub>4</sub> emissions per t<sub>DM</sub> of feedstock are derived from 2000 data since the livestock population used by Fritsche et al. (2004a, 2004b) was only available for that year.

*Sources:*

- Derivation as for the corresponding 2010-2030 values in Table A.2.
- Table A.9 (column 3). Note that the total cattle (swine) population is entered for both solid and liquid manure.
- Own calculation, based on the formula (4) = (2) · 1,000 / ((3) · 1,000,000).
- Own calculation, based on the assumption that one cow contributes 39% to solid cattle manure and 61% to liquid cattle manure and one swine contributes 45% to solid swine manure and 55% to liquid swine manure. Thereby, the relative contributions are derived from column 4, which reveals that the total of 1.86 t<sub>DM</sub> (= 0.726 + 1.134) of solid and liquid manure is produced by a cow and 0.069 t<sub>DM</sub> (= 0.031 + 0.038) by a swine. That is, the total cattle (swine) population from column 3 is split 39:61 (45:55) between solid and liquid cattle (swine) manure.
- Own calculation, transforming the values from column 5 – which refer to the number of animals grown annually – into their annual averages as required by Dong et al. (2006). For poultry, it is assumed that flocks of fattened chicken are replaced 10 times a year and those of fattened turkeys 2.8 times a year, while laying hens are alive for a complete year (Fritsche et al. 2004b: Table 19). Since the entire poultry population is associated with solid manure, the annual average population can be directly derived from Table A.9 (column 3), i.e. as  $96.6 = 462.0/10 + 23.2/2.8 + 42.1$ . For the remaining animals, it is assumed that they are alive for the entire year.
- Table A.10 (column 6).
- Calculated as (8) = (6) · (7) · 1,000, i.e. adapted from equation 10.22 of Dong et al. (2006).
- Own calculation, based on the formula (9) = (8) / ((2) · 1,000).

**Table A.12: Emissions from Cattle Manure Management**

Feedstocks	Storage condition	CH <sub>4</sub> emissions		CO <sub>2</sub> emissions	CO <sub>2</sub> :CH <sub>4</sub> ratio <sup>c</sup>	Average CO <sub>2</sub> :CH <sub>4</sub> ratio <sup>d</sup>
		g CH <sub>4</sub> /kg <sub>DM</sub> feedstock <sup>a</sup>	g CO <sub>2</sub> e/kg <sub>DM</sub> feedstock <sup>b</sup>	g CO <sub>2</sub> /kg <sub>DM</sub> feedstock <sup>a</sup>		
		(1)	(2)	(3)	(4)	(5)
Dairy cattle manure	Stockpile, 3 months	7.92	198.00	440.00	2.22	3.32
Beef cattle manure		2.85	71.25	358.11	5.03	
Dairy cattle manure	Slurry, 3 months	15.96	399.00	208.13	0.52	0.54
Beef cattle manure		9.76	244.00	141.69	0.58	

Values rounded.

Sources:

- Pattey et al. (2005: Table 5).
- Own calculation, multiplying the CH<sub>4</sub> emissions (column 1) by their 100-year GWP of 25 (Forster et al. 2007).
- Own calculation, (4) = (3)/(2).
- Weighted average of the respective values in column 4, where the weights are based on the distribution of dairy cows and other cattle in Germany in 2000 from Table A.9 (column 3) and, thus, amount to 0.39 = 2.6/6.6 for other cattle and 0.61 = 4.0/6.6 for dairy cattle.

**Table A.13: Emissions from Liquid Swine Manure Management**

Feedstocks	Storage condition	CH <sub>4</sub> emissions <sup>a</sup>	CO <sub>2</sub> emissions <sup>b</sup>	CO <sub>2</sub> :CH <sub>4</sub> ratio <sup>c</sup>	
		g CO <sub>2</sub> e/(d · kg animal)	g CO <sub>2</sub> /(d · kg animal)	(3)	(4)
		(1)	(2)	(3)	(4)
Liquid swine manure	Uncovered concrete tank	6.90	0.85	0.12	0.51
	Uncovered earthen manure basin	7.88	2.01	0.26	
	Covered (blown chopped straw) earthen manure basin	1.49	1.73	1.16	

Values rounded.

Sources:

- Laguë et al. (2005: Table 4); average CH<sub>4</sub> emissions; however, based on the 100-year GWP of 25 (Forster et al. 2007) instead of 21 as used by Laguë et al. (2005).
- Laguë et al. (2005: Table 4); average CO<sub>2</sub> emissions.
- Own calculation, where (3) = (2)/(1) and (4) gives the simple average over the values in column 3.

**Table A.14: CO<sub>2</sub> Emissions from Manure Management**

Feedstocks	Conventional feedstock management (Teichmann 2014: Table 12)	CH <sub>4</sub> emissions		CO <sub>2</sub> emissions
		t CH <sub>4</sub> /t <sub>DM</sub> feedstock <sup>a</sup>	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock <sup>c</sup>	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock
		(1)	(2)	(3)
Solid cattle manure	Solid storage, land spread	0.004	0.100	0.332 <sup>d</sup>
Solid swine manure	Solid storage, land spread	0.022	0.550	0.332 <sup>f</sup>
Solid poultry manure	Solid storage, land spread	0.004	0.100	0.332 <sup>f</sup>
Liquid cattle and swine manure	Liquid storage, land spread	0.021 <sup>b</sup>	0.525	0.281 <sup>e</sup>

Values rounded.

Sources:

- Table A.11 (column 9).
- Weighted average of the values for liquid cattle manure and liquid swine manure (Table A.11, column 9), where the weights are given by the shares of 83% (17%) of liquid cattle (swine) manure in total liquid cattle and swine manure as derived from the corresponding dry-mass values of Table A.11 (column 2), i.e. 0.021 = 0.013 · 0.83 + 0.060 · 0.17.
- Own calculation, multiplying the CH<sub>4</sub> emissions (column 1) by their 100-year GWP of 25 (Forster et al. 2007).
- Own calculation, using the average ratio of CO<sub>2</sub>-to-CH<sub>4</sub> emissions from cattle manure under stockpile – 3.32 (Table A.12, column 5) –, i.e. (3) = (2) · 3.32.
- Own calculation, using the weighted average of the average ratio of CO<sub>2</sub>-to-CH<sub>4</sub> emissions from cattle manure under slurry storage – 0.54 (see Table A.12, column 5) – and the average ratio of CO<sub>2</sub>-to-CH<sub>4</sub> emissions from liquid swine manure – 0.51 (see Table A.13, column 4) –, where the weights are given by the shares of 83% (17%) of liquid cattle (swine) manure in total liquid cattle and swine manure as derived from the corresponding dry-mass values of Table A.11 (column 2), i.e. (3) = (2) · (0.54 · 0.83 + 0.51 · 0.17).
- Due to the lack of data for CO<sub>2</sub> emissions from solid swine and poultry manure, the same CO<sub>2</sub> emission factor was used as for solid cattle manure.

**Table A.15: Emission Factors for Direct N<sub>2</sub>O Emissions from Manure Management**

Feedstocks	Conventional feedstock management (see Teichmann 2014: Table 12)	Emission factor		
		kg N <sub>2</sub> O-N/kg N		kg N <sub>2</sub> O/kg N <sup>i</sup>
		(1)	(2)	(3)
Solid cattle manure	Solid storage, land spread	Dairy cattle: 0.01215 <sup>a</sup> Other cattle: 0.01202 <sup>b</sup>	0.0121 <sup>c</sup>	0.0190
Solid swine manure	Solid storage, land spread		0.01204 <sup>d</sup>	0.0189
Solid poultry manure	Solid storage, land spread		0.001 <sup>e</sup>	0.0016
Liquid cattle manure	Liquid storage, land spread	Dairy cattle: 0.00303 <sup>f</sup> Other cattle: 0.00355 <sup>g</sup>	0.00323 <sup>c</sup>	0.0051
Liquid swine manure	Liquid storage, land spread		0.00322 <sup>h</sup>	0.0051

Values rounded.

Sources:

- 2009-2011 average from UBA (2013: Table 202, straw-based).
- 2009-2011 average from UBA (2013: Table 203, straw-based).
- Weighted average of the values in column 1, where the weights are based on the distribution of dairy cows and other cattle in Germany in 2000 from Table A.9 (column 3) and, thus, amount to  $0.39 = 2.6/6.6$  for other cattle and  $0.61 = 4.0/6.6$  for dairy cattle.
- 2009-2011 average from UBA (2013: Table 204, straw-based).
- UBA (2013: Table 201).
- 2009-2011 average from UBA (2013: Table 202, slurry-based).
- 2009-2011 average from UBA (2013: Table 203, slurry-based).
- 2009-2011 average from UBA (2013: Table 204, slurry-based).
- Own calculation, transforming the values in column 2 using  $N_2O = N_2O-N \cdot 44/28$  as given in Dong et al. (2006).

Note that bedding material (straw) is counted as an emission source in solid-manure systems in UBA (2013).

**Table A.16: Default Fractions of Manure Nitrogen Volatilizing as NH<sub>3</sub> and NO<sub>x</sub>**

Feedstocks	Conventional feedstock management (see Teichmann 2014: Table 12)	Manure-management system used as reference <sup>a</sup>	Fraction <sup>a</sup>	
			%	
Solid cattle manure	Solid storage, land spread	Dairy cow, solid storage	30	
Solid swine manure	Solid storage, land spread	Swine, solid storage	45	
Solid poultry manure	Solid storage, land spread	Poultry with litter	40	
Liquid cattle manure	Liquid storage, land spread	Dairy cow, liquid/slurry	40	41 <sup>b</sup>
Liquid swine manure	Liquid storage, land spread	Swine, liquid/slurry	48	

Values rounded.

Sources:

- Dong et al. (2006: Table 10.22).
- Weighted average of the values for liquid cattle manure and liquid swine manure, where the weights are given by the shares of 83% (17%) of liquid cattle (swine) manure in total liquid cattle and swine manure as derived from the corresponding dry-mass values of Table A.11 (column 2), i.e. calculated as  $41 = 40 \cdot 0.83 + 48 \cdot 0.17$ .

**Table A.17: Loss Fractions of Manure Nitrogen from Manure Management**

Feedstocks	Conventional feedstock management (see Teichmann 2014: Table 12)	Fraction <sup>*</sup>
		%
Solid cattle manure	Solid storage, land spread	31.2
Solid swine manure	Solid storage, land spread	46.2
Solid poultry manure	Solid storage, land spread	40.1
Liquid cattle and swine manure	Liquid storage, land spread	41.3

Values rounded.

Sources:

- \* Own calculation, summing up the N<sub>2</sub>O-N directly lost from manure management as given in Table A.15 (column 2), multiplied by 100, and the default fractions of manure nitrogen volatilizing as NH<sub>3</sub> and NO<sub>x</sub> from Table A.16.

## A.6 Net GHG Emissions from Transports and Soil Additions

The study by Teichmann (2014) considers CO<sub>2</sub> emissions from the transportation of biomass to the pyrolysis units, from the transportation of biochar from the pyrolysis units to the farms where the biochar is applied to the soil, and from the agricultural machinery used to add the biochar to the soil, all adjusted for the corresponding emissions from conventional feedstock management. This section provides the data necessary to derive the respective emissions from transports and soil additions and displays the supplementary results tables referred to and discussed in Sections 4.4 and 4.5 of Teichmann (2014).

The input data for the calculation of the CO<sub>2</sub> emissions from transports and soil additions include the mean transport distances for the transportation of biomass (biochar) to (from) the pyrolysis units (Table A.18) as well as the diesel fuel consumption for trucks and tractors as derived in Table A.19. The data from Table A.19 further enter the calculation of the CO<sub>2</sub> emissions per tonne and kilometer of biomass transported (Table A.20) and per tonne and kilometer of biochar transported (Table A.21).

The combination of the values from Table A.20 with the mean transport distances from Table A.18 gives the CO<sub>2</sub> emissions from the transportation of biomass to the pyrolysis units displayed in Tables 24 and 25 in Teichmann (2014: Section 4.4) for the *Max 1* and *Max 2* scenarios and in Tables A.22-A.25 for the remaining biomass scenarios. Likewise, the multiplication of the respective values from Table A.21 with those from Table A.18 results in the CO<sub>2</sub> emissions from the transportation of biochar to the farms given in Tables 26 and 27 in Teichmann (2014: Section 4.4) for the *Max 1* and *Max 2* scenarios and in Tables A.26-A.29 for the remaining biomass scenarios.

Finally, Tables A.30-A.35 present the net GHG emissions from all transports and soil additions for all biomass scenarios as referred to in Section 4.5 of Teichmann (2014).

**Table A.18: Mean Transport Distances, Germany, 2015-2050**

		Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
		2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
Biomass scenarios		km					km					km				
Scenario <i>Max 1</i>	(A)	4.7	3.6	2.7	2.6	2.6	13.2	10.2	7.6	7.5	7.5	44.8	34.7	25.8	25.4	25.3
Scenario <i>Med 1</i>	(B)	5.0	3.8	3.5	3.5	3.4	14.2	10.7	9.9	9.8	9.7	48.3	36.2	33.8	33.2	33.1
Scenario <i>Min 1</i>	(C)	5.5	5.3	5.0	4.9	4.9	15.5	15.1	14.1	13.8	13.8	52.8	51.2	47.8	47.0	46.8
Scenario <i>Max 2</i>	(D)	2.9	2.7	2.3	2.3	2.3	8.2	7.6	6.6	6.5	6.5	27.8	25.8	22.5	22.1	22.0
Scenario <i>Med 2</i>	(E)	3.4	3.1	2.9	2.8	2.8	9.5	8.7	8.1	8.0	7.9	32.4	29.4	27.5	27.1	27.0
Scenario <i>Min 2</i>	(F)	4.2	4.1	3.8	3.7	3.7	11.9	11.5	10.6	10.5	10.4	40.5	39.1	36.1	35.7	35.5

Sources: Own calculations, based on equation (VI) from Teichmann (2014) and the number of pyrolysis units of scale  $i$  at time  $t$  for biomass scenario  $s$ ,  $PU_{its}$ , given in Table 11 of Teichmann (2014), i.e. calculated as  $1/2 \cdot (348,672 \text{ km}^2 / PU_{its})^{1/2}$ . Values rounded.

Note that the mean transport distances for the transportation of biomass to the pyrolysis units and of biochar from the pyrolysis units to the farms are assumed to be symmetric.

**Table A.19: Transport Fuels, Germany, 2010-2050**

			2010	2015	2020	2030	2040	2050
<b>Diesel fuel efficiency in goods traffic by trucks<sup>a</sup></b>	Index	(A)	0.94	0.87	0.83	0.71	0.67	0.63
	l/100 km <sup>c</sup>	(B)	35.6 <sup>b</sup>	32.9	31.4	26.9	25.4	23.9
<b>Diesel fuel consumption - Trucks</b>	l/km <sup>d</sup>	(C)	0.356	0.329	0.314	0.269	0.254	0.239
	l/(t · km) <sup>e</sup>	(D)	<b>0.020</b>	<b>0.018</b>	<b>0.017</b>	<b>0.015</b>	<b>0.014</b>	<b>0.013</b>
<b>Diesel fuel consumption - Tractors</b>	l/100 km <sup>g</sup>	(E)	30.1 <sup>f</sup>	27.9	26.6	22.7	21.5	20.2
	l/km <sup>h</sup>	(F)	0.301	0.279	0.266	0.227	0.215	0.202
	l/(t · km) <sup>i</sup>	(G)	<b>0.050</b>	<b>0.046</b>	<b>0.044</b>	<b>0.038</b>	<b>0.036</b>	<b>0.034</b>

Values rounded.

*Sources:*

- Nitsch et al. (2012: Table 3-2). While the values for 2015-2050 were directly given, the value for 2010 was calculated based on the diesel consumption by trucks of 1.22 MJ/(t · km) in 2005 and 1.15 MJ/(t · km) in 2010 and the 2005 index of 1.00 (Nitsch et al. 2012: Table 3-2). Note that the values for diesel and bio-diesel coincide.
- Kunert and Radke (2013: Table 3), referring to average diesel consumption by *semi-trailers* in Germany. Note that the average diesel consumption by *trucks* (19.0 l/100 km in 2010) is not used since this refers to both heavy and light trucks (the latter having a payload of <3.5 t) and, thus, underestimates the diesel consumption for the load of 18 t as used in Teichmann (2014).
- Own calculation, based on the 2010 value and the efficiencies given in row A. Note that it is not differentiated between fossil diesel and biodiesel since they have nearly the same heating values – 35.87 MJ/l for fossil diesel and 32.65 MJ/l for biodiesel (FNR 2012c: 28).
- Own calculation, (C) = (B)/100.
- Own calculation, assuming an average load per truck of 18 t, i.e. (D) = (C)/18. The 18 t have been derived from FNR (2005: Tables 6-11 and 6-16), which shows that the cheapest modes of transport for wood chips tend to be truck versions with a transport volume of 80 m<sup>3</sup> and a payload of 23 t. Using these types of trucks as a reference for all feedstocks and for biochar to be transported and assuming an average load factor of 0.8, about 18 t of freight can be carried per truck. Note that the volume constraint of 80 m<sup>3</sup> might be violated at 18 t for freight densities below 0.225 t/m<sup>3</sup>. Due to the lack of data for the densities of all the feedstocks and biochar, however, the analysis is simplified by abstracting from the volume constraint.
- Kunert and Radke (2013: Table 3), referring to average diesel consumption by *remaining tractors* in Germany, which include agricultural tractors.
- Own calculation, based on the 2010 value and the efficiencies given in row A. Note that it is not differentiated between fossil diesel and biodiesel since they have nearly the same heating values – 35.87 MJ/l for fossil diesel and 32.65 MJ/l for biodiesel (FNR 2012c: 28).
- Own calculation, (F) = (E)/100.
- Own calculation, assuming an average load per journey of 6 t as in Shackley et al. (2011: Box 3), i.e. (D) = (C)/6. Note that Shackley et al. (2011: Box 3) assume that biochar is added to soil by a fertilizer spreader pulled by a tractor.

**Table A.20: CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units**

Feedstocks	CO <sub>2</sub> emissions				
	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /(t <sub>DM</sub> feedstock · km)				
	(1)	(2)	(3)	(4)	(5)
Cereal straw	0.000049	0.000047	0.000040	0.000038	0.000036
Forestry residues	0.000051	0.000048	0.000041	0.000039	0.000037
Open-country biomass residues	0.000049	0.000047	0.000040	0.000038	0.000035
Industrial wood waste	0.000049	0.000047	0.000040	0.000038	0.000036
Wood in municipal solid waste	0.000051	0.000048	0.000041	0.000039	0.000037
Green waste: Compensation areas	0.000048	0.000046	0.000039	0.000037	0.000035
Biomass: Habitat-connectivity areas	0.000049	0.000047	0.000040	0.000038	0.000035
Green waste: Extensive grassland	0.000049	0.000047	0.000040	0.000038	0.000035
Short-rotation coppice: Erosion areas	0.000055	0.000053	0.000045	0.000042	0.000040
Sewage sludge	0.000220	0.000210	0.000180	0.000170	0.000160
Solid cattle manure	0.000124	0.000118	0.000101	0.000096	0.000090
Solid swine manure	0.000210	0.000201	0.000172	0.000162	0.000152
Solid poultry manure	0.000052	0.000050	0.000043	0.000040	0.000038
Liquid cattle and swine manure	0.000461	0.000440	0.000376	0.000355	0.000334
Sugar-beet leaf and potato haulm	0.000282	0.000269	0.000230	0.000217	0.000205
Commercial and industrial waste	0.000117	0.000111	0.000095	0.000090	0.000085
Organic municipal solid waste	0.000155	0.000148	0.000127	0.000120	0.000112
Digestates	0.000307	0.000293	0.000251	0.000237	0.000223

Sources: Own calculation, multiplying the semi-trailer-related diesel consumption per tonne of freight and kilometer (Table A.19, row D) by the assumed share of fossil diesel of 93% (Teichmann 2014), the diesel heating value of 35.87 MJ/l (FNR 2012c: 28) and the CO<sub>2</sub> emission factor for diesel fuel of 74.0 t CO<sub>2</sub>/TJ (UBA 2013: Table 347, p. 741), and accounting for the fact that fresh biomass is transported instead of dry biomass, i.e. calculated as semi-trailer diesel consumption (Table A.19, row D) · 0.93 · 100/(100 – water content (Table 8, column 4)) · 35.87 · 74.0/1,000,000. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.21: CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms**

Feedstocks	CO <sub>2</sub> emissions				
	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /(t <sub>DM</sub> feedstock · km)				
	(1)	(2)	(3)	(4)	(5)
Cereal straw	0.000015	0.000015	0.000013	0.000012	0.000011
Forestry residues	0.000014	0.000013	0.000011	0.000010	0.000010
Open-country biomass residues	0.000014	0.000013	0.000011	0.000011	0.000010
Industrial wood waste	0.000013	0.000013	0.000011	0.000010	0.000009
Wood in municipal solid waste	0.000014	0.000013	0.000011	0.000010	0.000010
Green waste: Compensation areas	0.000014	0.000014	0.000012	0.000011	0.000010
Biomass: Habitat-connectivity areas	0.000014	0.000013	0.000011	0.000011	0.000010
Green waste: Extensive grassland	0.000014	0.000013	0.000011	0.000011	0.000010
Short-rotation coppice: Erosion areas	0.000011	0.000011	0.000009	0.000009	0.000008
Sewage sludge	0.000022	0.000021	0.000018	0.000017	0.000016
Solid cattle manure	0.000021	0.000020	0.000017	0.000016	0.000015
Solid swine manure	0.000021	0.000020	0.000017	0.000016	0.000015
Solid poultry manure	0.000020	0.000019	0.000016	0.000015	0.000014
Liquid cattle and swine manure	0.000020	0.000019	0.000017	0.000016	0.000015
Sugar-beet leaf and potato haulm	0.000020	0.000019	0.000017	0.000016	0.000015
Commercial and industrial waste	0.000017	0.000016	0.000014	0.000013	0.000012
Organic municipal solid waste	0.000020	0.000019	0.000017	0.000016	0.000015
Digestates	0.000022	0.000021	0.000018	0.000017	0.000016

Sources: Own calculation, multiplying the semi-trailer-related diesel consumption per tonne of freight and kilometer (Table A.19, row D) by the assumed share of fossil diesel of 93% (Teichmann 2014), the diesel heating value of 35.87 MJ/l (FNR 2012c: 28) and the CO<sub>2</sub> emission factor for diesel fuel of 74.0 t CO<sub>2</sub>/TJ (UBA 2013: Table 347, p. 741), i.e. calculated as semi-trailer diesel consumption (Table A.19, row D) · 0.93 · char yield (Table 8, column 6)/100 · 35.87 · 74.0/1,000,000. Values rounded.

Note that we do not differentiate between biochar fresh weight and biochar dry weight (see Table A.7, comment \*\*\*\*).

Note that tables numbered without the leading “A.” refer to Teichmann (2014).



**Table A.22: CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00025	0.00018	0.00014	0.00013	0.00012	0.00070	0.00050	0.00040	0.00037	0.00035	0.00237	0.00170	0.00135	0.00126	0.00118
Forestry residues	0.00025	0.00018	0.00015	0.00013	0.00013	0.00072	0.00051	0.00041	0.00038	0.00036	0.00245	0.00175	0.00140	0.00130	0.00121
Open-country biomass residues	0.00025	0.00018	0.00014	0.00013	0.00012	0.00070	0.00050	0.00040	0.00037	0.00035	0.00237	0.00169	0.00135	0.00125	0.00117
Industrial wood waste	0.00025	0.00018	0.00014	0.00013	0.00012	0.00070	0.00050	0.00040	0.00037	0.00035	0.00238	0.00170	0.00136	0.00126	0.00118
Wood in municipal solid waste	0.00026	0.00018	0.00015	0.00014	0.00013	0.00072	0.00052	0.00041	0.00038	0.00036	0.00245	0.00175	0.00140	0.00130	0.00122
Green waste: Compensation areas	0.00024	0.00017	0.00014	0.00013	0.00012	0.00069	0.00049	0.00039	0.00036	0.00034	0.00233	0.00167	0.00133	0.00123	0.00116
Biomass: Habitat-connectivity areas	0.00025	0.00018	0.00014	0.00013	0.00012	0.00070	0.00050	0.00040	0.00037	0.00035	0.00237	0.00169	0.00135	0.00125	0.00117
Green waste: Extensive grassland	0.00025	0.00018	0.00014	0.00013	0.00012	0.00070	0.00050	0.00040	0.00037	0.00035	0.00237	0.00169	0.00135	0.00125	0.00117
Short-rotation coppice: Erosion areas	0.00028	0.00020	0.00016	0.00015	0.00014	0.00078	0.00056	0.00045	0.00041	0.00039	0.00266	0.00190	0.00152	0.00141	0.00132
Sewage sludge	0.00111	0.00079	0.00063	0.00059	0.00055	0.00313	0.00224	0.00179	0.00166	0.00155	0.01065	0.00762	0.00608	0.00564	0.00528
Solid cattle manure	0.00062	0.00045	0.00036	0.00033	0.00031	0.00177	0.00126	0.00101	0.00094	0.00088	0.00600	0.00429	0.00342	0.00318	0.00298
Solid swine manure	0.00106	0.00076	0.00060	0.00056	0.00052	0.00299	0.00214	0.00171	0.00158	0.00148	0.01016	0.00726	0.00580	0.00538	0.00504
Solid poultry manure	0.00026	0.00019	0.00015	0.00014	0.00013	0.00074	0.00053	0.00042	0.00039	0.00037	0.00252	0.00180	0.00144	0.00134	0.00125
Liquid cattle and swine manure	0.00232	0.00166	0.00132	0.00123	0.00115	0.00656	0.00469	0.00374	0.00347	0.00325	0.02229	0.01593	0.01272	0.01180	0.01105
Sugar-beet leaf and potato haulm	0.00142	0.00102	0.00081	0.00075	0.00070	0.00402	0.00287	0.00229	0.00213	0.00199	0.01365	0.00976	0.00779	0.00723	0.00677
Commercial and industrial waste	0.00059	0.00042	0.00034	0.00031	0.00029	0.00166	0.00119	0.00095	0.00088	0.00082	0.00564	0.00403	0.00322	0.00299	0.00280
Organic municipal solid waste	0.00078	0.00056	0.00045	0.00041	0.00039	0.00221	0.00158	0.00126	0.00117	0.00110	0.00751	0.00536	0.00428	0.00398	0.00372
Digestates (energy crops)	0.00155	0.00110	0.00088	0.00082	0.00077	0.00437	0.00313	0.00249	0.00232	0.00217	0.01486	0.01062	0.00848	0.00787	0.00737

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.18, row B. Values rounded.

**Table A.23: CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00027	0.00025	0.00020	0.00018	0.00017	0.00076	0.00071	0.00056	0.00052	0.00049	0.00259	0.00240	0.00191	0.00178	0.00166
Forestry residues	0.00028	0.00026	0.00021	0.00019	0.00018	0.00079	0.00073	0.00058	0.00054	0.00051	0.00268	0.00248	0.00198	0.00183	0.00172
Open-country biomass residues	0.00027	0.00025	0.00020	0.00018	0.00017	0.00076	0.00070	0.00056	0.00052	0.00049	0.00259	0.00239	0.00191	0.00177	0.00166
Industrial wood waste	0.00027	0.00025	0.00020	0.00019	0.00017	0.00076	0.00071	0.00056	0.00052	0.00049	0.00260	0.00240	0.00192	0.00178	0.00167
Wood in municipal solid waste	0.00028	0.00026	0.00021	0.00019	0.00018	0.00079	0.00073	0.00058	0.00054	0.00051	0.00268	0.00248	0.00198	0.00184	0.00172
Green waste: Compensation areas	0.00027	0.00025	0.00020	0.00018	0.00017	0.00075	0.00069	0.00055	0.00051	0.00048	0.00255	0.00236	0.00188	0.00175	0.00163
Biomass: Habitat-connectivity areas	0.00027	0.00025	0.00020	0.00018	0.00017	0.00076	0.00070	0.00056	0.00052	0.00049	0.00259	0.00239	0.00191	0.00177	0.00166
Green waste: Extensive grassland	0.00027	0.00025	0.00020	0.00018	0.00017	0.00076	0.00070	0.00056	0.00052	0.00049	0.00259	0.00239	0.00191	0.00177	0.00166
Short-rotation coppice: Erosion areas	0.00030	0.00028	0.00022	0.00021	0.00019	0.00086	0.00079	0.00063	0.00059	0.00055	0.00291	0.00269	0.00215	0.00199	0.00187
Sewage sludge	0.00121	0.00112	0.00089	0.00083	0.00078	0.00343	0.00317	0.00253	0.00235	0.00220	0.01164	0.01077	0.00860	0.00798	0.00747
Solid cattle manure	0.00068	0.00063	0.00050	0.00047	0.00044	0.00193	0.00178	0.00142	0.00132	0.00124	0.00656	0.00607	0.00484	0.00449	0.00421
Solid swine manure	0.00116	0.00107	0.00085	0.00079	0.00074	0.00327	0.00302	0.00241	0.00224	0.00210	0.01110	0.01027	0.00820	0.00761	0.00712
Solid poultry manure	0.00029	0.00027	0.00021	0.00020	0.00018	0.00081	0.00075	0.00060	0.00056	0.00052	0.00276	0.00255	0.00204	0.00189	0.00177
Liquid cattle and swine manure	0.00253	0.00234	0.00187	0.00174	0.00163	0.00717	0.00663	0.00529	0.00491	0.00460	0.02436	0.02253	0.01799	0.01669	0.01563
Sugar-beet leaf and potato haulm	0.00155	0.00144	0.00115	0.00106	0.00100	0.00439	0.00406	0.00324	0.00301	0.00282	0.01492	0.01380	0.01102	0.01022	0.00957
Commercial and industrial waste	0.00064	0.00059	0.00047	0.00044	0.00041	0.00181	0.00168	0.00134	0.00124	0.00116	0.00617	0.00571	0.00455	0.00423	0.00396
Organic municipal solid waste	0.00085	0.00079	0.00063	0.00058	0.00055	0.00241	0.00223	0.00178	0.00165	0.00155	0.00820	0.00759	0.00606	0.00562	0.00526
Digestates (energy crops)	0.00169	0.00156	0.00125	0.00116	0.00108	0.00478	0.00442	0.00353	0.00327	0.00307	0.01624	0.01502	0.01199	0.01113	0.01042

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.18, row C. Values rounded.

**Table A.24: CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00017	0.00014	0.00011	0.00011	0.00010	0.00047	0.00041	0.00032	0.00030	0.00028	0.00159	0.00138	0.00110	0.00102	0.00096
Forestry residues	0.00017	0.00015	0.00012	0.00011	0.00010	0.00048	0.00042	0.00033	0.00031	0.00029	0.00164	0.00142	0.00114	0.00106	0.00099
Open-country biomass residues	0.00017	0.00014	0.00011	0.00011	0.00010	0.00047	0.00040	0.00032	0.00030	0.00028	0.00159	0.00138	0.00110	0.00102	0.00096
Industrial wood waste	0.00017	0.00014	0.00011	0.00011	0.00010	0.00047	0.00041	0.00032	0.00030	0.00028	0.00159	0.00138	0.00110	0.00103	0.00096
Wood in municipal solid waste	0.00017	0.00015	0.00012	0.00011	0.00010	0.00048	0.00042	0.00033	0.00031	0.00029	0.00164	0.00142	0.00114	0.00106	0.00099
Green waste: Compensation areas	0.00016	0.00014	0.00011	0.00010	0.00010	0.00046	0.00040	0.00032	0.00030	0.00028	0.00156	0.00135	0.00108	0.00101	0.00094
Biomass: Habitat-connectivity areas	0.00017	0.00014	0.00011	0.00011	0.00010	0.00047	0.00040	0.00032	0.00030	0.00028	0.00159	0.00138	0.00110	0.00102	0.00096
Green waste: Extensive grassland	0.00017	0.00014	0.00011	0.00011	0.00010	0.00047	0.00040	0.00032	0.00030	0.00028	0.00159	0.00138	0.00110	0.00102	0.00096
Short-rotation coppice: Erosion areas	0.00019	0.00016	0.00013	0.00012	0.00011	0.00052	0.00045	0.00036	0.00034	0.00032	0.00178	0.00155	0.00124	0.00115	0.00108
Sewage sludge (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Solid cattle manure (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Solid swine manure (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Solid poultry manure (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Liquid cattle and swine manure (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Sugar-beet leaf and potato haulm (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Commercial and industrial waste (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Organic municipal solid waste (D)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601
Digestates (energy crops)	0.00104	0.00090	0.00072	0.00067	0.00063	0.00293	0.00254	0.00203	0.00189	0.00177	0.00996	0.00863	0.00690	0.00642	0.00601

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.18, row E. Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

**Table A.25: CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00021	0.00019	0.00015	0.00014	0.00013	0.00059	0.00054	0.00043	0.00040	0.00037	0.00199	0.00183	0.00145	0.00135	0.00126
Forestry residues	0.00021	0.00020	0.00016	0.00014	0.00014	0.00060	0.00056	0.00044	0.00041	0.00038	0.00205	0.00189	0.00149	0.00139	0.00130
Open-country biomass residues	0.00021	0.00019	0.00015	0.00014	0.00013	0.00058	0.00054	0.00043	0.00040	0.00037	0.00199	0.00183	0.00145	0.00135	0.00126
Industrial wood waste	0.00021	0.00019	0.00015	0.00014	0.00013	0.00059	0.00054	0.00043	0.00040	0.00037	0.00199	0.00184	0.00145	0.00135	0.00126
Wood in municipal solid waste	0.00021	0.00020	0.00016	0.00014	0.00014	0.00060	0.00056	0.00044	0.00041	0.00038	0.00206	0.00189	0.00150	0.00139	0.00130
Green waste: Compensation areas	0.00020	0.00019	0.00015	0.00014	0.00013	0.00058	0.00053	0.00042	0.00039	0.00036	0.00195	0.00180	0.00142	0.00132	0.00124
Biomass: Habitat-connectivity areas	0.00021	0.00019	0.00015	0.00014	0.00013	0.00058	0.00054	0.00043	0.00040	0.00037	0.00199	0.00183	0.00145	0.00135	0.00126
Green waste: Extensive grassland	0.00021	0.00019	0.00015	0.00014	0.00013	0.00058	0.00054	0.00043	0.00040	0.00037	0.00199	0.00183	0.00145	0.00135	0.00126
Short-rotation coppice: Erosion areas	0.00023	0.00021	0.00017	0.00016	0.00015	0.00066	0.00060	0.00048	0.00044	0.00042	0.00223	0.00206	0.00162	0.00151	0.00141
Sewage sludge (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Solid cattle manure (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Solid swine manure (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Solid poultry manure (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Liquid cattle and swine manure (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Sugar-beet leaf and potato haulm (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Commercial and industrial waste (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Organic municipal solid waste (D)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790
Digestates (energy crops)	0.00130	0.00119	0.00094	0.00088	0.00082	0.00367	0.00338	0.00267	0.00248	0.00232	0.01246	0.01148	0.00907	0.00844	0.00790

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.18, row F. Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

**Table A.26: CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00008	0.00006	0.00004	0.00004	0.00004	0.00022	0.00016	0.00012	0.00012	0.00011	0.00074	0.00053	0.00042	0.00039	0.00037
Forestry residues	0.00007	0.00005	0.00004	0.00004	0.00003	0.00019	0.00014	0.00011	0.00010	0.00010	0.00066	0.00047	0.00037	0.00035	0.00032
Open-country biomass residues	0.00007	0.00005	0.00004	0.00004	0.00003	0.00020	0.00014	0.00011	0.00011	0.00010	0.00068	0.00048	0.00039	0.00036	0.00034
Industrial wood waste	0.00007	0.00005	0.00004	0.00003	0.00003	0.00019	0.00013	0.00011	0.00010	0.00009	0.00063	0.00045	0.00036	0.00034	0.00031
Wood in municipal solid waste	0.00007	0.00005	0.00004	0.00004	0.00003	0.00019	0.00014	0.00011	0.00010	0.00010	0.00066	0.00047	0.00037	0.00035	0.00032
Green waste: Compensation areas	0.00007	0.00005	0.00004	0.00004	0.00004	0.00021	0.00015	0.00012	0.00011	0.00010	0.00070	0.00050	0.00040	0.00037	0.00035
Biomass: Habitat-connectivity areas	0.00007	0.00005	0.00004	0.00004	0.00003	0.00020	0.00014	0.00011	0.00011	0.00010	0.00068	0.00048	0.00039	0.00036	0.00034
Green waste: Extensive grassland	0.00007	0.00005	0.00004	0.00004	0.00003	0.00020	0.00014	0.00011	0.00011	0.00010	0.00068	0.00048	0.00039	0.00036	0.00034
Short-rotation coppice: Erosion areas	0.00006	0.00004	0.00003	0.00003	0.00003	0.00016	0.00011	0.00009	0.00009	0.00008	0.00055	0.00039	0.00031	0.00029	0.00027
Sewage sludge	0.00011	0.00008	0.00006	0.00006	0.00006	0.00031	0.00023	0.00018	0.00017	0.00016	0.00107	0.00076	0.00061	0.00057	0.00053
Solid cattle manure	0.00011	0.00008	0.00006	0.00006	0.00005	0.00030	0.00022	0.00017	0.00016	0.00015	0.00103	0.00073	0.00059	0.00054	0.00051
Solid swine manure	0.00011	0.00008	0.00006	0.00006	0.00005	0.00030	0.00022	0.00017	0.00016	0.00015	0.00103	0.00073	0.00059	0.00054	0.00051
Solid poultry manure	0.00010	0.00007	0.00006	0.00005	0.00005	0.00028	0.00020	0.00016	0.00015	0.00014	0.00096	0.00069	0.00055	0.00051	0.00048
Liquid cattle and swine manure	0.00010	0.00007	0.00006	0.00005	0.00005	0.00029	0.00021	0.00017	0.00015	0.00014	0.00098	0.00070	0.00056	0.00052	0.00049
Sugar-beet leaf and potato haulm	0.00010	0.00007	0.00006	0.00005	0.00005	0.00029	0.00021	0.00017	0.00015	0.00014	0.00098	0.00070	0.00056	0.00052	0.00049
Commercial and industrial waste	0.00008	0.00006	0.00005	0.00004	0.00004	0.00024	0.00017	0.00014	0.00013	0.00012	0.00081	0.00058	0.00046	0.00043	0.00040
Organic municipal solid waste	0.00010	0.00007	0.00006	0.00005	0.00005	0.00029	0.00021	0.00017	0.00015	0.00014	0.00098	0.00070	0.00056	0.00052	0.00049
Digestates (energy crops)	0.00011	0.00008	0.00006	0.00006	0.00006	0.00031	0.00023	0.00018	0.00017	0.00016	0.00107	0.00076	0.00061	0.00057	0.00053

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.18, row B. Values rounded.

**Table A.27: CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00008	0.00008	0.00006	0.00006	0.00005	0.00024	0.00022	0.00018	0.00016	0.00015	0.00081	0.00075	0.00060	0.00056	0.00052
Forestry residues	0.00007	0.00007	0.00006	0.00005	0.00005	0.00021	0.00019	0.00016	0.00014	0.00014	0.00072	0.00066	0.00053	0.00049	0.00046
Open-country biomass residues	0.00008	0.00007	0.00006	0.00005	0.00005	0.00022	0.00020	0.00016	0.00015	0.00014	0.00074	0.00068	0.00055	0.00051	0.00047
Industrial wood waste	0.00007	0.00007	0.00005	0.00005	0.00005	0.00020	0.00019	0.00015	0.00014	0.00013	0.00069	0.00064	0.00051	0.00047	0.00044
Wood in municipal solid waste	0.00007	0.00007	0.00006	0.00005	0.00005	0.00021	0.00019	0.00016	0.00014	0.00014	0.00072	0.00066	0.00053	0.00049	0.00046
Green waste: Compensation areas	0.00008	0.00007	0.00006	0.00005	0.00005	0.00022	0.00021	0.00017	0.00015	0.00014	0.00076	0.00071	0.00056	0.00052	0.00049
Biomass: Habitat-connectivity areas	0.00008	0.00007	0.00006	0.00005	0.00005	0.00022	0.00020	0.00016	0.00015	0.00014	0.00074	0.00068	0.00055	0.00051	0.00047
Green waste: Extensive grassland	0.00008	0.00007	0.00006	0.00005	0.00005	0.00022	0.00020	0.00016	0.00015	0.00014	0.00074	0.00068	0.00055	0.00051	0.00047
Short-rotation coppice: Erosion areas	0.00006	0.00006	0.00005	0.00004	0.00004	0.00018	0.00016	0.00013	0.00012	0.00011	0.00060	0.00055	0.00044	0.00041	0.00038
Sewage sludge	0.00012	0.00011	0.00009	0.00008	0.00008	0.00034	0.00032	0.00025	0.00024	0.00022	0.00117	0.00108	0.00086	0.00080	0.00075
Solid cattle manure	0.00012	0.00011	0.00009	0.00008	0.00007	0.00033	0.00031	0.00024	0.00023	0.00021	0.00112	0.00104	0.00083	0.00077	0.00072
Solid swine manure	0.00012	0.00011	0.00009	0.00008	0.00007	0.00033	0.00031	0.00024	0.00023	0.00021	0.00112	0.00104	0.00083	0.00077	0.00072
Solid poultry manure	0.00011	0.00010	0.00008	0.00007	0.00007	0.00031	0.00029	0.00023	0.00021	0.00020	0.00105	0.00097	0.00078	0.00072	0.00067
Liquid cattle and swine manure	0.00011	0.00010	0.00008	0.00008	0.00007	0.00032	0.00029	0.00023	0.00022	0.00020	0.00107	0.00099	0.00079	0.00074	0.00069
Sugar-beet leaf and potato haulm	0.00011	0.00010	0.00008	0.00008	0.00007	0.00032	0.00029	0.00023	0.00022	0.00020	0.00107	0.00099	0.00079	0.00074	0.00069
Commercial and industrial waste	0.00009	0.00008	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00088	0.00082	0.00065	0.00061	0.00057
Organic municipal solid waste	0.00011	0.00010	0.00008	0.00008	0.00007	0.00032	0.00029	0.00023	0.00022	0.00020	0.00107	0.00099	0.00079	0.00074	0.00069
Digestates (energy crops)	0.00012	0.00011	0.00009	0.00008	0.00008	0.00034	0.00032	0.00025	0.00024	0.00022	0.00117	0.00108	0.00086	0.00080	0.00075

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.18, row C. Values rounded.

**Table A.28: CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00005	0.00004	0.00004	0.00003	0.00003	0.00015	0.00013	0.00010	0.00009	0.00009	0.00050	0.00043	0.00034	0.00032	0.00030
Forestry residues	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00011	0.00009	0.00008	0.00008	0.00044	0.00038	0.00030	0.00028	0.00026
Open-country biomass residues	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00012	0.00009	0.00009	0.00008	0.00045	0.00039	0.00031	0.00029	0.00027
Industrial wood waste	0.00004	0.00004	0.00003	0.00003	0.00003	0.00012	0.00011	0.00009	0.00008	0.00008	0.00042	0.00037	0.00029	0.00027	0.00026
Wood in municipal solid waste	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00011	0.00009	0.00008	0.00008	0.00044	0.00038	0.00030	0.00028	0.00026
Green waste: Compensation areas	0.00005	0.00004	0.00003	0.00003	0.00003	0.00014	0.00012	0.00010	0.00009	0.00008	0.00047	0.00041	0.00032	0.00030	0.00028
Biomass: Habitat-connectivity areas	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00012	0.00009	0.00009	0.00008	0.00045	0.00039	0.00031	0.00029	0.00027
Green waste: Extensive grassland	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00012	0.00009	0.00009	0.00008	0.00045	0.00039	0.00031	0.00029	0.00027
Short-rotation coppice: Erosion areas	0.00004	0.00003	0.00003	0.00002	0.00002	0.00011	0.00009	0.00007	0.00007	0.00006	0.00037	0.00032	0.00025	0.00024	0.00022
Sewage sludge (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Solid cattle manure (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Solid swine manure (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Solid poultry manure (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Liquid cattle and swine manure (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Sugar-beet leaf and potato haulm (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Commercial and industrial waste (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Organic municipal solid waste (D)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043
Digestates (energy crops)	0.00007	0.00006	0.00005	0.00005	0.00005	0.00021	0.00018	0.00015	0.00014	0.00013	0.00072	0.00062	0.00050	0.00046	0.00043

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.18, row E. Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

**Table A.29: CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00006	0.00006	0.00005	0.00004	0.00004	0.00018	0.00017	0.00013	0.00012	0.00012	0.00062	0.00057	0.00045	0.00042	0.00039
Forestry residues	0.00006	0.00005	0.00004	0.00004	0.00004	0.00016	0.00015	0.00012	0.00011	0.00010	0.00055	0.00051	0.00040	0.00037	0.00035
Open-country biomass residues	0.00006	0.00005	0.00004	0.00004	0.00004	0.00017	0.00015	0.00012	0.00011	0.00011	0.00057	0.00052	0.00041	0.00038	0.00036
Industrial wood waste	0.00006	0.00005	0.00004	0.00004	0.00004	0.00016	0.00014	0.00011	0.00011	0.00010	0.00053	0.00049	0.00039	0.00036	0.00034
Wood in municipal solid waste	0.00006	0.00005	0.00004	0.00004	0.00004	0.00016	0.00015	0.00012	0.00011	0.00010	0.00055	0.00051	0.00040	0.00037	0.00035
Green waste: Compensation areas	0.00006	0.00006	0.00004	0.00004	0.00004	0.00017	0.00016	0.00013	0.00012	0.00011	0.00059	0.00054	0.00043	0.00040	0.00037
Biomass: Habitat-connectivity areas	0.00006	0.00005	0.00004	0.00004	0.00004	0.00017	0.00015	0.00012	0.00011	0.00011	0.00057	0.00052	0.00041	0.00038	0.00036
Green waste: Extensive grassland	0.00006	0.00005	0.00004	0.00004	0.00004	0.00017	0.00015	0.00012	0.00011	0.00011	0.00057	0.00052	0.00041	0.00038	0.00036
Short-rotation coppice: Erosion areas	0.00005	0.00004	0.00003	0.00003	0.00003	0.00013	0.00012	0.00010	0.00009	0.00009	0.00046	0.00042	0.00033	0.00031	0.00029
Sewage sludge (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Solid cattle manure (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Solid swine manure (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Solid poultry manure (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Liquid cattle and swine manure (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Sugar-beet leaf and potato haulm (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Commercial and industrial waste (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Organic municipal solid waste (D)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057
Digestates (energy crops)	0.00009	0.00009	0.00007	0.00006	0.00006	0.00026	0.00024	0.00019	0.00018	0.00017	0.00090	0.00083	0.00065	0.00061	0.00057

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.18, row F. Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.



**Table A.30: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Max 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00042	-0.00033	-0.00024	-0.00022	-0.00021	-0.00097	-0.00074	-0.00050	-0.00046	-0.00043	-0.00300	-0.00224	-0.00145	-0.00135	-0.00127
Forestry residues	-0.00040	-0.00032	-0.00023	-0.00021	-0.00020	-0.00095	-0.00072	-0.00048	-0.00045	-0.00042	-0.00298	-0.00222	-0.00144	-0.00134	-0.00125
Open-country biomass residues	0.00084	0.00087	0.00079	0.00075	0.00070	0.00030	0.00047	0.00054	0.00051	0.00048	-0.00169	-0.00100	-0.00040	-0.00036	-0.00033
Industrial wood waste	0.00005	0.00011	0.00014	0.00014	0.00013	-0.00048	-0.00028	-0.00011	-0.00010	-0.00009	-0.00245	-0.00173	-0.00103	-0.00096	-0.00089
Wood in municipal solid waste	0.00085	0.00088	0.00080	0.00076	0.00071	0.00031	0.00048	0.00054	0.00052	0.00049	-0.00173	-0.00102	-0.00041	-0.00037	-0.00034
Green waste: Compensation areas	-0.00040	-0.00032	-0.00023	-0.00021	-0.00020	-0.00094	-0.00072	-0.00048	-0.00045	-0.00042	-0.00292	-0.00218	-0.00141	-0.00131	-0.00123
Biomass: Habitat-connectivity areas	0.00084	0.00087	0.00079	0.00075	0.00070	0.00030	0.00047	0.00054	0.00051	0.00048	-0.00169	-0.00100	-0.00040	-0.00036	-0.00033
Green waste: Extensive grassland	0.00084	0.00087	0.00079	0.00075	0.00070	0.00030	0.00047	0.00054	0.00051	0.00048	-0.00169	-0.00100	-0.00040	-0.00036	-0.00033
Short-rotation coppice: Erosion areas	0.00010	0.00016	0.00019	0.00018	0.00017	-0.00047	-0.00025	-0.00008	-0.00007	-0.00006	-0.00256	-0.00180	-0.00106	-0.00098	-0.00092
Sewage sludge	0.00148	0.00166	0.00160	0.00152	0.00143	-0.00058	0.00014	0.00063	0.00062	0.00059	-0.00826	-0.00553	-0.00298	-0.00274	-0.00255
Solid cattle manure	-0.00018	-0.00002	0.00009	0.00009	0.00008	-0.00142	-0.00094	-0.00049	-0.00045	-0.00042	-0.00602	-0.00433	-0.00266	-0.00246	-0.00230
Solid swine manure	-0.00012	0.00012	0.00027	0.00027	0.00025	-0.00209	-0.00134	-0.00065	-0.00060	-0.00056	-0.00942	-0.00674	-0.00410	-0.00380	-0.00355
Solid poultry manure	-0.00021	-0.00013	-0.00005	-0.00005	-0.00005	-0.00082	-0.00058	-0.00034	-0.00032	-0.00030	-0.00310	-0.00226	-0.00142	-0.00131	-0.00123
Liquid cattle and swine manure	0.00006	0.00054	0.00082	0.00079	0.00075	-0.00405	-0.00249	-0.00111	-0.00100	-0.00093	-0.01928	-0.01373	-0.00828	-0.00766	-0.00716
Sugar-beet leaf and potato haulm	-0.00157	-0.00119	-0.00079	-0.00074	-0.00069	-0.00415	-0.00309	-0.00201	-0.00186	-0.00175	-0.01373	-0.01016	-0.00651	-0.00605	-0.00566
Commercial and industrial waste	0.00110	0.00119	0.00111	0.00106	0.00099	-0.00004	0.00035	0.00058	0.00056	0.00053	-0.00426	-0.00277	-0.00141	-0.00129	-0.00120
Organic municipal solid waste	0.00122	0.00135	0.00128	0.00122	0.00114	-0.00027	0.00024	0.00058	0.00056	0.00053	-0.00583	-0.00386	-0.00204	-0.00187	-0.00174
Digestates (energy crops)	0.00186	0.00211	0.00205	0.00195	0.00183	-0.00095	0.00004	0.00073	0.00072	0.00068	-0.01137	-0.00766	-0.00418	-0.00384	-0.00358

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table 24 (columns 1 to 5) – Table 26 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table 24 (columns 6 to 10) – Table 26 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table 24 (columns 11 to 15) – Table 26 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.31: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00044	-0.00034	-0.00028	-0.00026	-0.00025	-0.00103	-0.00077	-0.00062	-0.00058	-0.00054	-0.00323	-0.00234	-0.00187	-0.00174	-0.00163
Forestry residues	-0.00043	-0.00033	-0.00027	-0.00025	-0.00023	-0.00102	-0.00075	-0.00061	-0.00056	-0.00053	-0.00321	-0.00232	-0.00186	-0.00172	-0.00161
Open-country biomass residues	0.00082	0.00086	0.00075	0.00071	0.00066	0.00024	0.00044	0.00041	0.00040	0.00038	-0.00191	-0.00109	-0.00081	-0.00074	-0.00069
Industrial wood waste	0.00003	0.00010	0.00010	0.00010	0.00009	-0.00054	-0.00031	-0.00023	-0.00021	-0.00019	-0.00267	-0.00182	-0.00144	-0.00133	-0.00124
Wood in municipal solid waste	0.00083	0.00087	0.00076	0.00072	0.00068	0.00024	0.00045	0.00042	0.00040	0.00038	-0.00195	-0.00112	-0.00083	-0.00076	-0.00070
Green waste: Compensation areas	-0.00043	-0.00033	-0.00027	-0.00025	-0.00024	-0.00100	-0.00074	-0.00060	-0.00056	-0.00052	-0.00314	-0.00227	-0.00182	-0.00169	-0.00158
Biomass: Habitat-connectivity areas	0.00082	0.00086	0.00075	0.00071	0.00066	0.00024	0.00044	0.00041	0.00040	0.00038	-0.00191	-0.00109	-0.00081	-0.00074	-0.00069
Green waste: Extensive grassland	0.00082	0.00086	0.00075	0.00071	0.00066	0.00024	0.00044	0.00041	0.00040	0.00038	-0.00191	-0.00109	-0.00081	-0.00074	-0.00069
Short-rotation coppice: Erosion areas	0.00008	0.00015	0.00014	0.00014	0.00013	-0.00053	-0.00028	-0.00020	-0.00018	-0.00017	-0.00280	-0.00190	-0.00150	-0.00138	-0.00129
Sewage sludge	0.00140	0.00162	0.00144	0.00137	0.00129	-0.00083	0.00003	0.00017	0.00019	0.00018	-0.00911	-0.00588	-0.00456	-0.00420	-0.00392
Solid cattle manure	-0.00023	-0.00005	-0.00001	0.00000	0.00000	-0.00157	-0.00100	-0.00077	-0.00071	-0.00066	-0.00653	-0.00455	-0.00360	-0.00334	-0.00312
Solid swine manure	-0.00021	0.00008	0.00012	0.00012	0.00012	-0.00233	-0.00144	-0.00110	-0.00101	-0.00094	-0.01023	-0.00708	-0.00560	-0.00519	-0.00485
Solid poultry manure	-0.00024	-0.00014	-0.00010	-0.00009	-0.00009	-0.00090	-0.00061	-0.00048	-0.00045	-0.00042	-0.00336	-0.00237	-0.00188	-0.00175	-0.00164
Liquid cattle and swine manure	-0.00012	0.00047	0.00050	0.00049	0.00047	-0.00455	-0.00270	-0.00203	-0.00185	-0.00173	-0.02097	-0.01444	-0.01140	-0.01055	-0.00987
Sugar-beet leaf and potato haulm	-0.00168	-0.00124	-0.00099	-0.00093	-0.00087	-0.00446	-0.00323	-0.00258	-0.00240	-0.00225	-0.01479	-0.01061	-0.00848	-0.00787	-0.00737
Commercial and industrial waste	0.00105	0.00117	0.00102	0.00097	0.00092	-0.00017	0.00029	0.00032	0.00032	0.00031	-0.00473	-0.00297	-0.00227	-0.00209	-0.00195
Organic municipal solid waste	0.00116	0.00132	0.00116	0.00111	0.00104	-0.00045	0.00016	0.00024	0.00025	0.00024	-0.00645	-0.00412	-0.00318	-0.00292	-0.00273
Digestates (energy crops)	0.00174	0.00206	0.00183	0.00174	0.00164	-0.00129	-0.00011	0.00010	0.00013	0.00014	-0.01253	-0.00814	-0.00632	-0.00582	-0.00544

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table A.22 (columns 1 to 5) – Table A.26 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.22 (columns 6 to 10) – Table A.26 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.22 (columns 11 to 15) – Table A.26 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.32: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00047	-0.00044	-0.00036	-0.00033	-0.00031	-0.00112	-0.00104	-0.00083	-0.00078	-0.00073	-0.00352	-0.00326	-0.00261	-0.00242	-0.00227
Forestry residues	-0.00046	-0.00042	-0.00034	-0.00032	-0.00030	-0.00110	-0.00102	-0.00082	-0.00076	-0.00072	-0.00350	-0.00324	-0.00259	-0.00240	-0.00225
Open-country biomass residues	0.00079	0.00076	0.00067	0.00064	0.00060	0.00016	0.00018	0.00020	0.00020	0.00019	-0.00219	-0.00200	-0.00153	-0.00141	-0.00131
Industrial wood waste	0.00000	0.00001	0.00003	0.00003	0.00003	-0.00063	-0.00057	-0.00043	-0.00040	-0.00037	-0.00295	-0.00272	-0.00215	-0.00199	-0.00186
Wood in municipal solid waste	0.00080	0.00077	0.00068	0.00065	0.00061	0.00015	0.00018	0.00020	0.00020	0.00019	-0.00224	-0.00204	-0.00157	-0.00144	-0.00134
Green waste: Compensation areas	-0.00045	-0.00042	-0.00034	-0.00032	-0.00030	-0.00108	-0.00101	-0.00081	-0.00075	-0.00070	-0.00342	-0.00317	-0.00253	-0.00235	-0.00220
Biomass: Habitat-connectivity areas	0.00079	0.00076	0.00067	0.00064	0.00060	0.00016	0.00018	0.00020	0.00020	0.00019	-0.00219	-0.00200	-0.00153	-0.00141	-0.00131
Green waste: Extensive grassland	0.00079	0.00076	0.00067	0.00064	0.00060	0.00016	0.00018	0.00020	0.00020	0.00019	-0.00219	-0.00200	-0.00153	-0.00141	-0.00131
Short-rotation coppice: Erosion areas	0.00004	0.00005	0.00006	0.00007	0.00006	-0.00062	-0.00056	-0.00043	-0.00039	-0.00037	-0.00309	-0.00285	-0.00225	-0.00209	-0.00195
Sewage sludge	0.00128	0.00126	0.00115	0.00110	0.00104	-0.00115	-0.00099	-0.00065	-0.00057	-0.00052	-0.01020	-0.00936	-0.00733	-0.00677	-0.00633
Solid cattle manure	-0.00030	-0.00026	-0.00018	-0.00016	-0.00015	-0.00176	-0.00161	-0.00126	-0.00116	-0.00109	-0.00718	-0.00663	-0.00526	-0.00488	-0.00457
Solid swine manure	-0.00031	-0.00026	-0.00016	-0.00013	-0.00012	-0.00264	-0.00241	-0.00187	-0.00173	-0.00161	-0.01127	-0.01039	-0.00824	-0.00764	-0.00715
Solid poultry manure	-0.00027	-0.00025	-0.00019	-0.00017	-0.00016	-0.00099	-0.00092	-0.00072	-0.00067	-0.00063	-0.00368	-0.00340	-0.00271	-0.00251	-0.00235
Liquid cattle and swine manure	-0.00034	-0.00025	-0.00008	-0.00004	-0.00003	-0.00518	-0.00473	-0.00365	-0.00336	-0.00313	-0.02313	-0.02133	-0.01690	-0.01566	-0.01465
Sugar-beet leaf and potato haulm	-0.00182	-0.00169	-0.00135	-0.00126	-0.00118	-0.00486	-0.00450	-0.00360	-0.00334	-0.00313	-0.01615	-0.01494	-0.01194	-0.01108	-0.01037
Commercial and industrial waste	0.00099	0.00097	0.00087	0.00083	0.00078	-0.00035	-0.00027	-0.00012	-0.00009	-0.00008	-0.00533	-0.00488	-0.00380	-0.00350	-0.00328
Organic municipal solid waste	0.00108	0.00106	0.00095	0.00091	0.00086	-0.00069	-0.00058	-0.00035	-0.00030	-0.00027	-0.00723	-0.00663	-0.00518	-0.00478	-0.00447
Digestates (energy crops)	0.00159	0.00157	0.00144	0.00138	0.00130	-0.00172	-0.00150	-0.00101	-0.00089	-0.00083	-0.01401	-0.01286	-0.01008	-0.00931	-0.00871

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table A.23 (columns 1 to 5) – Table A.27 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.23 (columns 6 to 10) – Table A.27 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.23 (columns 11 to 15) – Table A.27 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.33: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Max 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00030	-0.00028	-0.00022	-0.00020	-0.00019	-0.00064	-0.00058	-0.00044	-0.00041	-0.00039	-0.00191	-0.00170	-0.00128	-0.00119	-0.00111
Forestry residues	-0.00029	-0.00026	-0.00021	-0.00019	-0.00018	-0.00063	-0.00056	-0.00043	-0.00040	-0.00038	-0.00189	-0.00168	-0.00126	-0.00117	-0.00110
Open-country biomass residues	0.00095	0.00092	0.00081	0.00076	0.00072	0.00062	0.00063	0.00059	0.00056	0.00053	-0.00062	-0.00047	-0.00023	-0.00020	-0.00018
Industrial wood waste	0.00016	0.00017	0.00016	0.00015	0.00014	-0.00017	-0.00012	-0.00006	-0.00005	-0.00004	-0.00139	-0.00120	-0.00086	-0.00080	-0.00075
Wood in municipal solid waste	0.00097	0.00094	0.00082	0.00077	0.00073	0.00063	0.00064	0.00060	0.00057	0.00053	-0.00063	-0.00048	-0.00024	-0.00021	-0.00019
Green waste: Compensation areas	-0.00029	-0.00027	-0.00021	-0.00020	-0.00018	-0.00062	-0.00056	-0.00043	-0.00040	-0.00037	-0.00185	-0.00165	-0.00124	-0.00115	-0.00108
Biomass: Habitat-connectivity areas	0.00095	0.00092	0.00081	0.00076	0.00072	0.00062	0.00063	0.00059	0.00056	0.00053	-0.00062	-0.00047	-0.00023	-0.00020	-0.00018
Green waste: Extensive grassland	0.00095	0.00092	0.00081	0.00076	0.00072	0.00062	0.00063	0.00059	0.00056	0.00053	-0.00062	-0.00047	-0.00023	-0.00020	-0.00018
Short-rotation coppice: Erosion areas	0.00022	0.00022	0.00021	0.00020	0.00019	-0.00013	-0.00009	-0.00002	-0.00002	-0.00002	-0.00143	-0.00124	-0.00088	-0.00082	-0.00076
Sewage sludge (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Solid cattle manure (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Solid swine manure (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Solid poultry manure (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Liquid cattle and swine manure (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Sugar-beet leaf and potato haulm (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Commercial and industrial waste (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Organic municipal solid waste (D)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280
Digestates (energy crops)	0.00245	0.00240	0.00215	0.00203	0.00191	0.00070	0.00086	0.00100	0.00096	0.00091	-0.00576	-0.00486	-0.00326	-0.00300	-0.00280

Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

*Sources:*

- a) Columns 1 to 5 = – Table 25 (columns 1 to 5) – Table 27 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table 25 (columns 6 to 10) – Table 27 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table 25 (columns 11 to 15) – Table 27 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.34: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00033	-0.00030	-0.00025	-0.00023	-0.00022	-0.00073	-0.00064	-0.00052	-0.00049	-0.00046	-0.00221	-0.00192	-0.00154	-0.00144	-0.00134
Forestry residues	-0.00032	-0.00029	-0.00023	-0.00022	-0.00021	-0.00072	-0.00063	-0.00051	-0.00047	-0.00044	-0.00218	-0.00190	-0.00153	-0.00142	-0.00133
Open-country biomass residues	0.00092	0.00090	0.00078	0.00074	0.00069	0.00053	0.00056	0.00051	0.00049	0.00046	-0.00091	-0.00069	-0.00049	-0.00044	-0.00041
Industrial wood waste	0.00013	0.00015	0.00013	0.00013	0.00012	-0.00025	-0.00019	-0.00013	-0.00012	-0.00011	-0.00168	-0.00142	-0.00112	-0.00104	-0.00097
Wood in municipal solid waste	0.00094	0.00091	0.00079	0.00075	0.00070	0.00054	0.00057	0.00052	0.00049	0.00047	-0.00093	-0.00070	-0.00050	-0.00045	-0.00042
Green waste: Compensation areas	-0.00032	-0.00029	-0.00024	-0.00022	-0.00021	-0.00071	-0.00062	-0.00050	-0.00047	-0.00044	-0.00214	-0.00186	-0.00150	-0.00139	-0.00130
Biomass: Habitat-connectivity areas	0.00092	0.00090	0.00078	0.00074	0.00069	0.00053	0.00056	0.00051	0.00049	0.00046	-0.00091	-0.00069	-0.00049	-0.00044	-0.00041
Green waste: Extensive grassland	0.00092	0.00090	0.00078	0.00074	0.00069	0.00053	0.00056	0.00051	0.00049	0.00046	-0.00091	-0.00069	-0.00049	-0.00044	-0.00041
Short-rotation coppice: Erosion areas	0.00019	0.00020	0.00018	0.00017	0.00016	-0.00022	-0.00016	-0.00010	-0.00009	-0.00009	-0.00174	-0.00147	-0.00115	-0.00107	-0.00100
Sewage sludge (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Solid cattle manure (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Solid swine manure (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Solid poultry manure (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Liquid cattle and swine manure (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Sugar-beet leaf and potato haulm (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Commercial and industrial waste (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Organic municipal solid waste (D)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398
Digestates (energy crops)	0.00229	0.00228	0.00200	0.00190	0.00179	0.00026	0.00052	0.00060	0.00059	0.00057	-0.00728	-0.00601	-0.00462	-0.00426	-0.00398

Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

*Sources:*

- a) Columns 1 to 5 = – Table A.24 (columns 1 to 5) – Table A.28 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.24 (columns 6 to 10) – Table A.28 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.24 (columns 11 to 15) – Table A.28 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.35: Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00039	-0.00036	-0.00029	-0.00027	-0.00026	-0.00089	-0.00082	-0.00065	-0.00061	-0.00057	-0.00273	-0.00252	-0.00200	-0.00186	-0.00174
Forestry residues	-0.00037	-0.00035	-0.00028	-0.00026	-0.00025	-0.00087	-0.00080	-0.00064	-0.00060	-0.00056	-0.00271	-0.00250	-0.00198	-0.00184	-0.00172
Open-country biomass residues	0.00087	0.00084	0.00073	0.00069	0.00065	0.00038	0.00039	0.00038	0.00036	0.00035	-0.00142	-0.00127	-0.00093	-0.00086	-0.00080
Industrial wood waste	0.00008	0.00009	0.00009	0.00009	0.00008	-0.00040	-0.00036	-0.00026	-0.00024	-0.00022	-0.00218	-0.00200	-0.00156	-0.00145	-0.00135
Wood in municipal solid waste	0.00088	0.00085	0.00074	0.00071	0.00066	0.00039	0.00039	0.00038	0.00037	0.00035	-0.00145	-0.00130	-0.00095	-0.00088	-0.00082
Green waste: Compensation areas	-0.00037	-0.00035	-0.00028	-0.00026	-0.00025	-0.00086	-0.00079	-0.00063	-0.00059	-0.00055	-0.00265	-0.00245	-0.00194	-0.00181	-0.00169
Biomass: Habitat-connectivity areas	0.00087	0.00084	0.00073	0.00069	0.00065	0.00038	0.00039	0.00038	0.00036	0.00035	-0.00142	-0.00127	-0.00093	-0.00086	-0.00080
Green waste: Extensive grassland	0.00087	0.00084	0.00073	0.00069	0.00065	0.00038	0.00039	0.00038	0.00036	0.00035	-0.00142	-0.00127	-0.00093	-0.00086	-0.00080
Short-rotation coppice: Erosion areas	0.00013	0.00013	0.00013	0.00013	0.00012	-0.00038	-0.00034	-0.00024	-0.00022	-0.00021	-0.00228	-0.00209	-0.00162	-0.00151	-0.00141
Sewage sludge (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Solid cattle manure (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Solid swine manure (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Solid poultry manure (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Liquid cattle and swine manure (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Sugar-beet leaf and potato haulm (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Commercial and industrial waste (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Organic municipal solid waste (D)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601
Digestates (energy crops)	0.00201	0.00196	0.00176	0.00168	0.00158	-0.00053	-0.00038	-0.00009	-0.00005	-0.00003	-0.00995	-0.00906	-0.00695	-0.00643	-0.00601

Values rounded. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates.

*Sources:*

- a) Columns 1 to 5 = – Table A.25 (columns 1 to 5) – Table A.29 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.25 (columns 6 to 10) – Table A.29 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.25 (columns 11 to 15) – Table A.29 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

## **A.7 Total Net Avoided GHG Emissions per Dry-Feedstock Tonne**

With regard to the total net GHG emissions that are avoided per tonne of dry feedstock that is turned into slow-pyrolysis biochar, this section contains the supplementary results tables and sensitivity checks referred to and discussed in Section 4.5 of Teichmann (2014).

In particular, Tables A.36-A.51 cover the supplementary results for the total net avoided GHG emissions associated with the biomass scenarios *Med 1*, *Min 1*, *Med 2* and *Min 2* in 2030 and all the biomass scenarios in 2015 and 2050.

Concerning the sensitivity of the results, Teichmann (2014) performs sensitivity checks for the following assumptions: First, it is analyzed how the total net avoided GHG emissions react to an increase in the stability of biochar from digestible biomass residues and digestates from 34% to 68%. Second, it is checked how the total net avoided GHG emissions change when the long-term stability of biomass carbon added to soil is reduced from 10% to zero. While Tables A.52-A.58 present the total net avoided GHG emissions when 68% biochar carbon sequestration is assumed for all feedstocks, Tables A.59-A.65 display the total net avoided GHG emissions for zero biomass carbon sequestration.

**Table A.36: Total Net Avoided GHG Emissions, 2030, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.401	-0.261	0.008
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.581	-0.429	-0.156	-0.476	-0.341	-0.100	-0.586	-0.434	-0.161	-0.481	-0.346	-0.105
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.341	0.388	0.428	0.439	0.450	0.309	0.339	0.385	0.426	0.436	0.448
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.384	0.498	0.697	0.499	0.594	0.758	0.380	0.493	0.692	0.495	0.589	0.753
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.712	0.656	0.546	0.825	0.751	0.607
Liquid cattle and swine manure	-2.045	-1.582	-0.735	-1.927	-1.484	-0.672	-2.048	-1.585	-0.737	-1.930	-1.486	-0.675	-2.057	-1.594	-0.747	-1.939	-1.495	-0.684
Sugar-beet leaf and potato haulm	-1.308	-1.079	-0.664	-1.197	-0.986	-0.605	-1.310	-1.081	-0.666	-1.199	-0.988	-0.607	-1.316	-1.087	-0.672	-1.205	-0.994	-0.613
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.701	0.702	0.695	0.825	0.806	0.761	0.698	0.700	0.693	0.822	0.803	0.759
Organic municipal solid waste	0.068	0.153	0.302	0.180	0.246	0.362	0.067	0.152	0.301	0.179	0.245	0.361	0.064	0.148	0.298	0.176	0.242	0.357
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.748	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table 31 (column 11) + Table A.31 (column 3)
- b) (2) = Table 31 (column 12) + Table A.31 (column 3)
- c) (3) = Table 31 (column 13) + Table A.31 (column 3)
- d) (4) = Table 31 (column 14) + Table A.31 (column 3)
- e) (5) = Table 31 (column 15) + Table A.31 (column 3)
- f) (6) = Table 31 (column 16) + Table A.31 (column 3)

- g) (7) = Table 31 (column 11) + Table A.31 (column 8)
- h) (8) = Table 31 (column 12) + Table A.31 (column 8)
- i) (9) = Table 31 (column 13) + Table A.31 (column 8)
- j) (10) = Table 31 (column 14) + Table A.31 (column 8)
- k) (11) = Table 31 (column 15) + Table A.31 (column 8)
- l) (12) = Table 31 (column 16) + Table A.31 (column 8)

- m) (13) = Table 31 (column 11) + Table A.31 (column 13)
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- p) (16) = Table 31 (column 14) + Table A.31 (column 13)
- q) (17) = Table 31 (column 15) + Table A.31 (column 13)
- r) (18) = Table 31 (column 16) + Table A.31 (column 13)

Note that tables numbered without the leading "A." refer to Teichmann (2014).



**Table A.37: Total Net Avoided GHG Emissions, 2030, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.801	0.648	1.002	0.904	0.714	0.876	0.799	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.949	0.860	0.686	1.077	0.967	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.493	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.009	-0.530	-0.368	-0.060	-0.402	-0.262	0.008
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.582	-0.430	-0.157	-0.477	-0.342	-0.101	-0.589	-0.436	-0.164	-0.484	-0.349	-0.108
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.388	0.428	0.439	0.450	0.307	0.337	0.384	0.424	0.435	0.446
Solid swine manure	0.385	0.499	0.698	0.500	0.594	0.759	0.384	0.497	0.696	0.498	0.593	0.757	0.377	0.491	0.690	0.492	0.586	0.751
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.657	0.547	0.826	0.752	0.608	0.711	0.655	0.545	0.824	0.750	0.606
Liquid cattle and swine manure	-2.046	-1.583	-0.736	-1.928	-1.484	-0.673	-2.049	-1.586	-0.739	-1.931	-1.488	-0.676	-2.063	-1.600	-0.752	-1.945	-1.501	-0.689
Sugar-beet leaf and potato haulm	-1.309	-1.080	-0.665	-1.198	-0.987	-0.605	-1.311	-1.082	-0.667	-1.200	-0.989	-0.608	-1.319	-1.090	-0.675	-1.208	-0.997	-0.616
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.806	0.762	0.700	0.702	0.695	0.824	0.805	0.761	0.697	0.698	0.691	0.821	0.802	0.757
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.067	0.151	0.300	0.179	0.245	0.360	0.062	0.146	0.296	0.174	0.240	0.355
Digestates (energy crops)	-0.856	-0.621	-0.198	-0.747	-0.530	-0.141	-0.858	-0.624	-0.201	-0.750	-0.533	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table 31 (column 11) + Table A.32 (column 3)
- b) (2) = Table 31 (column 12) + Table A.32 (column 3)
- c) (3) = Table 31 (column 13) + Table A.32 (column 3)
- d) (4) = Table 31 (column 14) + Table A.32 (column 3)
- e) (5) = Table 31 (column 15) + Table A.32 (column 3)
- f) (6) = Table 31 (column 16) + Table A.32 (column 3)

- g) (7) = Table 31 (column 11) + Table A.32 (column 8)
- h) (8) = Table 31 (column 12) + Table A.32 (column 8)
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- m) (13) = Table 31 (column 11) + Table A.32 (column 13)
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- q) (17) = Table 31 (column 15) + Table A.32 (column 13)
- r) (18) = Table 31 (column 16) + Table A.32 (column 13)

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.38: Total Net Avoided GHG Emissions, 2030, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.862	-0.627	-0.204	-0.753	-0.537	-0.147

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.34 (column 3) | g) (7) = Table 31 (column 11) + Table A.34 (column 8)  | m) (13) = Table 31 (column 11) + Table A.34 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.34 (column 3) | h) (8) = Table 31 (column 12) + Table A.34 (column 8)  | n) (14) = Table 31 (column 12) + Table A.34 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.34 (column 3) | i) (9) = Table 31 (column 13) + Table A.34 (column 8)  | o) (15) = Table 31 (column 13) + Table A.34 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.34 (column 3) | j) (10) = Table 31 (column 14) + Table A.34 (column 8) | p) (16) = Table 31 (column 14) + Table A.34 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.34 (column 3) | k) (11) = Table 31 (column 15) + Table A.34 (column 8) | q) (17) = Table 31 (column 15) + Table A.34 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.34 (column 3) | l) (12) = Table 31 (column 16) + Table A.34 (column 8) | r) (18) = Table 31 (column 16) + Table A.34 (column 13) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.39: Total Net Avoided GHG Emissions, 2030, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.141
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.35 (column 3) | g) (7) = Table 31 (column 11) + Table A.35 (column 8)  | m) (13) = Table 31 (column 11) + Table A.35 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.35 (column 3) | h) (8) = Table 31 (column 12) + Table A.35 (column 8)  | n) (14) = Table 31 (column 12) + Table A.35 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.35 (column 3) | i) (9) = Table 31 (column 13) + Table A.35 (column 8)  | o) (15) = Table 31 (column 13) + Table A.35 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.35 (column 3) | j) (10) = Table 31 (column 14) + Table A.35 (column 8) | p) (16) = Table 31 (column 14) + Table A.35 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.35 (column 3) | k) (11) = Table 31 (column 15) + Table A.35 (column 8) | q) (17) = Table 31 (column 15) + Table A.35 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.35 (column 3) | l) (12) = Table 31 (column 16) + Table A.35 (column 8) | r) (18) = Table 31 (column 16) + Table A.35 (column 13) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.40: Total Net Avoided GHG Emissions, 2015, Scenario *Max 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.002	0.904	0.714	0.876	0.798	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.079	0.970	0.756	0.951	0.862	0.687	1.079	0.969	0.756	0.949	0.860	0.685	1.077	0.967	0.753
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.282	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.072	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.492	1.382	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.771	0.702	0.566	0.895	0.806	0.632
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.282	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.282	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.400	-0.260	0.009	-0.530	-0.369	-0.061	-0.402	-0.262	0.007
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.582	-0.430	-0.157	-0.477	-0.342	-0.101	-0.589	-0.437	-0.164	-0.485	-0.350	-0.109
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.388	0.428	0.438	0.450	0.307	0.336	0.383	0.423	0.434	0.445
Solid swine manure	0.385	0.499	0.698	0.500	0.595	0.759	0.383	0.497	0.696	0.498	0.593	0.757	0.376	0.489	0.688	0.491	0.585	0.749
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.657	0.547	0.826	0.752	0.608	0.711	0.655	0.545	0.824	0.750	0.605
Liquid cattle and swine manure	-2.046	-1.583	-0.735	-1.928	-1.484	-0.672	-2.050	-1.587	-0.739	-1.932	-1.488	-0.677	-2.065	-1.602	-0.755	-1.947	-1.503	-0.692
Sugar-beet leaf and potato haulm	-1.309	-1.080	-0.665	-1.198	-0.987	-0.606	-1.311	-1.082	-0.667	-1.200	-0.990	-0.608	-1.321	-1.092	-0.677	-1.210	-0.999	-0.618
Commercial and industrial waste	0.701	0.703	0.696	0.826	0.807	0.762	0.700	0.702	0.695	0.824	0.806	0.761	0.696	0.698	0.691	0.820	0.801	0.757
Organic municipal solid waste	0.068	0.153	0.302	0.180	0.246	0.362	0.067	0.151	0.300	0.179	0.245	0.360	0.061	0.146	0.295	0.173	0.239	0.355
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.624	-0.201	-0.750	-0.533	-0.143	-0.868	-0.634	-0.211	-0.760	-0.543	-0.153

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.30 (column 1) | g) (7) = Table 31 (column 11) + Table A.30 (column 6)  | m) (13) = Table 31 (column 11) + Table A.30 (column 11) |
| b) (2) = Table 31 (column 12) + Table A.30 (column 1) | h) (8) = Table 31 (column 12) + Table A.30 (column 6)  | n) (14) = Table 31 (column 12) + Table A.30 (column 11) |
| c) (3) = Table 31 (column 13) + Table A.30 (column 1) | i) (9) = Table 31 (column 13) + Table A.30 (column 6)  | o) (15) = Table 31 (column 13) + Table A.30 (column 11) |
| d) (4) = Table 31 (column 14) + Table A.30 (column 1) | j) (10) = Table 31 (column 14) + Table A.30 (column 6) | p) (16) = Table 31 (column 14) + Table A.30 (column 11) |
| e) (5) = Table 31 (column 15) + Table A.30 (column 1) | k) (11) = Table 31 (column 15) + Table A.30 (column 6) | q) (17) = Table 31 (column 15) + Table A.30 (column 11) |
| f) (6) = Table 31 (column 16) + Table A.30 (column 1) | l) (12) = Table 31 (column 16) + Table A.30 (column 6) | r) (18) = Table 31 (column 16) + Table A.30 (column 11) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.41: Total Net Avoided GHG Emissions, 2015, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.002	0.904	0.714	0.876	0.798	0.646	0.999	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755	0.949	0.860	0.685	1.077	0.967	0.753
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.254	1.178	1.026	1.380	1.282	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.142	-0.420	-0.251	0.072	-0.293	-0.145	0.140
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.366	1.278	1.103	1.494	1.384	1.171	1.364	1.275	1.101	1.492	1.382	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.771	0.702	0.566	0.895	0.805	0.632
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.254	1.178	1.026	1.380	1.282	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.254	1.178	1.026	1.380	1.282	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.400	-0.260	0.009	-0.530	-0.369	-0.061	-0.403	-0.262	0.007
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.582	-0.430	-0.157	-0.477	-0.342	-0.101	-0.590	-0.438	-0.165	-0.485	-0.351	-0.109
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.387	0.428	0.438	0.450	0.306	0.336	0.383	0.423	0.433	0.445
Solid swine manure	0.385	0.499	0.698	0.500	0.594	0.759	0.383	0.496	0.695	0.498	0.592	0.757	0.375	0.489	0.688	0.490	0.584	0.749
Solid poultry manure	0.713	0.658	0.548	0.827	0.753	0.608	0.713	0.657	0.547	0.826	0.752	0.608	0.710	0.655	0.545	0.824	0.749	0.605
Liquid cattle and swine manure	-2.046	-1.583	-0.736	-1.928	-1.484	-0.673	-2.050	-1.587	-0.740	-1.932	-1.489	-0.677	-2.067	-1.604	-0.756	-1.949	-1.505	-0.693
Sugar-beet leaf and potato haulm	-1.309	-1.080	-0.665	-1.198	-0.987	-0.606	-1.312	-1.083	-0.668	-1.201	-0.990	-0.609	-1.322	-1.093	-0.678	-1.211	-1.000	-0.619
Commercial and industrial waste	0.701	0.703	0.696	0.826	0.807	0.762	0.700	0.702	0.695	0.824	0.805	0.761	0.696	0.697	0.690	0.820	0.801	0.756
Organic municipal solid waste	0.068	0.153	0.302	0.180	0.246	0.362	0.066	0.151	0.300	0.179	0.245	0.360	0.060	0.145	0.294	0.173	0.239	0.354
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.624	-0.201	-0.750	-0.533	-0.143	-0.870	-0.635	-0.212	-0.761	-0.544	-0.155

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table 31 (column 11) + Table A.31 (column 1)
- b) (2) = Table 31 (column 12) + Table A.31 (column 1)
- c) (3) = Table 31 (column 13) + Table A.31 (column 1)
- d) (4) = Table 31 (column 14) + Table A.31 (column 1)
- e) (5) = Table 31 (column 15) + Table A.31 (column 1)
- f) (6) = Table 31 (column 16) + Table A.31 (column 1)

- g) (7) = Table 31 (column 11) + Table A.31 (column 6)
- h) (8) = Table 31 (column 12) + Table A.31 (column 6)
- i) (9) = Table 31 (column 13) + Table A.31 (column 6)
- j) (10) = Table 31 (column 14) + Table A.31 (column 6)
- k) (11) = Table 31 (column 15) + Table A.31 (column 6)
- l) (12) = Table 31 (column 16) + Table A.31 (column 6)

- m) (13) = Table 31 (column 11) + Table A.31 (column 11)
- n) (14) = Table 31 (column 12) + Table A.31 (column 11)
- o) (15) = Table 31 (column 13) + Table A.31 (column 11)
- p) (16) = Table 31 (column 14) + Table A.31 (column 11)
- q) (17) = Table 31 (column 15) + Table A.31 (column 11)
- r) (18) = Table 31 (column 16) + Table A.31 (column 11)

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.42: Total Net Avoided GHG Emissions, 2015, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.002	0.904	0.714	0.876	0.798	0.645	0.999	0.901	0.711
Forestry residues	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755	0.949	0.860	0.685	1.076	0.966	0.753
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.143	0.142	-0.421	-0.252	0.072	-0.293	-0.145	0.140
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.366	1.277	1.103	1.494	1.384	1.171	1.364	1.275	1.101	1.492	1.382	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.771	0.702	0.566	0.895	0.805	0.632
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.260	0.009	-0.531	-0.369	-0.061	-0.403	-0.263	0.007
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.582	-0.430	-0.157	-0.477	-0.343	-0.101	-0.591	-0.439	-0.166	-0.486	-0.352	-0.110
Solid cattle manure	0.312	0.342	0.389	0.429	0.439	0.451	0.311	0.340	0.387	0.427	0.438	0.449	0.305	0.335	0.382	0.422	0.433	0.444
Solid swine manure	0.385	0.498	0.697	0.500	0.594	0.759	0.383	0.496	0.695	0.498	0.592	0.756	0.374	0.487	0.687	0.489	0.583	0.748
Solid poultry manure	0.713	0.658	0.548	0.827	0.753	0.608	0.713	0.657	0.547	0.826	0.752	0.608	0.710	0.655	0.545	0.823	0.749	0.605
Liquid cattle and swine manure	-2.046	-1.583	-0.736	-1.928	-1.484	-0.673	-2.051	-1.588	-0.741	-1.933	-1.489	-0.678	-2.069	-1.606	-0.759	-1.951	-1.507	-0.696
Sugar-beet leaf and potato haulm	-1.309	-1.080	-0.665	-1.198	-0.987	-0.606	-1.312	-1.083	-0.668	-1.201	-0.990	-0.609	-1.323	-1.094	-0.679	-1.212	-1.002	-0.620
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.700	0.702	0.695	0.824	0.805	0.761	0.695	0.697	0.690	0.819	0.800	0.756
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.066	0.151	0.300	0.178	0.245	0.360	0.060	0.144	0.294	0.172	0.238	0.353
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.859	-0.624	-0.202	-0.750	-0.534	-0.144	-0.871	-0.637	-0.214	-0.763	-0.546	-0.156

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.32 (column 1) | g) (7) = Table 31 (column 11) + Table A.32 (column 6)  | m) (13) = Table 31 (column 11) + Table A.32 (column 11) |
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| c) (3) = Table 31 (column 13) + Table A.32 (column 1) | i) (9) = Table 31 (column 13) + Table A.32 (column 6)  | o) (15) = Table 31 (column 13) + Table A.32 (column 11) |
| d) (4) = Table 31 (column 14) + Table A.32 (column 1) | j) (10) = Table 31 (column 14) + Table A.32 (column 6) | p) (16) = Table 31 (column 14) + Table A.32 (column 11) |
| e) (5) = Table 31 (column 15) + Table A.32 (column 1) | k) (11) = Table 31 (column 15) + Table A.32 (column 6) | q) (17) = Table 31 (column 15) + Table A.32 (column 11) |
| f) (6) = Table 31 (column 16) + Table A.32 (column 1) | l) (12) = Table 31 (column 16) + Table A.32 (column 6) | r) (18) = Table 31 (column 16) + Table A.32 (column 11) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.43: Total Net Avoided GHG Emissions, 2015, Scenario *Max 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.493	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.059	-0.401	-0.261	0.008
Sewage sludge (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Solid cattle manure (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Solid swine manure (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Solid poultry manure (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Liquid cattle and swine manure (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Sugar-beet leaf and potato haulm (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Commercial and industrial waste (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Organic municipal solid waste (D)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148
Digestates (energy crops)	-0.855	-0.620	-0.197	-0.746	-0.529	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.863	-0.628	-0.206	-0.754	-0.538	-0.148

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.33 (column 1) | g) (7) = Table 31 (column 11) + Table A.33 (column 6)  | m) (13) = Table 31 (column 11) + Table A.33 (column 11) |
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Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.44: Total Net Avoided GHG Emissions, 2015, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.255	1.179	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.255	1.179	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.383	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.255	1.179	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008
Sewage sludge (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid cattle manure (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid swine manure (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Solid poultry manure (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Liquid cattle and swine manure (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Sugar-beet leaf and potato haulm (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Commercial and industrial waste (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Organic municipal solid waste (D)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149
Digestates (energy crops)	-0.855	-0.620	-0.198	-0.746	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.864	-0.630	-0.207	-0.756	-0.539	-0.149

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
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Note that tables numbered without the leading “A.” refer to Teichmann (2014).



**Table A.45: Total Net Avoided GHG Emissions, 2015, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.801	0.648	1.002	0.904	0.714	0.876	0.799	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.687	1.079	0.969	0.756	0.949	0.860	0.686	1.077	0.967	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.101	1.493	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.702	0.566	0.895	0.806	0.632
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.530	-0.369	-0.060	-0.402	-0.262	0.008
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.858	-0.623	-0.200	-0.749	-0.532	-0.143	-0.867	-0.633	-0.210	-0.759	-0.542	-0.152

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.35 (column 1) | g) (7) = Table 31 (column 11) + Table A.35 (column 6)  | m) (13) = Table 31 (column 11) + Table A.35 (column 11) |
| b) (2) = Table 31 (column 12) + Table A.35 (column 1) | h) (8) = Table 31 (column 12) + Table A.35 (column 6)  | n) (14) = Table 31 (column 12) + Table A.35 (column 11) |
| c) (3) = Table 31 (column 13) + Table A.35 (column 1) | i) (9) = Table 31 (column 13) + Table A.35 (column 6)  | o) (15) = Table 31 (column 13) + Table A.35 (column 11) |
| d) (4) = Table 31 (column 14) + Table A.35 (column 1) | j) (10) = Table 31 (column 14) + Table A.35 (column 6) | p) (16) = Table 31 (column 14) + Table A.35 (column 11) |
| e) (5) = Table 31 (column 15) + Table A.35 (column 1) | k) (11) = Table 31 (column 15) + Table A.35 (column 6) | q) (17) = Table 31 (column 15) + Table A.35 (column 11) |
| f) (6) = Table 31 (column 16) + Table A.35 (column 1) | l) (12) = Table 31 (column 16) + Table A.35 (column 6) | r) (18) = Table 31 (column 16) + Table A.35 (column 11) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.46: Total Net Avoided GHG Emissions, 2050, Scenario *Max 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.003	0.905	0.715	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.904	0.714
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.171
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.581	-0.429	-0.156	-0.476	-0.341	-0.100	-0.584	-0.432	-0.159	-0.479	-0.344	-0.103
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.342	0.389	0.429	0.439	0.451	0.310	0.340	0.387	0.427	0.437	0.449
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.385	0.498	0.697	0.500	0.594	0.758	0.382	0.495	0.694	0.497	0.591	0.755
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.827	0.752	0.608	0.712	0.657	0.547	0.826	0.752	0.607
Liquid cattle and swine manure	-2.045	-1.582	-0.735	-1.927	-1.483	-0.672	-2.047	-1.584	-0.736	-1.929	-1.485	-0.673	-2.053	-1.590	-0.743	-1.935	-1.491	-0.680
Sugar-beet leaf and potato haulm	-1.308	-1.079	-0.664	-1.197	-0.986	-0.605	-1.309	-1.080	-0.665	-1.198	-0.987	-0.606	-1.313	-1.084	-0.669	-1.202	-0.991	-0.610
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.701	0.702	0.695	0.825	0.806	0.762	0.699	0.701	0.694	0.823	0.804	0.760
Organic municipal solid waste	0.068	0.153	0.302	0.180	0.246	0.362	0.067	0.152	0.301	0.180	0.246	0.361	0.065	0.150	0.299	0.177	0.244	0.359
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.861	-0.626	-0.203	-0.752	-0.535	-0.146

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.30 (column 5) | g) (7) = Table 31 (column 11) + Table A.30 (column 10)  | m) (13) = Table 31 (column 11) + Table A.30 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.30 (column 5) | h) (8) = Table 31 (column 12) + Table A.30 (column 10)  | n) (14) = Table 31 (column 12) + Table A.30 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.30 (column 5) | i) (9) = Table 31 (column 13) + Table A.30 (column 10)  | o) (15) = Table 31 (column 13) + Table A.30 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.30 (column 5) | j) (10) = Table 31 (column 14) + Table A.30 (column 10) | p) (16) = Table 31 (column 14) + Table A.30 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.30 (column 5) | k) (11) = Table 31 (column 15) + Table A.30 (column 10) | q) (17) = Table 31 (column 15) + Table A.30 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.30 (column 5) | l) (12) = Table 31 (column 16) + Table A.30 (column 10) | r) (18) = Table 31 (column 16) + Table A.30 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.47: Total Net Avoided GHG Emissions, 2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.366	1.277	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.703	0.567	0.896	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.059	-0.401	-0.261	0.009
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.581	-0.429	-0.156	-0.476	-0.341	-0.100	-0.585	-0.433	-0.160	-0.480	-0.345	-0.104
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.342	0.388	0.429	0.439	0.451	0.309	0.339	0.386	0.426	0.437	0.448
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.385	0.498	0.697	0.499	0.594	0.758	0.381	0.494	0.693	0.495	0.590	0.754
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.712	0.657	0.547	0.825	0.751	0.607
Liquid cattle and swine manure	-2.045	-1.582	-0.735	-1.927	-1.484	-0.672	-2.047	-1.585	-0.737	-1.929	-1.486	-0.674	-2.056	-1.593	-0.745	-1.938	-1.494	-0.682
Sugar-beet leaf and potato haulm	-1.308	-1.079	-0.664	-1.197	-0.986	-0.605	-1.310	-1.080	-0.666	-1.199	-0.988	-0.606	-1.315	-1.086	-0.671	-1.204	-0.993	-0.612
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.701	0.702	0.695	0.825	0.806	0.761	0.698	0.700	0.693	0.823	0.804	0.759
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.067	0.152	0.301	0.179	0.245	0.361	0.064	0.149	0.298	0.176	0.243	0.358
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.200	-0.748	-0.532	-0.142	-0.863	-0.628	-0.205	-0.754	-0.537	-0.148

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.31 (column 5) | g) (7) = Table 31 (column 11) + Table A.31 (column 10)  | m) (13) = Table 31 (column 11) + Table A.31 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.31 (column 5) | h) (8) = Table 31 (column 12) + Table A.31 (column 10)  | n) (14) = Table 31 (column 12) + Table A.31 (column 15) |
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Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.48: Total Net Avoided GHG Emissions, 2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.000	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.262	0.008
Sewage sludge	-0.580	-0.428	-0.155	-0.475	-0.340	-0.099	-0.582	-0.430	-0.157	-0.477	-0.342	-0.101	-0.588	-0.435	-0.163	-0.483	-0.348	-0.107
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.388	0.428	0.439	0.450	0.308	0.338	0.384	0.425	0.435	0.447
Solid swine manure	0.385	0.499	0.698	0.500	0.595	0.759	0.384	0.497	0.696	0.499	0.593	0.757	0.378	0.492	0.691	0.493	0.587	0.752
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.711	0.656	0.546	0.825	0.750	0.606
Liquid cattle and swine manure	-2.046	-1.583	-0.735	-1.928	-1.484	-0.673	-2.049	-1.586	-0.739	-1.931	-1.487	-0.676	-2.060	-1.597	-0.750	-1.942	-1.499	-0.687
Sugar-beet leaf and potato haulm	-1.308	-1.079	-0.664	-1.197	-0.987	-0.605	-1.310	-1.081	-0.666	-1.199	-0.989	-0.607	-1.318	-1.089	-0.674	-1.207	-0.996	-0.615
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.806	0.762	0.700	0.702	0.695	0.824	0.806	0.761	0.697	0.699	0.692	0.821	0.802	0.758
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.361	0.067	0.151	0.300	0.179	0.245	0.360	0.062	0.147	0.296	0.175	0.241	0.356
Digestates (energy crops)	-0.856	-0.621	-0.199	-0.747	-0.531	-0.141	-0.858	-0.623	-0.201	-0.749	-0.533	-0.143	-0.866	-0.631	-0.209	-0.757	-0.541	-0.151

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.32 (column 5) | g) (7) = Table 31 (column 11) + Table A.32 (column 10)  | m) (13) = Table 31 (column 11) + Table A.32 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.32 (column 5) | h) (8) = Table 31 (column 12) + Table A.32 (column 10)  | n) (14) = Table 31 (column 12) + Table A.32 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.32 (column 5) | i) (9) = Table 31 (column 13) + Table A.32 (column 10)  | o) (15) = Table 31 (column 13) + Table A.32 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.32 (column 5) | j) (10) = Table 31 (column 14) + Table A.32 (column 10) | p) (16) = Table 31 (column 14) + Table A.32 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.32 (column 5) | k) (11) = Table 31 (column 15) + Table A.32 (column 10) | q) (17) = Table 31 (column 15) + Table A.32 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.32 (column 5) | l) (12) = Table 31 (column 16) + Table A.32 (column 10) | r) (18) = Table 31 (column 16) + Table A.32 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.49: Total Net Avoided GHG Emissions, 2050, Scenario *Max 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.003	0.905	0.715	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.002	0.904	0.714
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.687	1.079	0.969	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.103	1.494	1.384	1.171
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.260	0.009
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.856	-0.622	-0.199	-0.748	-0.531	-0.141	-0.860	-0.625	-0.203	-0.751	-0.535	-0.145

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.33 (column 5) | g) (7) = Table 31 (column 11) + Table A.33 (column 10)  | m) (13) = Table 31 (column 11) + Table A.33 (column 15) |
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Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.50: Total Net Avoided GHG Emissions, 2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.903	0.714
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.622	-0.199	-0.748	-0.531	-0.142	-0.861	-0.627	-0.204	-0.753	-0.536	-0.146

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
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Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.51: Total Net Avoided GHG Emissions, 2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.277	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.569	0.898	0.808	0.635	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.059	-0.401	-0.261	0.008
Sewage sludge (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Solid cattle manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Solid swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Solid poultry manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Liquid cattle and swine manure (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Sugar-beet leaf and potato haulm (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Commercial and industrial waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Organic municipal solid waste (D)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148
Digestates (energy crops)	-0.855	-0.621	-0.198	-0.747	-0.530	-0.140	-0.857	-0.623	-0.200	-0.749	-0.532	-0.142	-0.863	-0.629	-0.206	-0.755	-0.538	-0.148

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.35 (column 5) | g) (7) = Table 31 (column 11) + Table A.35 (column 10)  | m) (13) = Table 31 (column 11) + Table A.35 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.35 (column 5) | h) (8) = Table 31 (column 12) + Table A.35 (column 10)  | n) (14) = Table 31 (column 12) + Table A.35 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.35 (column 5) | i) (9) = Table 31 (column 13) + Table A.35 (column 10)  | o) (15) = Table 31 (column 13) + Table A.35 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.35 (column 5) | j) (10) = Table 31 (column 14) + Table A.35 (column 10) | p) (16) = Table 31 (column 14) + Table A.35 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.35 (column 5) | k) (11) = Table 31 (column 15) + Table A.35 (column 10) | q) (17) = Table 31 (column 15) + Table A.35 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.35 (column 5) | l) (12) = Table 31 (column 16) + Table A.35 (column 10) | r) (18) = Table 31 (column 16) + Table A.35 (column 15) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.52: Total Net Avoided GHG Emissions from Sections 4.1 to 4.3\* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Emissions from biochar		Emissions from conventional feedstock management						Combustion of pyrolysis by-products				Energy input for biochar production					
	Stable C <sup>a</sup>	N <sub>2</sub> O <sup>b</sup>	CH <sub>4</sub> <sup>c</sup>	N <sub>2</sub> O <sup>d</sup>	Stable C <sup>e</sup>	Fossil-fuel substitution			CH <sub>4</sub> , N <sub>2</sub> O <sup>i</sup>	Fossil-fuel substitution			No process heat recovery			Process heat recovery		
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock		t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1)	(2)	(3)	(4)	(5)	(6a) <sup>f</sup>	(6b) <sup>g</sup>	(6c) <sup>h</sup>	(7)	(8a) <sup>j</sup>	(8b) <sup>k</sup>	(8c) <sup>l</sup>	(9a) <sup>m</sup>	(9b) <sup>n</sup>	(9c) <sup>o</sup>	(10a) <sup>p</sup>	(10b) <sup>q</sup>	(10c) <sup>r</sup>
Cereal straw	0.59	-0.042	-	0.027	-0.172	-	-	-	-0.0004	0.658	0.550	0.342	-0.185	-0.155	-0.099	-0.061	-0.051	-0.033
Forestry residues	0.61	-0.026	-	0.010	-0.180	-	-	-	-0.0005	0.745	0.623	0.387	-0.203	-0.170	-0.108	-0.075	-0.063	-0.040
Open-country biomass residues	0.53	-0.025	0.276	0.071	-0.067	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Industrial wood waste	0.59	-0.003	0.005	0.017	-	-1.567	-1.310	-0.813	-0.0005	0.728	0.609	0.378	-0.191	-0.160	-0.102	-0.063	-0.053	-0.034
Wood in municipal solid waste	0.61	-0.019	0.294	0.015	-0.072	-	-	-	-0.0005	0.745	0.623	0.387	-0.203	-0.170	-0.108	-0.075	-0.063	-0.040
Green waste: Compensation areas	0.50	-0.044	-	0.059	-0.165	-	-	-	-0.0004	0.600	0.502	0.312	-0.179	-0.149	-0.095	-0.055	-0.046	-0.029
Biomass: Habitat-connectivity areas	0.53	-0.025	0.276	0.071	-0.067	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Green waste: Extensive grassland	0.53	-0.025	0.276	0.071	-0.067	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Short-rotation coppice: Erosion areas	0.45	-0.016	0.005	0.017	-	-1.567	-1.310	-0.813	-0.0005	0.821	0.686	0.426	-0.237	-0.198	-0.126	-0.109	-0.091	-0.058
Sewage sludge	0.43	-0.159	0.084	0.306	-0.099	-	-	-	-0.0004	0.584	0.488	0.303	-1.510	-1.263	-0.805	-1.405	-1.175	-0.749
Solid cattle manure	0.60	-0.075	0.100	0.282	-0.112	-	-	-	-0.0004	0.586	0.490	0.304	-0.767	-0.641	-0.409	-0.651	-0.544	-0.347
Solid swine manure	0.57	-0.120	0.550	0.493	-0.133	-	-	-	-0.0005	0.751	0.628	0.390	-1.442	-1.205	-0.768	-1.327	-1.109	-0.707
Solid poultry manure	0.50	-0.107	0.100	0.228	-0.098	-	-	-	-0.0003	0.535	0.447	0.278	-0.196	-0.164	-0.105	-0.083	-0.070	-0.044
Liquid cattle and swine manure	0.49	-0.090	0.525	0.230	-0.135	-	-	-	-0.0004	0.599	0.501	0.311	-3.421	-2.860	-1.823	-3.303	-2.761	-1.760
Sugar-beet leaf and potato haulm	0.57	-0.115	-	0.076	-0.158	-	-	-	-0.0004	0.610	0.510	0.316	-2.006	-1.677	-1.069	-1.895	-1.584	-1.010
Commercial and industrial waste	0.61	-0.115	0.300	0.293	-0.073	-	-	-	-0.0004	0.709	0.593	0.368	-0.718	-0.601	-0.383	-0.594	-0.497	-0.317
Organic municipal solid waste	0.71	-0.071	0.186	0.160	-0.045	-	-	-	-0.0003	0.492	0.411	0.255	-1.007	-0.842	-0.536	-0.895	-0.748	-0.477
Digestates	0.51	-0.100	0.086	0.431	-0.102	-	-	-	-0.0005	0.770	0.644	0.400	-2.199	-1.839	-1.172	-2.091	-1.748	-1.114

Table will be continued on the next page.



**Table A.52 continued**

Feedstocks	Total net avoided GHG emissions (Sections 4.1 to 4.3*) – 68% biochar carbon sequestration for all feedstocks					
	No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(11) <sup>s</sup>	(12) <sup>t</sup>	(13) <sup>u</sup>	(14) <sup>v</sup>	(15) <sup>w</sup>	(16) <sup>x</sup>
Cereal straw	0.879	0.801	0.649	1.003	0.905	0.715
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756
Open-country biomass residues	1.256	1.179	1.028	1.382	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143
Wood in municipal solid waste	1.366	1.277	1.103	1.494	1.384	1.171
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.809	0.635
Biomass: Habitat-connectivity areas	1.256	1.179	1.028	1.382	1.284	1.095
Green waste: Extensive grassland	1.256	1.179	1.028	1.382	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010
Sewage sludge	-0.367	-0.215	0.058	-0.262	-0.128	0.114
Solid cattle manure	0.611	0.641	0.688	0.728	0.739	0.750
Solid swine manure	0.673	0.786	0.985	0.787	0.882	1.046
Solid poultry manure	0.966	0.911	0.801	1.079	1.005	0.861
Liquid cattle and swine manure	-1.799	-1.336	-0.489	-1.681	-1.237	-0.426
Sugar-beet leaf and potato haulm	-1.021	-0.792	-0.377	-0.910	-0.699	-0.318
Commercial and industrial waste	1.005	1.006	0.999	1.129	1.110	1.065
Organic municipal solid waste	0.420	0.505	0.654	0.533	0.599	0.714
Digestates	-0.601	-0.366	0.057	-0.492	-0.275	0.114

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) Table 13, column 4; multiplying the values for digestable biomass residues and digestates by 2 | i) Table 19, column 8; shown as a negative value  | q) Table 23, column 8; shown as a negative value                  |
| b) Table 17, column 9; shown as a negative value  | j) Table 20, column 4                             | r) Table 23, column 12; shown as a negative value                 |
| c) Table 14, column 5   | k) Table 20, column 8                             | s) (11) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (9a)  |
| d) Table 16, column 13  | l) Table 20, column 12                            | t) (12) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (9b)  |
| e) Table 15, column 3; shown as a negative value  | m) Table 22, column 4; shown as a negative value  | u) (13) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (9c)  |
| f) Table 18, column 4; shown as a negative value  | n) Table 22, column 8; shown as a negative value  | v) (14) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (10a) |
| g) Table 18, column 8; shown as a negative value  | o) Table 22, column 12; shown as a negative value | w) (15) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (10b) |
| h) Table 18, column 12; shown as a negative value   | p) Table 23, column 4; shown as a negative value  | x) (16) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (10c) |

\* The sections refer to Teichmann (2014). Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.53: Total Net Avoided GHG Emissions, 2030, Scenario *Max 1* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge	-0.366	-0.214	0.059	-0.261	-0.126	0.115	-0.367	-0.215	0.058	-0.262	-0.127	0.114	-0.370	-0.218	0.055	-0.265	-0.131	0.111
Solid cattle manure	0.611	0.641	0.688	0.728	0.739	0.750	0.611	0.641	0.687	0.728	0.738	0.750	0.609	0.638	0.685	0.725	0.736	0.747
Solid swine manure	0.673	0.786	0.985	0.788	0.882	1.046	0.672	0.785	0.984	0.787	0.881	1.045	0.668	0.782	0.981	0.783	0.878	1.042
Solid poultry manure	0.966	0.910	0.800	1.079	1.005	0.861	0.966	0.910	0.800	1.079	1.005	0.860	0.965	0.909	0.799	1.078	1.004	0.859
Liquid cattle and swine manure	-1.798	-1.335	-0.488	-1.680	-1.236	-0.425	-1.800	-1.337	-0.490	-1.682	-1.238	-0.427	-1.807	-1.344	-0.497	-1.689	-1.245	-0.434
Sugar-beet leaf and potato haulm	-1.022	-0.793	-0.378	-0.911	-0.700	-0.319	-1.023	-0.794	-0.379	-0.912	-0.701	-0.320	-1.028	-0.799	-0.384	-0.917	-0.706	-0.325
Commercial and industrial waste	1.006	1.007	1.000	1.130	1.111	1.067	1.005	1.007	1.000	1.129	1.111	1.066	1.003	1.005	0.998	1.127	1.109	1.064
Organic municipal solid waste	0.422	0.506	0.655	0.534	0.600	0.715	0.421	0.505	0.655	0.533	0.599	0.715	0.418	0.503	0.652	0.531	0.597	0.712
Digestates (energy crops)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.370	0.053	-0.496	-0.280	0.110

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.52 (column 11) + Table A.30 (column 3)
- b) (2) = Table A.52 (column 12) + Table A.30 (column 3)
- c) (3) = Table A.52 (column 13) + Table A.30 (column 3)
- d) (4) = Table A.52 (column 14) + Table A.30 (column 3)
- e) (5) = Table A.52 (column 15) + Table A.30 (column 3)
- f) (6) = Table A.52 (column 16) + Table A.30 (column 3)

- g) (7) = Table A.52 (column 11) + Table A.30 (column 8)
- h) (8) = Table A.52 (column 12) + Table A.30 (column 8)
- i) (9) = Table A.52 (column 13) + Table A.30 (column 8)
- j) (10) = Table A.52 (column 14) + Table A.30 (column 8)
- k) (11) = Table A.52 (column 15) + Table A.30 (column 8)
- l) (12) = Table A.52 (column 16) + Table A.30 (column 8)

- m) (13) = Table A.52 (column 11) + Table A.30 (column 13)
- n) (14) = Table A.52 (column 12) + Table A.30 (column 13)
- o) (15) = Table A.52 (column 13) + Table A.30 (column 13)
- p) (16) = Table A.52 (column 14) + Table A.30 (column 13)
- q) (17) = Table A.52 (column 15) + Table A.30 (column 13)
- r) (18) = Table A.52 (column 16) + Table A.30 (column 13)

**Table A.54: Total Net Avoided GHG Emissions, 2030, Scenario *Med 1* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.401	-0.261	0.008
Sewage sludge	-0.366	-0.214	0.059	-0.261	-0.126	0.115	-0.367	-0.215	0.058	-0.262	-0.127	0.114	-0.372	-0.220	0.053	-0.267	-0.132	0.109
Solid cattle manure	0.611	0.641	0.688	0.728	0.739	0.750	0.611	0.640	0.687	0.727	0.738	0.749	0.608	0.637	0.684	0.724	0.735	0.746
Solid swine manure	0.673	0.786	0.985	0.787	0.882	1.046	0.671	0.785	0.984	0.786	0.881	1.045	0.667	0.780	0.979	0.782	0.876	1.040
Solid poultry manure	0.966	0.910	0.800	1.079	1.005	0.861	0.966	0.910	0.800	1.079	1.005	0.860	0.964	0.909	0.799	1.077	1.003	0.859
Liquid cattle and swine manure	-1.798	-1.335	-0.488	-1.680	-1.237	-0.425	-1.801	-1.338	-0.491	-1.683	-1.239	-0.428	-1.810	-1.347	-0.500	-1.692	-1.249	-0.437
Sugar-beet leaf and potato haulm	-1.022	-0.793	-0.378	-0.911	-0.700	-0.319	-1.024	-0.795	-0.380	-0.913	-0.702	-0.321	-1.030	-0.801	-0.386	-0.919	-0.708	-0.327
Commercial and industrial waste	1.006	1.007	1.000	1.130	1.111	1.066	1.005	1.007	1.000	1.129	1.110	1.066	1.003	1.004	0.997	1.127	1.108	1.063
Organic municipal solid waste	0.421	0.506	0.655	0.534	0.600	0.715	0.421	0.505	0.654	0.533	0.599	0.714	0.417	0.502	0.651	0.529	0.596	0.711
Digestates (energy crops)	-0.599	-0.364	0.059	-0.490	-0.274	0.116	-0.600	-0.366	0.057	-0.492	-0.275	0.115	-0.607	-0.372	0.050	-0.498	-0.282	0.108

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.52 (column 11) + Table A.31 (column 3)
- b) (2) = Table A.52 (column 12) + Table A.31 (column 3)
- c) (3) = Table A.52 (column 13) + Table A.31 (column 3)
- d) (4) = Table A.52 (column 14) + Table A.31 (column 3)
- e) (5) = Table A.52 (column 15) + Table A.31 (column 3)
- f) (6) = Table A.52 (column 16) + Table A.31 (column 3)

- g) (7) = Table A.52 (column 11) + Table A.31 (column 8)
- h) (8) = Table A.52 (column 12) + Table A.31 (column 8)
- i) (9) = Table A.52 (column 13) + Table A.31 (column 8)
- j) (10) = Table A.52 (column 14) + Table A.31 (column 8)
- k) (11) = Table A.52 (column 15) + Table A.31 (column 8)
- l) (12) = Table A.52 (column 16) + Table A.31 (column 8)

- m) (13) = Table A.52 (column 11) + Table A.31 (column 13)
- n) (14) = Table A.52 (column 12) + Table A.31 (column 13)
- o) (15) = Table A.52 (column 13) + Table A.31 (column 13)
- p) (16) = Table A.52 (column 14) + Table A.31 (column 13)
- q) (17) = Table A.52 (column 15) + Table A.31 (column 13)
- r) (18) = Table A.52 (column 16) + Table A.31 (column 13)

**Table A.55: Total Net Avoided GHG Emissions, 2030, Scenario *Min 1* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.801	0.648	1.002	0.904	0.714	0.876	0.799	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.949	0.860	0.686	1.077	0.967	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.493	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.009	-0.530	-0.368	-0.060	-0.402	-0.262	0.008
Sewage sludge	-0.366	-0.214	0.059	-0.261	-0.126	0.115	-0.368	-0.216	0.057	-0.263	-0.128	0.113	-0.375	-0.223	0.050	-0.270	-0.135	0.106
Solid cattle manure	0.611	0.641	0.688	0.728	0.738	0.750	0.610	0.640	0.687	0.727	0.737	0.749	0.606	0.636	0.683	0.723	0.733	0.745
Solid swine manure	0.672	0.786	0.985	0.787	0.882	1.046	0.671	0.784	0.983	0.785	0.880	1.044	0.664	0.778	0.977	0.779	0.873	1.038
Solid poultry manure	0.966	0.910	0.800	1.079	1.005	0.861	0.965	0.910	0.800	1.078	1.004	0.860	0.963	0.908	0.798	1.077	1.002	0.858
Liquid cattle and swine manure	-1.799	-1.336	-0.489	-1.681	-1.237	-0.426	-1.803	-1.340	-0.492	-1.684	-1.241	-0.429	-1.816	-1.353	-0.506	-1.698	-1.254	-0.443
Sugar-beet leaf and potato haulm	-1.023	-0.793	-0.379	-0.912	-0.701	-0.319	-1.025	-0.796	-0.381	-0.914	-0.703	-0.322	-1.033	-0.804	-0.389	-0.922	-0.711	-0.330
Commercial and industrial waste	1.006	1.007	1.000	1.130	1.111	1.066	1.005	1.006	0.999	1.129	1.110	1.065	1.001	1.003	0.996	1.125	1.106	1.062
Organic municipal solid waste	0.421	0.506	0.655	0.534	0.600	0.715	0.420	0.504	0.654	0.532	0.598	0.714	0.415	0.500	0.649	0.527	0.594	0.709
Digestates (energy crops)	-0.599	-0.365	0.058	-0.491	-0.274	0.116	-0.602	-0.367	0.056	-0.493	-0.276	0.113	-0.611	-0.376	0.047	-0.502	-0.285	0.104

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.52 (column 11) + Table A.32 (column 3)
- b) (2) = Table A.52 (column 12) + Table A.32 (column 3)
- c) (3) = Table A.52 (column 13) + Table A.32 (column 3)
- d) (4) = Table A.52 (column 14) + Table A.32 (column 3)
- e) (5) = Table A.52 (column 15) + Table A.32 (column 3)
- f) (6) = Table A.52 (column 16) + Table A.32 (column 3)

- g) (7) = Table A.52 (column 11) + Table A.32 (column 8)
- h) (8) = Table A.52 (column 12) + Table A.32 (column 8)
- i) (9) = Table A.52 (column 13) + Table A.32 (column 8)
- j) (10) = Table A.52 (column 14) + Table A.32 (column 8)
- k) (11) = Table A.52 (column 15) + Table A.32 (column 8)
- l) (12) = Table A.52 (column 16) + Table A.32 (column 8)

- m) (13) = Table A.52 (column 11) + Table A.32 (column 13)
- n) (14) = Table A.52 (column 12) + Table A.32 (column 13)
- o) (15) = Table A.52 (column 13) + Table A.32 (column 13)
- p) (16) = Table A.52 (column 14) + Table A.32 (column 13)
- q) (17) = Table A.52 (column 15) + Table A.32 (column 13)
- r) (18) = Table A.52 (column 16) + Table A.32 (column 13)

**Table A.56: Total Net Avoided GHG Emissions, 2030, Scenario *Max 2* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.904	0.714
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.103	1.494	1.384	1.171
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Solid cattle manure (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Solid swine manure (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Solid poultry manure (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Liquid cattle and swine manure (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Sugar-beet leaf and potato haulm (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Commercial and industrial waste (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Organic municipal solid waste (D)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111
Digestates (energy crops)	-0.598	-0.364	0.059	-0.490	-0.273	0.117	-0.600	-0.365	0.058	-0.491	-0.274	0.115	-0.604	-0.369	0.053	-0.495	-0.279	0.111

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table A.52 (column 11) + Table A.33 (column 3) | g) (7) = Table A.52 (column 11) + Table A.33 (column 8)  | m) (13) = Table A.52 (column 11) + Table A.33 (column 13) |
| b) (2) = Table A.52 (column 12) + Table A.33 (column 3) | h) (8) = Table A.52 (column 12) + Table A.33 (column 8)  | n) (14) = Table A.52 (column 12) + Table A.33 (column 13) |
| c) (3) = Table A.52 (column 13) + Table A.33 (column 3) | i) (9) = Table A.52 (column 13) + Table A.33 (column 8)  | o) (15) = Table A.52 (column 13) + Table A.33 (column 13) |
| d) (4) = Table A.52 (column 14) + Table A.33 (column 3) | j) (10) = Table A.52 (column 14) + Table A.33 (column 8) | p) (16) = Table A.52 (column 14) + Table A.33 (column 13) |
| e) (5) = Table A.52 (column 15) + Table A.33 (column 3) | k) (11) = Table A.52 (column 15) + Table A.33 (column 8) | q) (17) = Table A.52 (column 15) + Table A.33 (column 13) |
| f) (6) = Table A.52 (column 16) + Table A.33 (column 3) | l) (12) = Table A.52 (column 16) + Table A.33 (column 8) | r) (18) = Table A.52 (column 16) + Table A.33 (column 13) |

**Table A.57: Total Net Avoided GHG Emissions, 2030, Scenario *Med 2* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Solid cattle manure (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Solid swine manure (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Solid poultry manure (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Liquid cattle and swine manure (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Sugar-beet leaf and potato haulm (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Commercial and industrial waste (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Organic municipal solid waste (D)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110
Digestates (energy crops)	-0.599	-0.364	0.059	-0.490	-0.273	0.116	-0.600	-0.365	0.057	-0.491	-0.275	0.115	-0.605	-0.371	0.052	-0.497	-0.280	0.110

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

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|---|--|---|
| a) (1) = Table A.52 (column 11) + Table A.34 (column 3) | g) (7) = Table A.52 (column 11) + Table A.34 (column 8)  | m) (13) = Table A.52 (column 11) + Table A.34 (column 13) |
| b) (2) = Table A.52 (column 12) + Table A.34 (column 3) | h) (8) = Table A.52 (column 12) + Table A.34 (column 8)  | n) (14) = Table A.52 (column 12) + Table A.34 (column 13) |
| c) (3) = Table A.52 (column 13) + Table A.34 (column 3) | i) (9) = Table A.52 (column 13) + Table A.34 (column 8)  | o) (15) = Table A.52 (column 13) + Table A.34 (column 13) |
| d) (4) = Table A.52 (column 14) + Table A.34 (column 3) | j) (10) = Table A.52 (column 14) + Table A.34 (column 8) | p) (16) = Table A.52 (column 14) + Table A.34 (column 13) |
| e) (5) = Table A.52 (column 15) + Table A.34 (column 3) | k) (11) = Table A.52 (column 15) + Table A.34 (column 8) | q) (17) = Table A.52 (column 15) + Table A.34 (column 13) |
| f) (6) = Table A.52 (column 16) + Table A.34 (column 3) | l) (12) = Table A.52 (column 16) + Table A.34 (column 8) | r) (18) = Table A.52 (column 16) + Table A.34 (column 13) |

**Table A.58: Total Net Avoided GHG Emissions, 2030, Scenario *Min 2* – 68% Biochar Carbon Sequestration for All Feedstocks**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.141
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008
Sewage sludge (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Solid cattle manure (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Solid swine manure (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Solid poultry manure (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Liquid cattle and swine manure (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Sugar-beet leaf and potato haulm (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Commercial and industrial waste (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Organic municipal solid waste (D)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108
Digestates (energy crops)	-0.599	-0.364	0.058	-0.490	-0.274	0.116	-0.601	-0.366	0.057	-0.492	-0.275	0.114	-0.607	-0.373	0.050	-0.499	-0.282	0.108

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

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|---|--|---|
| a) (1) = Table A.52 (column 11) + Table A.35 (column 3) | g) (7) = Table A.52 (column 11) + Table A.35 (column 8)  | m) (13) = Table A.52 (column 11) + Table A.35 (column 13) |
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**Table A.59: Total Net Avoided GHG Emissions from Sections 4.1 to 4.3\* – Zero Biomass Carbon Sequestration**

Feedstocks	Emissions from biochar		Emissions from conventional feedstock management						Combustion of pyrolysis by-products				Energy input for biochar production					
	Stable C <sup>a</sup>	N <sub>2</sub> O <sup>b</sup>	CH <sub>4</sub> <sup>c</sup>	N <sub>2</sub> O <sup>d</sup>	Stable C <sup>e</sup>	Fossil-fuel substitution			CH <sub>4</sub> , N <sub>2</sub> O <sup>i</sup>	Fossil-fuel substitution			No process heat recovery			Process heat recovery		
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock		t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1)	(2)	(3)	(4)	(5)	(6a) <sup>f</sup>	(6b) <sup>g</sup>	(6c) <sup>h</sup>	(7)	(8a) <sup>j</sup>	(8b) <sup>k</sup>	(8c) <sup>l</sup>	(9a) <sup>m</sup>	(9b) <sup>n</sup>	(9c) <sup>o</sup>	(10a) <sup>p</sup>	(10b) <sup>q</sup>	(10c) <sup>r</sup>
Cereal straw	0.59	-0.042	-	0.027	-	-	-	-	-0.0004	0.658	0.550	0.342	-0.185	-0.155	-0.099	-0.061	-0.051	-0.033
Forestry residues	0.61	-0.026	-	0.010	-	-	-	-	-0.0005	0.745	0.623	0.387	-0.203	-0.170	-0.108	-0.075	-0.063	-0.040
Open-country biomass residues	0.53	-0.025	0.276	0.071	-	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Industrial wood waste	0.59	-0.003	0.005	0.017	-	-1.567	-1.310	-0.813	-0.0005	0.728	0.609	0.378	-0.191	-0.160	-0.102	-0.063	-0.053	-0.034
Wood in municipal solid waste	0.61	-0.019	0.294	0.015	-	-	-	-	-0.0005	0.745	0.623	0.387	-0.203	-0.170	-0.108	-0.075	-0.063	-0.040
Green waste: Compensation areas	0.50	-0.044	-	0.059	-	-	-	-	-0.0004	0.600	0.502	0.312	-0.179	-0.149	-0.095	-0.055	-0.046	-0.029
Biomass: Habitat-connectivity areas	0.53	-0.025	0.276	0.071	-	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Green waste: Extensive grassland	0.53	-0.025	0.276	0.071	-	-	-	-	-0.0004	0.655	0.548	0.340	-0.187	-0.156	-0.099	-0.061	-0.051	-0.033
Short-rotation coppice: Erosion areas	0.45	-0.016	0.005	0.017	-	-1.567	-1.310	-0.813	-0.0005	0.821	0.686	0.426	-0.237	-0.198	-0.126	-0.109	-0.091	-0.058
Sewage sludge	0.21	-0.159	0.084	0.306	-	-	-	-	-0.0004	0.584	0.488	0.303	-1.510	-1.263	-0.805	-1.405	-1.175	-0.749
Solid cattle manure	0.30	-0.075	0.100	0.282	-	-	-	-	-0.0004	0.586	0.490	0.304	-0.767	-0.641	-0.409	-0.651	-0.544	-0.347
Solid swine manure	0.29	-0.120	0.550	0.493	-	-	-	-	-0.0005	0.751	0.628	0.390	-1.442	-1.205	-0.768	-1.327	-1.109	-0.707
Solid poultry manure	0.25	-0.107	0.100	0.228	-	-	-	-	-0.0003	0.535	0.447	0.278	-0.196	-0.164	-0.105	-0.083	-0.070	-0.044
Liquid cattle and swine manure	0.25	-0.090	0.525	0.230	-	-	-	-	-0.0004	0.599	0.501	0.311	-3.421	-2.860	-1.823	-3.303	-2.761	-1.760
Sugar-beet leaf and potato haulm	0.29	-0.115	-	0.076	-	-	-	-	-0.0004	0.610	0.510	0.316	-2.006	-1.677	-1.069	-1.895	-1.584	-1.010
Commercial and industrial waste	0.30	-0.115	0.300	0.293	-	-	-	-	-0.0004	0.709	0.593	0.368	-0.718	-0.601	-0.383	-0.594	-0.497	-0.317
Organic municipal solid waste	0.35	-0.071	0.186	0.160	-	-	-	-	-0.0003	0.492	0.411	0.255	-1.007	-0.842	-0.536	-0.895	-0.748	-0.477
Digestates	0.26	-0.100	0.086	0.431	-	-	-	-	-0.0005	0.770	0.644	0.400	-2.199	-1.839	-1.172	-2.091	-1.748	-1.114

Table will be continued on the next page.



**Table A.59 continued**

Feedstocks	Total net avoided GHG emissions (Sections 4.1 to 4.3*) – Zero biomass carbon sequestration					
	No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(11) <sup>s</sup>	(12) <sup>t</sup>	(13) <sup>u</sup>	(14) <sup>v</sup>	(15) <sup>w</sup>	(16) <sup>x</sup>
Cereal straw	1.051	0.974	0.821	1.175	1.077	0.887
Forestry residues	1.132	1.043	0.868	1.260	1.150	0.936
Open-country biomass residues	1.324	1.247	1.096	1.449	1.352	1.163
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143
Wood in municipal solid waste	1.438	1.349	1.175	1.566	1.456	1.243
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.974	0.800
Biomass: Habitat-connectivity areas	1.324	1.247	1.096	1.449	1.352	1.163
Green waste: Extensive grassland	1.324	1.247	1.096	1.449	1.352	1.163
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010
Sewage sludge	-0.482	-0.330	-0.057	-0.377	-0.242	-0.001
Solid cattle manure	0.425	0.455	0.501	0.542	0.552	0.564
Solid swine manure	0.519	0.632	0.831	0.633	0.728	0.892
Solid poultry manure	0.811	0.756	0.646	0.925	0.850	0.706
Liquid cattle and swine manure	-1.911	-1.448	-0.601	-1.793	-1.349	-0.538
Sugar-beet leaf and potato haulm	-1.150	-0.921	-0.506	-1.039	-0.828	-0.446
Commercial and industrial waste	0.774	0.775	0.768	0.898	0.879	0.834
Organic municipal solid waste	0.112	0.197	0.346	0.225	0.291	0.406
Digestates	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) Table 13, column 4                             | i) Table 19, column 8; shown as a negative value  | q) Table 23, column 8; shown as a negative value                  |
| b) Table 17, column 9; shown as a negative value  | j) Table 20, column 4                             | r) Table 23, column 12; shown as a negative value                 |
| c) Table 14, column 5                             | k) Table 20, column 8                             | s) (11) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (9a)  |
| d) Table 16, column 13                            | l) Table 20, column 12                            | t) (12) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (9b)  |
| e) Assumed zero biomass carbon sequestration      | m) Table 22, column 4; shown as a negative value  | u) (13) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (9c)  |
| f) Table 18, column 4; shown as a negative value  | n) Table 22, column 8; shown as a negative value  | v) (14) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (10a) |
| g) Table 18, column 8; shown as a negative value  | o) Table 22, column 12; shown as a negative value | w) (15) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (10b) |
| h) Table 18, column 12; shown as a negative value | p) Table 23, column 4; shown as a negative value  | x) (16) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (10c) |

\* The sections refer to Teichmann (2014). Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.60: Total Net Avoided GHG Emissions, 2030, Scenario *Max 1* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	1.051	0.974	0.821	1.175	1.077	0.887	1.051	0.973	0.821	1.175	1.077	0.887	1.050	0.972	0.820	1.174	1.076	0.886
Forestry residues	1.131	1.043	0.868	1.259	1.149	0.936	1.131	1.042	0.868	1.259	1.149	0.936	1.130	1.041	0.867	1.258	1.148	0.935
Open-country biomass residues	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.247	1.095	1.449	1.351	1.162
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.244	1.439	1.350	1.175	1.566	1.457	1.243	1.438	1.349	1.174	1.566	1.456	1.242
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.939	0.870	0.734	1.063	0.973	0.800	0.938	0.869	0.733	1.062	0.972	0.799
Biomass: Habitat-connectivity areas	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.247	1.095	1.449	1.351	1.162
Green waste: Extensive grassland	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.247	1.095	1.449	1.351	1.162
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge	-0.481	-0.329	-0.056	-0.376	-0.241	0.000	-0.482	-0.330	-0.057	-0.377	-0.242	-0.001	-0.485	-0.333	-0.060	-0.380	-0.245	-0.004
Solid cattle manure	0.425	0.455	0.502	0.542	0.552	0.564	0.424	0.454	0.501	0.541	0.552	0.563	0.422	0.452	0.499	0.539	0.549	0.561
Solid swine manure	0.519	0.632	0.831	0.634	0.728	0.892	0.518	0.631	0.830	0.633	0.727	0.891	0.514	0.628	0.827	0.629	0.724	0.888
Solid poultry manure	0.811	0.756	0.646	0.925	0.850	0.706	0.811	0.756	0.646	0.924	0.850	0.706	0.810	0.754	0.644	0.923	0.849	0.705
Liquid cattle and swine manure	-1.910	-1.447	-0.600	-1.792	-1.348	-0.537	-1.912	-1.449	-0.602	-1.794	-1.350	-0.539	-1.919	-1.456	-0.609	-1.801	-1.358	-0.546
Sugar-beet leaf and potato haulm	-1.150	-0.921	-0.506	-1.039	-0.829	-0.447	-1.152	-0.923	-0.508	-1.041	-0.830	-0.448	-1.156	-0.927	-0.512	-1.045	-0.834	-0.453
Commercial and industrial waste	0.775	0.776	0.769	0.899	0.880	0.835	0.774	0.776	0.769	0.898	0.880	0.835	0.772	0.774	0.767	0.896	0.878	0.833
Organic municipal solid waste	0.114	0.198	0.348	0.226	0.292	0.407	0.113	0.197	0.347	0.225	0.291	0.407	0.110	0.195	0.344	0.223	0.289	0.404
Digestates (energy crops)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.097	-0.646	-0.429	-0.040	-0.760	-0.525	-0.102	-0.651	-0.434	-0.045

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.59 (column 11) + Table A.30 (column 3)
- b) (2) = Table A.59 (column 12) + Table A.30 (column 3)
- c) (3) = Table A.59 (column 13) + Table A.30 (column 3)
- d) (4) = Table A.59 (column 14) + Table A.30 (column 3)
- e) (5) = Table A.59 (column 15) + Table A.30 (column 3)
- f) (6) = Table A.59 (column 16) + Table A.30 (column 3)

- g) (7) = Table A.59 (column 11) + Table A.30 (column 8)
- h) (8) = Table A.59 (column 12) + Table A.30 (column 8)
- i) (9) = Table A.59 (column 13) + Table A.30 (column 8)
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- l) (12) = Table A.59 (column 16) + Table A.30 (column 8)

- m) (13) = Table A.59 (column 11) + Table A.30 (column 13)
- n) (14) = Table A.59 (column 12) + Table A.30 (column 13)
- o) (15) = Table A.59 (column 13) + Table A.30 (column 13)
- p) (16) = Table A.59 (column 14) + Table A.30 (column 13)
- q) (17) = Table A.59 (column 15) + Table A.30 (column 13)
- r) (18) = Table A.59 (column 16) + Table A.30 (column 13)

**Table A.61: Total Net Avoided GHG Emissions, 2030, Scenario *Med 1* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	1.051	0.974	0.821	1.175	1.077	0.887	1.051	0.973	0.821	1.174	1.077	0.887	1.050	0.972	0.819	1.173	1.075	0.885
Forestry residues	1.131	1.042	0.868	1.259	1.149	0.936	1.131	1.042	0.867	1.259	1.149	0.936	1.130	1.041	0.866	1.258	1.148	0.934
Open-country biomass residues	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.243	1.439	1.350	1.175	1.566	1.456	1.243	1.437	1.348	1.174	1.565	1.455	1.242
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.939	0.869	0.733	1.062	0.973	0.799	0.937	0.868	0.732	1.061	0.972	0.798
Biomass: Habitat-connectivity areas	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Green waste: Extensive grassland	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.401	-0.261	0.008
Sewage sludge	-0.481	-0.329	-0.056	-0.376	-0.241	0.000	-0.482	-0.330	-0.057	-0.377	-0.242	-0.001	-0.487	-0.335	-0.062	-0.382	-0.247	-0.006
Solid cattle manure	0.425	0.455	0.501	0.542	0.552	0.564	0.424	0.454	0.501	0.541	0.551	0.563	0.421	0.451	0.498	0.538	0.549	0.560
Solid swine manure	0.519	0.632	0.831	0.633	0.728	0.892	0.517	0.631	0.830	0.632	0.727	0.891	0.513	0.626	0.825	0.628	0.722	0.886
Solid poultry manure	0.811	0.756	0.646	0.924	0.850	0.706	0.811	0.755	0.645	0.924	0.850	0.706	0.810	0.754	0.644	0.923	0.849	0.704
Liquid cattle and swine manure	-1.910	-1.447	-0.600	-1.792	-1.349	-0.537	-1.913	-1.450	-0.603	-1.795	-1.351	-0.540	-1.922	-1.459	-0.612	-1.804	-1.361	-0.549
Sugar-beet leaf and potato haulm	-1.151	-0.922	-0.507	-1.040	-0.829	-0.447	-1.152	-0.923	-0.508	-1.041	-0.830	-0.449	-1.158	-0.929	-0.514	-1.047	-0.836	-0.455
Commercial and industrial waste	0.775	0.776	0.769	0.899	0.880	0.835	0.774	0.776	0.769	0.898	0.879	0.835	0.771	0.773	0.766	0.896	0.877	0.832
Organic municipal solid waste	0.113	0.198	0.347	0.226	0.292	0.407	0.113	0.197	0.346	0.225	0.291	0.406	0.109	0.194	0.343	0.221	0.288	0.403
Digestates (energy crops)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.527	-0.104	-0.653	-0.436	-0.047

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.59 (column 11) + Table A.31 (column 3)
- b) (2) = Table A.59 (column 12) + Table A.31 (column 3)
- c) (3) = Table A.59 (column 13) + Table A.31 (column 3)
- d) (4) = Table A.59 (column 14) + Table A.31 (column 3)
- e) (5) = Table A.59 (column 15) + Table A.31 (column 3)
- f) (6) = Table A.59 (column 16) + Table A.31 (column 3)

- g) (7) = Table A.59 (column 11) + Table A.31 (column 8)
- h) (8) = Table A.59 (column 12) + Table A.31 (column 8)
- i) (9) = Table A.59 (column 13) + Table A.31 (column 8)
- j) (10) = Table A.59 (column 14) + Table A.31 (column 8)
- k) (11) = Table A.59 (column 15) + Table A.31 (column 8)
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- q) (17) = Table A.59 (column 15) + Table A.31 (column 13)
- r) (18) = Table A.59 (column 16) + Table A.31 (column 13)

**Table A.62: Total Net Avoided GHG Emissions, 2030, Scenario *Min 1* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	1.051	0.973	0.821	1.175	1.077	0.887	1.051	0.973	0.820	1.174	1.076	0.886	1.049	0.971	0.819	1.172	1.075	0.885
Forestry residues	1.131	1.042	0.868	1.259	1.149	0.936	1.131	1.042	0.867	1.259	1.149	0.935	1.129	1.040	0.865	1.257	1.147	0.934
Open-country biomass residues	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.322	1.245	1.094	1.448	1.350	1.161
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.243	1.438	1.349	1.175	1.566	1.456	1.243	1.437	1.348	1.173	1.564	1.454	1.241
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.938	0.869	0.733	1.062	0.973	0.799	0.937	0.868	0.732	1.061	0.971	0.798
Biomass: Habitat-connectivity areas	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.322	1.245	1.094	1.448	1.350	1.161
Green waste: Extensive grassland	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.322	1.245	1.094	1.448	1.350	1.161
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.009	-0.530	-0.368	-0.060	-0.402	-0.262	0.008
Sewage sludge	-0.481	-0.329	-0.056	-0.376	-0.241	0.000	-0.483	-0.331	-0.058	-0.378	-0.243	-0.002	-0.490	-0.337	-0.065	-0.385	-0.250	-0.009
Solid cattle manure	0.425	0.454	0.501	0.541	0.552	0.563	0.424	0.453	0.500	0.540	0.551	0.562	0.420	0.449	0.496	0.536	0.547	0.558
Solid swine manure	0.518	0.632	0.831	0.633	0.728	0.892	0.517	0.630	0.829	0.631	0.726	0.890	0.510	0.624	0.823	0.625	0.719	0.884
Solid poultry manure	0.811	0.756	0.646	0.924	0.850	0.706	0.811	0.755	0.645	0.924	0.850	0.705	0.809	0.753	0.643	0.922	0.848	0.703
Liquid cattle and swine manure	-1.911	-1.448	-0.601	-1.793	-1.349	-0.538	-1.915	-1.452	-0.604	-1.796	-1.353	-0.541	-1.928	-1.465	-0.618	-1.810	-1.366	-0.555
Sugar-beet leaf and potato haulm	-1.151	-0.922	-0.507	-1.040	-0.829	-0.448	-1.153	-0.924	-0.509	-1.042	-0.831	-0.450	-1.162	-0.932	-0.518	-1.051	-0.840	-0.458
Commercial and industrial waste	0.775	0.776	0.769	0.899	0.880	0.835	0.774	0.775	0.768	0.898	0.879	0.834	0.770	0.771	0.764	0.894	0.875	0.831
Organic municipal solid waste	0.113	0.198	0.347	0.226	0.292	0.407	0.112	0.196	0.346	0.224	0.290	0.406	0.107	0.192	0.341	0.219	0.286	0.401
Digestates (energy crops)	-0.754	-0.519	-0.097	-0.645	-0.429	-0.039	-0.756	-0.522	-0.099	-0.648	-0.431	-0.041	-0.765	-0.531	-0.108	-0.657	-0.440	-0.050

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- a) (1) = Table A.59 (column 11) + Table A.32 (column 3)
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- c) (3) = Table A.59 (column 13) + Table A.32 (column 3)
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- e) (5) = Table A.59 (column 15) + Table A.32 (column 3)
- f) (6) = Table A.59 (column 16) + Table A.32 (column 3)

- g) (7) = Table A.59 (column 11) + Table A.32 (column 8)
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- p) (16) = Table A.59 (column 14) + Table A.32 (column 13)
- q) (17) = Table A.59 (column 15) + Table A.32 (column 13)
- r) (18) = Table A.59 (column 16) + Table A.32 (column 13)

**Table A.63: Total Net Avoided GHG Emissions, 2030, Scenario *Max 2* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	1.051	0.974	0.821	1.175	1.077	0.887	1.051	0.973	0.821	1.175	1.077	0.887	1.050	0.973	0.820	1.174	1.076	0.886
Forestry residues	1.132	1.043	0.868	1.259	1.149	0.936	1.131	1.042	0.868	1.259	1.149	0.936	1.130	1.041	0.867	1.258	1.148	0.935
Open-country biomass residues	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.351	1.162
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.244	1.439	1.350	1.175	1.567	1.457	1.243	1.438	1.349	1.174	1.566	1.456	1.242
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.939	0.870	0.734	1.063	0.973	0.800	0.938	0.869	0.733	1.062	0.972	0.799
Biomass: Habitat-connectivity areas	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.351	1.162
Green waste: Extensive grassland	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.248	1.096	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.351	1.162
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Solid cattle manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Solid swine manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Solid poultry manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Liquid cattle and swine manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Sugar-beet leaf and potato haulm (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Commercial and industrial waste (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Organic municipal solid waste (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044
Digestates (energy crops)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.754	-0.520	-0.097	-0.646	-0.429	-0.039	-0.759	-0.524	-0.101	-0.650	-0.433	-0.044

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
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**Table A.64: Total Net Avoided GHG Emissions, 2030, Scenario *Med 2* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	1.051	0.974	0.821	1.175	1.077	0.887	1.051	0.973	0.821	1.175	1.077	0.887	1.050	0.972	0.820	1.174	1.076	0.886
Forestry residues	1.131	1.042	0.868	1.259	1.149	0.936	1.131	1.042	0.868	1.259	1.149	0.936	1.130	1.041	0.866	1.258	1.148	0.935
Open-country biomass residues	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.246	1.095	1.449	1.351	1.162
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.244	1.439	1.350	1.175	1.566	1.457	1.243	1.438	1.349	1.174	1.565	1.456	1.242
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.939	0.870	0.734	1.063	0.973	0.800	0.938	0.869	0.733	1.062	0.972	0.799
Biomass: Habitat-connectivity areas	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.246	1.095	1.449	1.351	1.162
Green waste: Extensive grassland	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.450	1.352	1.163	1.323	1.246	1.095	1.449	1.351	1.162
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Sewage sludge (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Solid cattle manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Solid swine manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Solid poultry manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Liquid cattle and swine manure (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Sugar-beet leaf and potato haulm (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Commercial and industrial waste (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Organic municipal solid waste (D)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045
Digestates (energy crops)	-0.753	-0.519	-0.096	-0.645	-0.428	-0.038	-0.755	-0.520	-0.098	-0.646	-0.430	-0.040	-0.760	-0.525	-0.103	-0.651	-0.435	-0.045

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

- |   |  |   |
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**Table A.65: Total Net Avoided GHG Emissions, 2030, Scenario *Min 2* – Zero Biomass Carbon Sequestration**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	1.051	0.973	0.821	1.175	1.077	0.887	1.051	0.973	0.821	1.174	1.076	0.887	1.049	0.972	0.819	1.173	1.075	0.885
Forestry residues	1.131	1.042	0.868	1.259	1.149	0.936	1.131	1.042	0.867	1.259	1.149	0.935	1.130	1.041	0.866	1.258	1.148	0.934
Open-country biomass residues	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.141
Wood in municipal solid waste	1.439	1.350	1.175	1.567	1.457	1.243	1.438	1.350	1.175	1.566	1.456	1.243	1.437	1.348	1.174	1.565	1.455	1.242
Green waste: Compensation areas	0.939	0.870	0.734	1.063	0.973	0.800	0.939	0.869	0.733	1.062	0.973	0.799	0.937	0.868	0.732	1.061	0.972	0.798
Biomass: Habitat-connectivity areas	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Green waste: Extensive grassland	1.325	1.248	1.097	1.450	1.352	1.163	1.324	1.247	1.096	1.449	1.352	1.163	1.323	1.246	1.095	1.448	1.351	1.162
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008
Sewage sludge (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Solid cattle manure (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Solid swine manure (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Solid poultry manure (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Liquid cattle and swine manure (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Sugar-beet leaf and potato haulm (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Commercial and industrial waste (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Organic municipal solid waste (D)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047
Digestates (energy crops)	-0.754	-0.519	-0.096	-0.645	-0.428	-0.039	-0.755	-0.521	-0.098	-0.647	-0.430	-0.040	-0.762	-0.528	-0.105	-0.654	-0.437	-0.047

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Note that for feedstocks indicated by (D), the relevant emissions are those associated with digestates. Values rounded.

*Sources:*

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- q) (17) = Table A.59 (column 15) + Table A.35 (column 13)
- r) (18) = Table A.59 (column 16) + Table A.35 (column 13)

## A.8 Revised Biomass Potentials for Biochar Production

Focusing on a reduced set of feedstocks after having shown that sewage sludge, liquid cattle and swine manure, sugar-beet leaf and potato haulm, and digestates avoid less GHG emissions when turned into biochar than under conventional feedstock management, Teichmann (2014) revises the assumptions necessary for the analysis of the technical GHG mitigation potentials of biochar, starting with the biomass scenarios for biochar.

As detailed in Section 5.1 of Teichmann (2014), assigning the assumed maximum biomass potentials available for biochar (cp. Section A.2 and Table A.6) to a reduced number of feedstocks, greater shares of the biomass potentials for bioenergy can be diverted into biochar production for the case when all the solid and digestible biomass residues are used directly for biochar production. Analogously to Table A.6, Table A.66 derives the upper bound for the percentage shares of the biomass for bioenergy potentially available for biochar, which serves as the basis for the revised biomass scenarios in Teichmann (2014: Table 34).

**Table A.66: Revised Maximum Biomass Potentials for Biochar from Biomass Residues in Germany, 2010-2050**

		Energy potential					Remaining biomass residues (C) as a percentage of (D) and (F), respectively				
		2010*	2020	2030	2040	2050	2010*	2020	2030	2040	2050
		PJ/a					%				
<i>Nitsch et al. (2004, "NaturschutzPlus" scenario)</i>											
Total biomass residues <sup>1</sup>		677	696	705	715	724					
Total biomass residues, adjusted <sup>2</sup>	(A)	554	591.3	705	715	724					
Actual 2010 energy provision <sup>3</sup>	(B)	500	500	500	500	500					
Remaining biomass residues, i.e. (C) = (A) – (B)	(C)	<b>54</b>	<b>91.3</b>	<b>205</b>	<b>215</b>	<b>224</b>	→ Assumed maximum biomass potentials for biochar				
<i>Teichmann (2014)</i>											
Solid biomass residues <sup>4</sup>	(D)	298.9	335.4	463.5	471.8	478.8	<b>18.07</b>	<b>27.22</b>	<b>44.23</b>	<b>45.57</b>	<b>46.78</b>
Revised digestible biomass residues <sup>5</sup>	(E)	50.3	53.4	54.0	55.8	56.8					
Revised total biomass residues, i.e. (F) = (D) + (E)	(F)	349.2	388.8	517.5	527.6	535.6	<b>15.46</b>	<b>23.48</b>	<b>39.61</b>	<b>40.75</b>	<b>41.82</b>

Values rounded.

Sources:

- 1) Nitsch et al. (2004, "NaturschutzPlus" scenario); without energy crops.
- 2) Adjusting the 2010 and 2020 energy potentials from biomass residues from Nitsch et al. (2004, "NaturschutzPlus" scenario) for the higher acreage used for energy crops analogously to the adjustments undertaken in Table A.1, comment (\*).
- 3) Nitsch et al. (2012); assumed to be constant over 2020-2050.
- 4) See Table A.1.
- 5) See Table A.2; excluding sewage sludge, liquid cattle and swine manure, and sugar-beet leaf and potato haulm.

\* The 2010 values will be used for 2015.



## A.9 Revised Transport Distances and Emissions

The adjustments made by Teichmann (2014) to the technical biomass potentials for biochar production and to the number of pyrolysis units lead to a revision of the mean transport distances for the transportation of biomass to the pyrolysis units and of biochar from the pyrolysis units to the farms for biochar soil application and, thus, to a revision of the CO<sub>2</sub> emissions associated with these transports. This section provides the data necessary to derive the revised transport-related emissions and presents the supplementary results tables referred to and discussed in Sections 5.3 and 5.4 of Teichmann (2014).

Thereby, the revised mean transport distances for the transportation of biomass (biochar) to (from) the pyrolysis units are displayed in Table A.67.

Based on the revised mean transport distances, the revised CO<sub>2</sub> emissions from the transportation of biomass to the pyrolysis units can be found in Tables 40 and 41 in Teichmann (2014: Section 5.3) for the *Max 1* and *Max 2* scenarios and in Tables A.68-A.71 for the remaining biomass scenarios. Likewise, the revised CO<sub>2</sub> emissions from the transportation of biochar to the farms are given in Tables 42 and 43 in Teichmann (2014: Section 5.3) for the *Max 1* and *Max 2* scenarios and in Tables A.72-A.75 for the remaining biomass scenarios.

Finally, Tables A.76-A.81 display the revised net GHG emissions from all transports and soil additions for all biomass scenarios as referred to in Section 5.4 of Teichmann (2014).

**Table A.67: Revised Mean Transport Distances, Germany, 2015-2050**

		Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
		2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
<b>Biomass scenarios</b>		km					km					km				
Scenario <i>Max 1</i>	(A)	5.9	4.4	3.1	3.1	3.0	16.8	12.4	8.7	8.6	8.6	57.0	42.0	29.7	29.3	29.1
Scenario <i>Med 1</i>	(B)	5.9	4.4	3.9	3.9	3.8	16.8	12.4	11.0	10.9	10.8	57.0	42.0	37.5	37.1	36.9
Scenario <i>Min 1</i>	(C)	5.9	5.6	5.0	5.0	5.0	16.8	16.0	14.3	14.1	14.0	57.0	54.3	48.4	47.9	47.6
Scenario <i>Max 2</i>	(D)	6.4	4.9	3.4	3.4	3.3	18.0	13.8	9.6	9.5	9.4	61.3	47.0	32.6	32.3	32.1
Scenario <i>Med 2</i>	(E)	6.4	4.9	4.2	4.1	4.1	18.0	13.8	11.8	11.7	11.6	61.3	47.0	40.0	39.6	39.3
Scenario <i>Min 2</i>	(F)	6.4	6.0	5.1	5.0	5.0	18.0	16.9	14.4	14.3	14.2	61.3	57.6	49.0	48.5	48.1

Sources: Own calculations, based on equation (VI) from Teichmann (2014) and the number of pyrolysis units of scale *i* at time *t* for biomass scenario *s*,  $PU_{i,s}$ , given in Table 39 of Teichmann (2014), i.e. calculated as  $1/2 \cdot (348,672 \text{ km}^2 / PU_{i,s})^{1/2}$ . Values rounded.

Note that the mean transport distances for the transportation of biomass to the pyrolysis units and of biochar from the pyrolysis units to the farms are assumed to be symmetric.

**Table A.68: Revised CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00029	0.00020	0.00016	0.00015	0.00014	0.00082	0.00058	0.00044	0.00041	0.00039	0.00280	0.00197	0.00150	0.00140	0.00131
Forestry residues	0.00030	0.00021	0.00016	0.00015	0.00014	0.00085	0.00060	0.00046	0.00043	0.00040	0.00289	0.00203	0.00155	0.00145	0.00135
Open-country biomass residues	0.00029	0.00020	0.00016	0.00015	0.00014	0.00082	0.00058	0.00044	0.00041	0.00038	0.00279	0.00197	0.00150	0.00140	0.00131
Industrial wood waste	0.00029	0.00021	0.00016	0.00015	0.00014	0.00082	0.00058	0.00044	0.00041	0.00039	0.00280	0.00197	0.00151	0.00141	0.00131
Wood in municipal solid waste	0.00030	0.00021	0.00016	0.00015	0.00014	0.00085	0.00060	0.00046	0.00043	0.00040	0.00289	0.00203	0.00155	0.00145	0.00135
Green waste: Compensation areas	0.00029	0.00020	0.00015	0.00014	0.00013	0.00081	0.00057	0.00043	0.00041	0.00038	0.00275	0.00193	0.00148	0.00138	0.00129
Biomass: Habitat-connectivity areas	0.00029	0.00020	0.00016	0.00015	0.00014	0.00082	0.00058	0.00044	0.00041	0.00038	0.00279	0.00197	0.00150	0.00140	0.00131
Green waste: Extensive grassland	0.00029	0.00020	0.00016	0.00015	0.00014	0.00082	0.00058	0.00044	0.00041	0.00038	0.00279	0.00197	0.00150	0.00140	0.00131
Short-rotation coppice: Erosion areas	0.00033	0.00023	0.00018	0.00016	0.00015	0.00092	0.00065	0.00050	0.00046	0.00043	0.00314	0.00221	0.00169	0.00157	0.00147
Solid cattle manure	0.00074	0.00052	0.00040	0.00037	0.00034	0.00208	0.00147	0.00112	0.00104	0.00098	0.00708	0.00498	0.00380	0.00355	0.00331
Solid swine manure	0.00125	0.00088	0.00067	0.00063	0.00058	0.00353	0.00248	0.00189	0.00177	0.00165	0.01198	0.00843	0.00643	0.00601	0.00561
Solid poultry manure	0.00031	0.00022	0.00017	0.00016	0.00014	0.00088	0.00062	0.00047	0.00044	0.00041	0.00297	0.00209	0.00160	0.00149	0.00139
Commercial and industrial waste	0.00069	0.00049	0.00037	0.00035	0.00032	0.00196	0.00138	0.00105	0.00098	0.00092	0.00666	0.00468	0.00357	0.00334	0.00312
Organic municipal solid waste	0.00092	0.00065	0.00049	0.00046	0.00043	0.00260	0.00183	0.00140	0.00131	0.00122	0.00885	0.00623	0.00475	0.00444	0.00415

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.67, row B. Values rounded.

**Table A.69: Revised CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00029	0.00026	0.00020	0.00019	0.00018	0.00082	0.00075	0.00057	0.00053	0.00050	0.00280	0.00254	0.00194	0.00181	0.00169
Forestry residues	0.00030	0.00027	0.00021	0.00019	0.00018	0.00085	0.00077	0.00059	0.00055	0.00051	0.00289	0.00262	0.00200	0.00187	0.00175
Open-country biomass residues	0.00029	0.00026	0.00020	0.00019	0.00018	0.00082	0.00075	0.00057	0.00053	0.00050	0.00279	0.00254	0.00194	0.00181	0.00169
Industrial wood waste	0.00029	0.00026	0.00020	0.00019	0.00018	0.00082	0.00075	0.00057	0.00053	0.00050	0.00280	0.00255	0.00194	0.00181	0.00169
Wood in municipal solid waste	0.00030	0.00027	0.00021	0.00019	0.00018	0.00085	0.00077	0.00059	0.00055	0.00051	0.00289	0.00263	0.00200	0.00187	0.00175
Green waste: Compensation areas	0.00029	0.00026	0.00020	0.00019	0.00017	0.00081	0.00073	0.00056	0.00052	0.00049	0.00275	0.00250	0.00191	0.00178	0.00166
Biomass: Habitat-connectivity areas	0.00029	0.00026	0.00020	0.00019	0.00018	0.00082	0.00075	0.00057	0.00053	0.00050	0.00279	0.00254	0.00194	0.00181	0.00169
Green waste: Extensive grassland	0.00029	0.00026	0.00020	0.00019	0.00018	0.00082	0.00075	0.00057	0.00053	0.00050	0.00279	0.00254	0.00194	0.00181	0.00169
Short-rotation coppice: Erosion areas	0.00033	0.00030	0.00023	0.00021	0.00020	0.00092	0.00084	0.00064	0.00060	0.00056	0.00314	0.00285	0.00218	0.00203	0.00190
Solid cattle manure	0.00074	0.00067	0.00051	0.00048	0.00045	0.00208	0.00189	0.00144	0.00135	0.00126	0.00708	0.00643	0.00491	0.00458	0.00428
Solid swine manure	0.00125	0.00113	0.00086	0.00081	0.00075	0.00353	0.00320	0.00244	0.00228	0.00213	0.01198	0.01088	0.00831	0.00776	0.00724
Solid poultry manure	0.00031	0.00028	0.00021	0.00020	0.00019	0.00088	0.00080	0.00061	0.00057	0.00053	0.00297	0.00270	0.00206	0.00193	0.00180
Commercial and industrial waste	0.00069	0.00063	0.00048	0.00045	0.00042	0.00196	0.00178	0.00136	0.00127	0.00118	0.00666	0.00605	0.00462	0.00431	0.00402
Organic municipal solid waste	0.00092	0.00084	0.00064	0.00060	0.00056	0.00260	0.00237	0.00181	0.00169	0.00157	0.00885	0.00804	0.00614	0.00573	0.00535

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.67, row C. Values rounded.

**Table A.70: Revised CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00031	0.00023	0.00017	0.00016	0.00015	0.00089	0.00065	0.00047	0.00044	0.00041	0.00301	0.00220	0.00160	0.00150	0.00140
Forestry residues	0.00032	0.00024	0.00017	0.00016	0.00015	0.00091	0.00067	0.00049	0.00045	0.00042	0.00311	0.00227	0.00165	0.00154	0.00144
Open-country biomass residues	0.00031	0.00023	0.00017	0.00016	0.00015	0.00088	0.00065	0.00047	0.00044	0.00041	0.00300	0.00220	0.00160	0.00149	0.00140
Industrial wood waste	0.00031	0.00023	0.00017	0.00016	0.00015	0.00089	0.00065	0.00047	0.00044	0.00041	0.00301	0.00221	0.00160	0.00150	0.00140
Wood in municipal solid waste	0.00032	0.00024	0.00017	0.00016	0.00015	0.00091	0.00067	0.00049	0.00046	0.00042	0.00311	0.00227	0.00165	0.00155	0.00144
Green waste: Compensation areas	0.00031	0.00023	0.00016	0.00015	0.00014	0.00087	0.00064	0.00046	0.00043	0.00040	0.00296	0.00216	0.00157	0.00147	0.00137
Biomass: Habitat-connectivity areas	0.00031	0.00023	0.00017	0.00016	0.00015	0.00088	0.00065	0.00047	0.00044	0.00041	0.00300	0.00220	0.00160	0.00149	0.00140
Green waste: Extensive grassland	0.00031	0.00023	0.00017	0.00016	0.00015	0.00088	0.00065	0.00047	0.00044	0.00041	0.00300	0.00220	0.00160	0.00149	0.00140
Short-rotation coppice: Erosion areas	0.00035	0.00026	0.00019	0.00017	0.00016	0.00099	0.00073	0.00053	0.00049	0.00046	0.00337	0.00247	0.00180	0.00168	0.00157

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.67, row E. Values rounded.

**Table A.71: Revised CO<sub>2</sub> Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00031	0.00028	0.00020	0.00019	0.00018	0.00089	0.00079	0.00058	0.00054	0.00050	0.00301	0.00270	0.00196	0.00183	0.00171
Forestry residues	0.00032	0.00029	0.00021	0.00020	0.00018	0.00091	0.00082	0.00060	0.00056	0.00052	0.00311	0.00278	0.00202	0.00189	0.00177
Open-country biomass residues	0.00031	0.00028	0.00020	0.00019	0.00018	0.00088	0.00079	0.00058	0.00054	0.00050	0.00300	0.00269	0.00196	0.00183	0.00171
Industrial wood waste	0.00031	0.00028	0.00020	0.00019	0.00018	0.00089	0.00079	0.00058	0.00054	0.00050	0.00301	0.00270	0.00196	0.00184	0.00171
Wood in municipal solid waste	0.00032	0.00029	0.00021	0.00020	0.00018	0.00091	0.00082	0.00060	0.00056	0.00052	0.00311	0.00279	0.00203	0.00189	0.00177
Green waste: Compensation areas	0.00031	0.00028	0.00020	0.00019	0.00017	0.00087	0.00078	0.00057	0.00053	0.00049	0.00296	0.00265	0.00193	0.00180	0.00168
Biomass: Habitat-connectivity areas	0.00031	0.00028	0.00020	0.00019	0.00018	0.00088	0.00079	0.00058	0.00054	0.00050	0.00300	0.00269	0.00196	0.00183	0.00171
Green waste: Extensive grassland	0.00031	0.00028	0.00020	0.00019	0.00018	0.00088	0.00079	0.00058	0.00054	0.00050	0.00300	0.00269	0.00196	0.00183	0.00171
Short-rotation coppice: Erosion areas	0.00035	0.00031	0.00023	0.00021	0.00020	0.00099	0.00089	0.00065	0.00060	0.00056	0.00337	0.00302	0.00220	0.00206	0.00192

Sources: Own calculation, multiplying the biomass transport emissions from Table A.20 by the respective mean transport distance from Table A.67, row F. Values rounded.

**Table A.72: Revised CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00009	0.00006	0.00005	0.00005	0.00004	0.00026	0.00018	0.00014	0.00013	0.00012	0.00088	0.00062	0.00047	0.00044	0.00041
Forestry residues	0.00008	0.00006	0.00004	0.00004	0.00004	0.00023	0.00016	0.00012	0.00011	0.00011	0.00077	0.00054	0.00042	0.00039	0.00036
Open-country biomass residues	0.00008	0.00006	0.00004	0.00004	0.00004	0.00023	0.00017	0.00013	0.00012	0.00011	0.00080	0.00056	0.00043	0.00040	0.00037
Industrial wood waste	0.00008	0.00005	0.00004	0.00004	0.00004	0.00022	0.00015	0.00012	0.00011	0.00010	0.00075	0.00053	0.00040	0.00037	0.00035
Wood in municipal solid waste	0.00008	0.00006	0.00004	0.00004	0.00004	0.00023	0.00016	0.00012	0.00011	0.00011	0.00077	0.00054	0.00042	0.00039	0.00036
Green waste: Compensation areas	0.00009	0.00006	0.00005	0.00004	0.00004	0.00024	0.00017	0.00013	0.00012	0.00011	0.00082	0.00058	0.00044	0.00041	0.00039
Biomass: Habitat-connectivity areas	0.00008	0.00006	0.00004	0.00004	0.00004	0.00023	0.00017	0.00013	0.00012	0.00011	0.00080	0.00056	0.00043	0.00040	0.00037
Green waste: Extensive grassland	0.00008	0.00006	0.00004	0.00004	0.00004	0.00023	0.00017	0.00013	0.00012	0.00011	0.00080	0.00056	0.00043	0.00040	0.00037
Short-rotation coppice: Erosion areas	0.00007	0.00005	0.00004	0.00003	0.00003	0.00019	0.00013	0.00010	0.00010	0.00009	0.00064	0.00045	0.00035	0.00032	0.00030
Solid cattle manure	0.00013	0.00009	0.00007	0.00006	0.00006	0.00036	0.00025	0.00019	0.00018	0.00017	0.00121	0.00085	0.00065	0.00061	0.00057
Solid swine manure	0.00013	0.00009	0.00007	0.00006	0.00006	0.00036	0.00025	0.00019	0.00018	0.00017	0.00121	0.00085	0.00065	0.00061	0.00057
Solid poultry manure	0.00012	0.00008	0.00006	0.00006	0.00006	0.00033	0.00023	0.00018	0.00017	0.00016	0.00113	0.00080	0.00061	0.00057	0.00053
Commercial and industrial waste	0.00010	0.00007	0.00005	0.00005	0.00005	0.00028	0.00020	0.00015	0.00014	0.00013	0.00095	0.00067	0.00051	0.00048	0.00045
Organic municipal solid waste	0.00012	0.00008	0.00006	0.00006	0.00006	0.00034	0.00024	0.00018	0.00017	0.00016	0.00116	0.00082	0.00062	0.00058	0.00054

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.67, row B. Values rounded.

**Table A.73: Revised CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00009	0.00008	0.00006	0.00006	0.00006	0.00026	0.00023	0.00018	0.00017	0.00016	0.00088	0.00080	0.00061	0.00057	0.00053
Forestry residues	0.00008	0.00007	0.00006	0.00005	0.00005	0.00023	0.00021	0.00016	0.00015	0.00014	0.00077	0.00070	0.00054	0.00050	0.00047
Open-country biomass residues	0.00008	0.00008	0.00006	0.00005	0.00005	0.00023	0.00021	0.00016	0.00015	0.00014	0.00080	0.00073	0.00055	0.00052	0.00048
Industrial wood waste	0.00008	0.00007	0.00005	0.00005	0.00005	0.00022	0.00020	0.00015	0.00014	0.00013	0.00075	0.00068	0.00052	0.00048	0.00045
Wood in municipal solid waste	0.00008	0.00007	0.00006	0.00005	0.00005	0.00023	0.00021	0.00016	0.00015	0.00014	0.00077	0.00070	0.00054	0.00050	0.00047
Green waste: Compensation areas	0.00009	0.00008	0.00006	0.00006	0.00005	0.00024	0.00022	0.00017	0.00016	0.00015	0.00082	0.00075	0.00057	0.00053	0.00050
Biomass: Habitat-connectivity areas	0.00008	0.00008	0.00006	0.00005	0.00005	0.00023	0.00021	0.00016	0.00015	0.00014	0.00080	0.00073	0.00055	0.00052	0.00048
Green waste: Extensive grassland	0.00008	0.00008	0.00006	0.00005	0.00005	0.00023	0.00021	0.00016	0.00015	0.00014	0.00080	0.00073	0.00055	0.00052	0.00048
Short-rotation coppice: Erosion areas	0.00007	0.00006	0.00005	0.00004	0.00004	0.00019	0.00017	0.00013	0.00012	0.00011	0.00064	0.00059	0.00045	0.00042	0.00039
Solid cattle manure	0.00013	0.00011	0.00009	0.00008	0.00008	0.00036	0.00032	0.00025	0.00023	0.00022	0.00121	0.00110	0.00084	0.00078	0.00073
Solid swine manure	0.00013	0.00011	0.00009	0.00008	0.00008	0.00036	0.00032	0.00025	0.00023	0.00022	0.00121	0.00110	0.00084	0.00078	0.00073
Solid poultry manure	0.00012	0.00011	0.00008	0.00008	0.00007	0.00033	0.00030	0.00023	0.00022	0.00020	0.00113	0.00103	0.00079	0.00073	0.00069
Commercial and industrial waste	0.00010	0.00009	0.00007	0.00006	0.00006	0.00028	0.00025	0.00019	0.00018	0.00017	0.00095	0.00087	0.00066	0.00062	0.00058
Organic municipal solid waste	0.00012	0.00011	0.00008	0.00008	0.00007	0.00034	0.00031	0.00024	0.00022	0.00021	0.00116	0.00105	0.00080	0.00075	0.00070

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.67, row C. Values rounded.

**Table A.74: Revised CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00010	0.00007	0.00005	0.00005	0.00005	0.00028	0.00020	0.00015	0.00014	0.00013	0.00094	0.00069	0.00050	0.00047	0.00044
Forestry residues	0.00009	0.00006	0.00005	0.00004	0.00004	0.00024	0.00018	0.00013	0.00012	0.00011	0.00083	0.00061	0.00044	0.00041	0.00039
Open-country biomass residues	0.00009	0.00007	0.00005	0.00004	0.00004	0.00025	0.00018	0.00013	0.00013	0.00012	0.00086	0.00063	0.00046	0.00043	0.00040
Industrial wood waste	0.00008	0.00006	0.00004	0.00004	0.00004	0.00024	0.00017	0.00013	0.00012	0.00011	0.00080	0.00059	0.00043	0.00040	0.00037
Wood in municipal solid waste	0.00009	0.00006	0.00005	0.00004	0.00004	0.00024	0.00018	0.00013	0.00012	0.00011	0.00083	0.00061	0.00044	0.00041	0.00039
Green waste: Compensation areas	0.00009	0.00007	0.00005	0.00005	0.00004	0.00026	0.00019	0.00014	0.00013	0.00012	0.00089	0.00065	0.00047	0.00044	0.00041
Biomass: Habitat-connectivity areas	0.00009	0.00007	0.00005	0.00004	0.00004	0.00025	0.00018	0.00013	0.00013	0.00012	0.00086	0.00063	0.00046	0.00043	0.00040
Green waste: Extensive grassland	0.00009	0.00007	0.00005	0.00004	0.00004	0.00025	0.00018	0.00013	0.00013	0.00012	0.00086	0.00063	0.00046	0.00043	0.00040
Short-rotation coppice: Erosion areas	0.00007	0.00005	0.00004	0.00004	0.00003	0.00020	0.00015	0.00011	0.00010	0.00009	0.00069	0.00051	0.00037	0.00034	0.00032

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.67, row E. Values rounded.

**Table A.75: Revised CO<sub>2</sub> Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock					t CO <sub>2</sub> /t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	0.00010	0.00009	0.00006	0.00006	0.00006	0.00028	0.00025	0.00018	0.00017	0.00016	0.00094	0.00084	0.00061	0.00057	0.00054
Forestry residues	0.00009	0.00008	0.00006	0.00005	0.00005	0.00024	0.00022	0.00016	0.00015	0.00014	0.00083	0.00074	0.00054	0.00051	0.00047
Open-country biomass residues	0.00009	0.00008	0.00006	0.00005	0.00005	0.00025	0.00023	0.00016	0.00015	0.00014	0.00086	0.00077	0.00056	0.00052	0.00049
Industrial wood waste	0.00008	0.00007	0.00005	0.00005	0.00005	0.00024	0.00021	0.00015	0.00014	0.00013	0.00080	0.00072	0.00052	0.00049	0.00046
Wood in municipal solid waste	0.00009	0.00008	0.00006	0.00005	0.00005	0.00024	0.00022	0.00016	0.00015	0.00014	0.00083	0.00074	0.00054	0.00051	0.00047
Green waste: Compensation areas	0.00009	0.00008	0.00006	0.00006	0.00005	0.00026	0.00023	0.00017	0.00016	0.00015	0.00089	0.00079	0.00058	0.00054	0.00050
Biomass: Habitat-connectivity areas	0.00009	0.00008	0.00006	0.00005	0.00005	0.00025	0.00023	0.00016	0.00015	0.00014	0.00086	0.00077	0.00056	0.00052	0.00049
Green waste: Extensive grassland	0.00009	0.00008	0.00006	0.00005	0.00005	0.00025	0.00023	0.00016	0.00015	0.00014	0.00086	0.00077	0.00056	0.00052	0.00049
Short-rotation coppice: Erosion areas	0.00007	0.00006	0.00005	0.00004	0.00004	0.00020	0.00018	0.00013	0.00012	0.00012	0.00069	0.00062	0.00045	0.00042	0.00039

Sources: Own calculation, multiplying the biochar transport emissions from Table A.21 by the respective mean transport distance from Table A.67, row F. Values rounded.

**Table A.76: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Max 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00050	-0.00038	-0.00026	-0.00024	-0.00023	-0.00120	-0.00087	-0.00055	-0.00052	-0.00048	-0.00379	-0.00270	-0.00165	-0.00155	-0.00144
Forestry residues	-0.00048	-0.00037	-0.00025	-0.00023	-0.00022	-0.00118	-0.00086	-0.00054	-0.00051	-0.00047	-0.00376	-0.00267	-0.00164	-0.00153	-0.00143
Open-country biomass residues	0.00076	0.00082	0.00077	0.00073	0.00068	0.00008	0.00034	0.00048	0.00046	0.00043	-0.00246	-0.00144	-0.00060	-0.00055	-0.00051
Industrial wood waste	-0.00003	0.00007	0.00012	0.00012	0.00011	-0.00070	-0.00041	-0.00016	-0.00015	-0.00014	-0.00321	-0.00217	-0.00123	-0.00114	-0.00107
Wood in municipal solid waste	0.00077	0.00083	0.00078	0.00074	0.00069	0.00008	0.00034	0.00048	0.00046	0.00044	-0.00251	-0.00148	-0.00061	-0.00056	-0.00052
Green waste: Compensation areas	-0.00048	-0.00037	-0.00025	-0.00023	-0.00022	-0.00116	-0.00084	-0.00054	-0.00050	-0.00047	-0.00368	-0.00262	-0.00161	-0.00150	-0.00140
Biomass: Habitat-connectivity areas	0.00076	0.00082	0.00077	0.00073	0.00068	0.00008	0.00034	0.00048	0.00046	0.00043	-0.00246	-0.00144	-0.00060	-0.00055	-0.00051
Green waste: Extensive grassland	0.00076	0.00082	0.00077	0.00073	0.00068	0.00008	0.00034	0.00048	0.00046	0.00043	-0.00246	-0.00144	-0.00060	-0.00055	-0.00051
Short-rotation coppice: Erosion areas	0.00002	0.00011	0.00017	0.00016	0.00015	-0.00070	-0.00039	-0.00014	-0.00013	-0.00012	-0.00337	-0.00227	-0.00127	-0.00118	-0.00110
Solid cattle manure	-0.00036	-0.00013	0.00004	0.00004	0.00004	-0.00194	-0.00124	-0.00063	-0.00058	-0.00054	-0.00779	-0.00535	-0.00311	-0.00290	-0.00271
Solid swine manure	-0.00041	-0.00005	0.00020	0.00019	0.00019	-0.00292	-0.00182	-0.00087	-0.00080	-0.00074	-0.01224	-0.00837	-0.00482	-0.00449	-0.00419
Solid poultry manure	-0.00030	-0.00018	-0.00008	-0.00007	-0.00007	-0.00108	-0.00073	-0.00041	-0.00038	-0.00036	-0.00398	-0.00277	-0.00164	-0.00153	-0.00143
Commercial and industrial waste	0.00093	0.00109	0.00107	0.00101	0.00096	-0.00052	0.00007	0.00046	0.00044	0.00042	-0.00589	-0.00371	-0.00182	-0.00169	-0.00157
Organic municipal solid waste	0.00100	0.00122	0.00123	0.00116	0.00109	-0.00090	-0.00012	0.00042	0.00041	0.00039	-0.00797	-0.00510	-0.00258	-0.00240	-0.00223

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table 40 (columns 1 to 5) – Table 42 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table 40 (columns 6 to 10) – Table 42 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table 40 (columns 11 to 15) – Table 42 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).



**Table A.77: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00050	-0.00038	-0.00030	-0.00028	-0.00026	-0.00120	-0.00087	-0.00068	-0.00063	-0.00059	-0.00379	-0.00270	-0.00207	-0.00193	-0.00180
Forestry residues	-0.00048	-0.00037	-0.00029	-0.00027	-0.00025	-0.00118	-0.00086	-0.00066	-0.00062	-0.00058	-0.00376	-0.00267	-0.00205	-0.00192	-0.00179
Open-country biomass residues	0.00076	0.00082	0.00073	0.00069	0.00065	0.00008	0.00034	0.00036	0.00034	0.00033	-0.00246	-0.00144	-0.00100	-0.00093	-0.00086
Industrial wood waste	-0.00003	0.00007	0.00008	0.00008	0.00008	-0.00070	-0.00041	-0.00028	-0.00026	-0.00024	-0.00321	-0.00217	-0.00163	-0.00152	-0.00141
Wood in municipal solid waste	0.00077	0.00083	0.00074	0.00070	0.00066	0.00008	0.00034	0.00036	0.00035	0.00033	-0.00251	-0.00148	-0.00103	-0.00095	-0.00088
Green waste: Compensation areas	-0.00048	-0.00037	-0.00029	-0.00027	-0.00025	-0.00116	-0.00084	-0.00065	-0.00061	-0.00057	-0.00368	-0.00262	-0.00201	-0.00188	-0.00175
Biomass: Habitat-connectivity areas	0.00076	0.00082	0.00073	0.00069	0.00065	0.00008	0.00034	0.00036	0.00034	0.00033	-0.00246	-0.00144	-0.00100	-0.00093	-0.00086
Green waste: Extensive grassland	0.00076	0.00082	0.00073	0.00069	0.00065	0.00008	0.00034	0.00036	0.00034	0.00033	-0.00246	-0.00144	-0.00100	-0.00093	-0.00086
Short-rotation coppice: Erosion areas	0.00002	0.00011	0.00012	0.00012	0.00011	-0.00070	-0.00039	-0.00026	-0.00024	-0.00022	-0.00337	-0.00227	-0.00170	-0.00158	-0.00147
Solid cattle manure	-0.00036	-0.00013	-0.00006	-0.00005	-0.00004	-0.00194	-0.00124	-0.00090	-0.00084	-0.00078	-0.00779	-0.00535	-0.00404	-0.00377	-0.00352
Solid swine manure	-0.00041	-0.00005	0.00004	0.00005	0.00005	-0.00292	-0.00182	-0.00130	-0.00121	-0.00112	-0.01224	-0.00837	-0.00630	-0.00588	-0.00548
Solid poultry manure	-0.00030	-0.00018	-0.00013	-0.00012	-0.00011	-0.00108	-0.00073	-0.00055	-0.00051	-0.00047	-0.00398	-0.00277	-0.00210	-0.00196	-0.00183
Commercial and industrial waste	0.00093	0.00109	0.00098	0.00093	0.00088	-0.00052	0.00007	0.00020	0.00020	0.00020	-0.00589	-0.00371	-0.00268	-0.00249	-0.00231
Organic municipal solid waste	0.00100	0.00122	0.00111	0.00105	0.00099	-0.00090	-0.00012	0.00009	0.00010	0.00010	-0.00797	-0.00510	-0.00371	-0.00345	-0.00321

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table A.68 (columns 1 to 5) – Table A.72 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.68 (columns 6 to 10) – Table A.72 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.68 (columns 11 to 15) – Table A.72 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.78: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00050	-0.00046	-0.00036	-0.00034	-0.00032	-0.00120	-0.00109	-0.00084	-0.00079	-0.00074	-0.00379	-0.00345	-0.00264	-0.00247	-0.00231
Forestry residues	-0.00048	-0.00044	-0.00035	-0.00033	-0.00030	-0.00118	-0.00108	-0.00083	-0.00078	-0.00073	-0.00376	-0.00342	-0.00262	-0.00245	-0.00229
Open-country biomass residues	0.00076	0.00074	0.00067	0.00063	0.00060	0.00008	0.00012	0.00019	0.00019	0.00018	-0.00246	-0.00218	-0.00156	-0.00145	-0.00135
Industrial wood waste	-0.00003	-0.00001	0.00002	0.00002	0.00002	-0.00070	-0.00062	-0.00044	-0.00041	-0.00038	-0.00321	-0.00290	-0.00218	-0.00203	-0.00190
Wood in municipal solid waste	0.00077	0.00075	0.00068	0.00064	0.00061	0.00008	0.00012	0.00019	0.00019	0.00018	-0.00251	-0.00223	-0.00160	-0.00148	-0.00138
Green waste: Compensation areas	-0.00048	-0.00044	-0.00035	-0.00033	-0.00030	-0.00116	-0.00106	-0.00082	-0.00077	-0.00072	-0.00368	-0.00335	-0.00257	-0.00240	-0.00224
Biomass: Habitat-connectivity areas	0.00076	0.00074	0.00067	0.00063	0.00060	0.00008	0.00012	0.00019	0.00019	0.00018	-0.00246	-0.00218	-0.00156	-0.00145	-0.00135
Green waste: Extensive grassland	0.00076	0.00074	0.00067	0.00063	0.00060	0.00008	0.00012	0.00019	0.00019	0.00018	-0.00246	-0.00218	-0.00156	-0.00145	-0.00135
Short-rotation coppice: Erosion areas	0.00002	0.00003	0.00006	0.00006	0.00006	-0.00070	-0.00062	-0.00044	-0.00041	-0.00038	-0.00337	-0.00304	-0.00229	-0.00213	-0.00199
Solid cattle manure	-0.00036	-0.00031	-0.00019	-0.00017	-0.00016	-0.00194	-0.00174	-0.00128	-0.00119	-0.00111	-0.00779	-0.00705	-0.00534	-0.00498	-0.00465
Solid swine manure	-0.00041	-0.00033	-0.00017	-0.00015	-0.00014	-0.00292	-0.00261	-0.00191	-0.00178	-0.00165	-0.01224	-0.01107	-0.00836	-0.00780	-0.00728
Solid poultry manure	-0.00030	-0.00027	-0.00019	-0.00018	-0.00017	-0.00108	-0.00098	-0.00073	-0.00069	-0.00064	-0.00398	-0.00361	-0.00274	-0.00256	-0.00239
Commercial and industrial waste	0.00093	0.00093	0.00086	0.00082	0.00077	-0.00052	-0.00039	-0.00015	-0.00012	-0.00011	-0.00589	-0.00527	-0.00387	-0.00360	-0.00335
Organic municipal solid waste	0.00100	0.00100	0.00095	0.00090	0.00085	-0.00090	-0.00073	-0.00037	-0.00033	-0.00030	-0.00797	-0.00715	-0.00527	-0.00491	-0.00457

Values rounded.

Sources:

a) Columns 1 to 5 = – Table A.69 (columns 1 to 5) – Table A.73 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

b) Columns 6 to 10 = – Table A.69 (columns 6 to 10) – Table A.73 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

c) Columns 11 to 15 = – Table A.69 (columns 11 to 15) – Table A.73 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.79: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Max 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00053	-0.00041	-0.00027	-0.00026	-0.00024	-0.00128	-0.00096	-0.00060	-0.00056	-0.00053	-0.00407	-0.00300	-0.00181	-0.00169	-0.00158
Forestry residues	-0.00051	-0.00040	-0.00026	-0.00025	-0.00023	-0.00126	-0.00095	-0.00059	-0.00055	-0.00051	-0.00404	-0.00298	-0.00179	-0.00168	-0.00157
Open-country biomass residues	0.00073	0.00079	0.00075	0.00071	0.00067	0.00000	0.00025	0.00043	0.00041	0.00039	-0.00273	-0.00174	-0.00075	-0.00069	-0.00064
Industrial wood waste	-0.00005	0.00004	0.00011	0.00010	0.00010	-0.00078	-0.00049	-0.00021	-0.00019	-0.00018	-0.00348	-0.00247	-0.00138	-0.00129	-0.00120
Wood in municipal solid waste	0.00074	0.00080	0.00076	0.00072	0.00068	-0.00001	0.00025	0.00044	0.00042	0.00040	-0.00279	-0.00178	-0.00077	-0.00071	-0.00066
Green waste: Compensation areas	-0.00051	-0.00040	-0.00026	-0.00025	-0.00023	-0.00124	-0.00093	-0.00058	-0.00054	-0.00051	-0.00395	-0.00292	-0.00176	-0.00165	-0.00154
Biomass: Habitat-connectivity areas	0.00073	0.00079	0.00075	0.00071	0.00067	0.00000	0.00025	0.00043	0.00041	0.00039	-0.00273	-0.00174	-0.00075	-0.00069	-0.00064
Green waste: Extensive grassland	0.00073	0.00079	0.00075	0.00071	0.00067	0.00000	0.00025	0.00043	0.00041	0.00039	-0.00273	-0.00174	-0.00075	-0.00069	-0.00064
Short-rotation coppice: Erosion areas	-0.00001	0.00008	0.00015	0.00014	0.00014	-0.00079	-0.00048	-0.00019	-0.00017	-0.00016	-0.00366	-0.00258	-0.00143	-0.00134	-0.00125

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table 41 (columns 1 to 5) – Table 43 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table 41 (columns 6 to 10) – Table 43 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table 41 (columns 11 to 15) – Table 43 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.80: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00053	-0.00041	-0.00031	-0.00029	-0.00028	-0.00128	-0.00096	-0.00071	-0.00067	-0.00062	-0.00407	-0.00300	-0.00220	-0.00205	-0.00192
Forestry residues	-0.00051	-0.00040	-0.00030	-0.00028	-0.00026	-0.00126	-0.00095	-0.00070	-0.00066	-0.00061	-0.00404	-0.00298	-0.00218	-0.00204	-0.00190
Open-country biomass residues	0.00073	0.00079	0.00071	0.00067	0.00064	0.00000	0.00025	0.00032	0.00031	0.00029	-0.00273	-0.00174	-0.00113	-0.00105	-0.00097
Industrial wood waste	-0.00005	0.00004	0.00007	0.00007	0.00006	-0.00078	-0.00049	-0.00032	-0.00029	-0.00027	-0.00348	-0.00247	-0.00175	-0.00164	-0.00152
Wood in municipal solid waste	0.00074	0.00080	0.00072	0.00068	0.00065	-0.00001	0.00025	0.00032	0.00031	0.00030	-0.00279	-0.00178	-0.00115	-0.00107	-0.00099
Green waste: Compensation areas	-0.00051	-0.00040	-0.00030	-0.00028	-0.00027	-0.00124	-0.00093	-0.00069	-0.00065	-0.00060	-0.00395	-0.00292	-0.00213	-0.00200	-0.00186
Biomass: Habitat-connectivity areas	0.00073	0.00079	0.00071	0.00067	0.00064	0.00000	0.00025	0.00032	0.00031	0.00029	-0.00273	-0.00174	-0.00113	-0.00105	-0.00097
Green waste: Extensive grassland	0.00073	0.00079	0.00071	0.00067	0.00064	0.00000	0.00025	0.00032	0.00031	0.00029	-0.00273	-0.00174	-0.00113	-0.00105	-0.00097
Short-rotation coppice: Erosion areas	-0.00001	0.00008	0.00011	0.00010	0.00010	-0.00079	-0.00048	-0.00030	-0.00028	-0.00026	-0.00366	-0.00258	-0.00183	-0.00171	-0.00159

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table A.70 (columns 1 to 5) – Table A.74 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.70 (columns 6 to 10) – Table A.74 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.70 (columns 11 to 15) – Table A.74 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.81: Revised Net GHG Emissions from Transports and Soil Additions, Germany, 2015-2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units <sup>a</sup> (à 2,000 t <sub>DM</sub> feedstock/a)					Medium-scale pyrolysis units <sup>b</sup> (à 16,000 t <sub>DM</sub> feedstock/a)					Large-scale pyrolysis units <sup>c</sup> (à 184,800 t <sub>DM</sub> feedstock/a)				
	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050	2015	2020	2030	2040	2050
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					t CO <sub>2</sub> e/t <sub>DM</sub> feedstock				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Cereal straw	-0.00053	-0.00048	-0.00036	-0.00034	-0.00032	-0.00128	-0.00115	-0.00085	-0.00080	-0.00075	-0.00407	-0.00365	-0.00267	-0.00250	-0.00233
Forestry residues	-0.00051	-0.00047	-0.00035	-0.00033	-0.00031	-0.00126	-0.00114	-0.00084	-0.00079	-0.00073	-0.00404	-0.00363	-0.00265	-0.00248	-0.00231
Open-country biomass residues	0.00073	0.00072	0.00066	0.00063	0.00059	0.00000	0.00006	0.00019	0.00018	0.00018	-0.00273	-0.00238	-0.00159	-0.00148	-0.00138
Industrial wood waste	-0.00005	-0.00003	0.00002	0.00002	0.00002	-0.00078	-0.00068	-0.00045	-0.00042	-0.00039	-0.00348	-0.00309	-0.00221	-0.00206	-0.00192
Wood in municipal solid waste	0.00074	0.00073	0.00067	0.00064	0.00060	-0.00001	0.00006	0.00019	0.00018	0.00018	-0.00279	-0.00243	-0.00163	-0.00151	-0.00141
Green waste: Compensation areas	-0.00051	-0.00046	-0.00035	-0.00033	-0.00031	-0.00124	-0.00112	-0.00083	-0.00077	-0.00072	-0.00395	-0.00355	-0.00259	-0.00243	-0.00227
Biomass: Habitat-connectivity areas	0.00073	0.00072	0.00066	0.00063	0.00059	0.00000	0.00006	0.00019	0.00018	0.00018	-0.00273	-0.00238	-0.00159	-0.00148	-0.00138
Green waste: Extensive grassland	0.00073	0.00072	0.00066	0.00063	0.00059	0.00000	0.00006	0.00019	0.00018	0.00018	-0.00273	-0.00238	-0.00159	-0.00148	-0.00138
Short-rotation coppice: Erosion areas	-0.00001	0.00001	0.00006	0.00006	0.00006	-0.00079	-0.00068	-0.00045	-0.00041	-0.00038	-0.00366	-0.00325	-0.00232	-0.00216	-0.00202

Values rounded.

Sources:

- a) Columns 1 to 5 = – Table A.71 (columns 1 to 5) – Table A.75 (columns 1 to 5) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- b) Columns 6 to 10 = – Table A.71 (columns 6 to 10) – Table A.75 (columns 6 to 10) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)
- c) Columns 11 to 15 = – Table A.71 (columns 11 to 15) – Table A.75 (columns 11 to 15) + Table 28 (columns 1 to 5) + Table 28 (columns 6 to 10) – Table 29 (columns 1 to 5) + Table 30 (columns 1 to 5)

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

## A.10 Revised Total Net Avoided GHG Emissions per Dry-Feedstock Tonne

Tables A.82-A.93 cover supplementary results tables for the revised total net avoided GHG emissions referred to in Section 5.4 of Teichmann (2014), i.e. corresponding to the biomass scenarios *Med 1*, *Min 1*, *Med 2* and *Min 2* in 2030 and all the biomass scenarios in 2015 and 2050.

**Table A.82: Revised Total Net Avoided GHG Emissions, 2030, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.341	0.388	0.428	0.439	0.450	0.309	0.338	0.385	0.425	0.436	0.447
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.384	0.497	0.696	0.499	0.593	0.758	0.379	0.492	0.691	0.494	0.588	0.753
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.712	0.656	0.546	0.825	0.751	0.606
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.701	0.702	0.695	0.825	0.806	0.761	0.698	0.699	0.692	0.822	0.803	0.758
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.067	0.151	0.301	0.179	0.245	0.361	0.063	0.148	0.297	0.175	0.242	0.357

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.77 (column 3) | g) (7) = Table 31 (column 11) + Table A.77 (column 8)  | m) (13) = Table 31 (column 11) + Table A.77 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.77 (column 3) | h) (8) = Table 31 (column 12) + Table A.77 (column 8)  | n) (14) = Table 31 (column 12) + Table A.77 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.77 (column 3) | i) (9) = Table 31 (column 13) + Table A.77 (column 8)  | o) (15) = Table 31 (column 13) + Table A.77 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.77 (column 3) | j) (10) = Table 31 (column 14) + Table A.77 (column 8) | p) (16) = Table 31 (column 14) + Table A.77 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.77 (column 3) | k) (11) = Table 31 (column 15) + Table A.77 (column 8) | q) (17) = Table 31 (column 15) + Table A.77 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.77 (column 3) | l) (12) = Table 31 (column 16) + Table A.77 (column 8) | r) (18) = Table 31 (column 16) + Table A.77 (column 13) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.83: Revised Total Net Avoided GHG Emissions, 2030, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.801	0.648	1.002	0.904	0.714	0.876	0.799	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.949	0.860	0.686	1.077	0.967	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.492	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.702	0.566	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.009	-0.530	-0.369	-0.060	-0.402	-0.262	0.008
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.388	0.428	0.438	0.450	0.307	0.337	0.384	0.424	0.434	0.446
Solid swine manure	0.385	0.499	0.698	0.500	0.594	0.759	0.384	0.497	0.696	0.498	0.593	0.757	0.377	0.490	0.689	0.492	0.586	0.751
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.657	0.547	0.826	0.752	0.608	0.711	0.655	0.545	0.824	0.750	0.606
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.806	0.762	0.700	0.702	0.695	0.824	0.805	0.761	0.697	0.698	0.691	0.821	0.802	0.757
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.066	0.151	0.300	0.179	0.245	0.360	0.062	0.146	0.295	0.174	0.240	0.355

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.78 (column 3) | g) (7) = Table 31 (column 11) + Table A.78 (column 8)  | m) (13) = Table 31 (column 11) + Table A.78 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.78 (column 3) | h) (8) = Table 31 (column 12) + Table A.78 (column 8)  | n) (14) = Table 31 (column 12) + Table A.78 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.78 (column 3) | i) (9) = Table 31 (column 13) + Table A.78 (column 8)  | o) (15) = Table 31 (column 13) + Table A.78 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.78 (column 3) | j) (10) = Table 31 (column 14) + Table A.78 (column 8) | p) (16) = Table 31 (column 14) + Table A.78 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.78 (column 3) | k) (11) = Table 31 (column 15) + Table A.78 (column 8) | q) (17) = Table 31 (column 15) + Table A.78 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.78 (column 3) | l) (12) = Table 31 (column 16) + Table A.78 (column 8) | r) (18) = Table 31 (column 16) + Table A.78 (column 13) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.84: Revised Total Net Avoided GHG Emissions, 2030, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.80 (column 3) | g) (7) = Table 31 (column 11) + Table A.80 (column 8)  | m) (13) = Table 31 (column 11) + Table A.80 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.80 (column 3) | h) (8) = Table 31 (column 12) + Table A.80 (column 8)  | n) (14) = Table 31 (column 12) + Table A.80 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.80 (column 3) | i) (9) = Table 31 (column 13) + Table A.80 (column 8)  | o) (15) = Table 31 (column 13) + Table A.80 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.80 (column 3) | j) (10) = Table 31 (column 14) + Table A.80 (column 8) | p) (16) = Table 31 (column 14) + Table A.80 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.80 (column 3) | k) (11) = Table 31 (column 15) + Table A.80 (column 8) | q) (17) = Table 31 (column 15) + Table A.80 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.80 (column 3) | l) (12) = Table 31 (column 16) + Table A.80 (column 8) | r) (18) = Table 31 (column 16) + Table A.80 (column 13) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).



**Table A.85: Revised Total Net Avoided GHG Emissions, 2030, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.714	0.878	0.801	0.648	1.002	0.904	0.714	0.876	0.799	0.646	1.000	0.902	0.712
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.949	0.860	0.686	1.077	0.967	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.492	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.702	0.566	0.895	0.806	0.632
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.009	-0.530	-0.369	-0.060	-0.402	-0.262	0.008

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.81 (column 3) | g) (7) = Table 31 (column 11) + Table A.81 (column 8)  | m) (13) = Table 31 (column 11) + Table A.81 (column 13) |
| b) (2) = Table 31 (column 12) + Table A.81 (column 3) | h) (8) = Table 31 (column 12) + Table A.81 (column 8)  | n) (14) = Table 31 (column 12) + Table A.81 (column 13) |
| c) (3) = Table 31 (column 13) + Table A.81 (column 3) | i) (9) = Table 31 (column 13) + Table A.81 (column 8)  | o) (15) = Table 31 (column 13) + Table A.81 (column 13) |
| d) (4) = Table 31 (column 14) + Table A.81 (column 3) | j) (10) = Table 31 (column 14) + Table A.81 (column 8) | p) (16) = Table 31 (column 14) + Table A.81 (column 13) |
| e) (5) = Table 31 (column 15) + Table A.81 (column 3) | k) (11) = Table 31 (column 15) + Table A.81 (column 8) | q) (17) = Table 31 (column 15) + Table A.81 (column 13) |
| f) (6) = Table 31 (column 16) + Table A.81 (column 3) | l) (12) = Table 31 (column 16) + Table A.81 (column 8) | r) (18) = Table 31 (column 16) + Table A.81 (column 13) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.86: Revised Total Net Avoided GHG Emissions, 2015, Scenario *Max 1, Med 1, Min 1*\***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
	(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>
Cereal straw	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.648	1.002	0.904	0.714	0.875	0.798	0.645	0.999	0.901	0.711
Forestry residues	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755	0.948	0.859	0.685	1.076	0.966	0.753
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.250	0.074	-0.291	-0.143	0.142	-0.421	-0.252	0.072	-0.293	-0.145	0.140
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.366	1.277	1.103	1.494	1.384	1.171	1.364	1.275	1.100	1.492	1.382	1.168
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634	0.770	0.701	0.565	0.894	0.805	0.631
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.180	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.282	1.093
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.260	0.009	-0.531	-0.370	-0.061	-0.403	-0.263	0.007
Solid cattle manure	0.312	0.342	0.389	0.429	0.439	0.451	0.311	0.340	0.387	0.427	0.438	0.449	0.305	0.334	0.381	0.421	0.432	0.443
Solid swine manure	0.385	0.498	0.697	0.500	0.594	0.758	0.383	0.496	0.695	0.497	0.592	0.756	0.373	0.487	0.686	0.488	0.582	0.747
Solid poultry manure	0.713	0.658	0.548	0.827	0.752	0.608	0.713	0.657	0.547	0.826	0.752	0.607	0.710	0.654	0.544	0.823	0.749	0.605
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.700	0.701	0.694	0.824	0.805	0.760	0.695	0.696	0.689	0.819	0.800	0.755
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.066	0.150	0.300	0.178	0.244	0.360	0.059	0.143	0.293	0.171	0.237	0.353

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.76 (column 1) | g) (7) = Table 31 (column 11) + Table A.76 (column 6)  | m) (13) = Table 31 (column 11) + Table A.76 (column 11) |
| b) (2) = Table 31 (column 12) + Table A.76 (column 1) | h) (8) = Table 31 (column 12) + Table A.76 (column 6)  | n) (14) = Table 31 (column 12) + Table A.76 (column 11) |
| c) (3) = Table 31 (column 13) + Table A.76 (column 1) | i) (9) = Table 31 (column 13) + Table A.76 (column 6)  | o) (15) = Table 31 (column 13) + Table A.76 (column 11) |
| d) (4) = Table 31 (column 14) + Table A.76 (column 1) | j) (10) = Table 31 (column 14) + Table A.76 (column 6) | p) (16) = Table 31 (column 14) + Table A.76 (column 11) |
| e) (5) = Table 31 (column 15) + Table A.76 (column 1) | k) (11) = Table 31 (column 15) + Table A.76 (column 6) | q) (17) = Table 31 (column 15) + Table A.76 (column 11) |
| f) (6) = Table 31 (column 16) + Table A.76 (column 1) | l) (12) = Table 31 (column 16) + Table A.76 (column 6) | r) (18) = Table 31 (column 16) + Table A.76 (column 11) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

\* Due to identical biomass potentials in 2015 (Table 35), the same results are obtained for the *Max 1, Med 1* and *Min 1* scenarios.

**Table A.87: Revised Total Net Avoided GHG Emissions, 2015, Scenario *Max 2, Med 2, Min 2*\***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.904	0.714	0.875	0.797	0.645	0.999	0.901	0.711
Forestry residues	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.079	0.969	0.755	0.948	0.859	0.684	1.076	0.966	0.752
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.281	1.092
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142	-0.421	-0.252	0.071	-0.293	-0.145	0.140
Wood in municipal solid waste	1.367	1.278	1.104	1.495	1.385	1.172	1.366	1.277	1.103	1.494	1.384	1.171	1.363	1.275	1.100	1.491	1.381	1.168
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634	0.770	0.701	0.565	0.894	0.805	0.631
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.281	1.092
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.256	1.179	1.028	1.382	1.284	1.095	1.254	1.177	1.026	1.379	1.281	1.092
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.059	-0.401	-0.260	0.009	-0.531	-0.370	-0.062	-0.404	-0.263	0.006

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |  |   |
|---|--|---|
| a) (1) = Table 31 (column 11) + Table A.79 (column 1) | g) (7) = Table 31 (column 11) + Table A.79 (column 6)  | m) (13) = Table 31 (column 11) + Table A.79 (column 11) |
| b) (2) = Table 31 (column 12) + Table A.79 (column 1) | h) (8) = Table 31 (column 12) + Table A.79 (column 6)  | n) (14) = Table 31 (column 12) + Table A.79 (column 11) |
| c) (3) = Table 31 (column 13) + Table A.79 (column 1) | i) (9) = Table 31 (column 13) + Table A.79 (column 6)  | o) (15) = Table 31 (column 13) + Table A.79 (column 11) |
| d) (4) = Table 31 (column 14) + Table A.79 (column 1) | j) (10) = Table 31 (column 14) + Table A.79 (column 6) | p) (16) = Table 31 (column 14) + Table A.79 (column 11) |
| e) (5) = Table 31 (column 15) + Table A.79 (column 1) | k) (11) = Table 31 (column 15) + Table A.79 (column 6) | q) (17) = Table 31 (column 15) + Table A.79 (column 11) |
| f) (6) = Table 31 (column 16) + Table A.79 (column 1) | l) (12) = Table 31 (column 16) + Table A.79 (column 6) | r) (18) = Table 31 (column 16) + Table A.79 (column 11) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

\* Due to identical biomass potentials in 2015 (Table 36), the same results are obtained for the *Max 2, Med 2* and *Min 2* scenarios.

**Table A.88: Revised Total Net Avoided GHG Emissions, 2050, Scenario *Max 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.878	0.800	0.648	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.951	0.862	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.095
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.277	1.102	1.494	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.095
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.095
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.342	0.389	0.429	0.439	0.451	0.310	0.340	0.386	0.427	0.437	0.448
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.385	0.498	0.697	0.499	0.594	0.758	0.381	0.495	0.694	0.496	0.590	0.755
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.827	0.752	0.608	0.712	0.657	0.547	0.825	0.751	0.607
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.807	0.762	0.701	0.702	0.695	0.825	0.806	0.761	0.699	0.700	0.693	0.823	0.804	0.759
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.067	0.152	0.301	0.180	0.246	0.361	0.065	0.149	0.299	0.177	0.243	0.358

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.76 (column 5) | g) (7) = Table 31 (column 11) + Table A.76 (column 10)  | m) (13) = Table 31 (column 11) + Table A.76 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.76 (column 5) | h) (8) = Table 31 (column 12) + Table A.76 (column 10)  | n) (14) = Table 31 (column 12) + Table A.76 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.76 (column 5) | i) (9) = Table 31 (column 13) + Table A.76 (column 10)  | o) (15) = Table 31 (column 13) + Table A.76 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.76 (column 5) | j) (10) = Table 31 (column 14) + Table A.76 (column 10) | p) (16) = Table 31 (column 14) + Table A.76 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.76 (column 5) | k) (11) = Table 31 (column 15) + Table A.76 (column 10) | q) (17) = Table 31 (column 15) + Table A.76 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.76 (column 5) | l) (12) = Table 31 (column 16) + Table A.76 (column 10) | r) (18) = Table 31 (column 16) + Table A.76 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.89: Revised Total Net Avoided GHG Emissions, 2050, Scenario *Med 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.898	0.808	0.635	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.179	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.401	-0.261	0.008
Solid cattle manure	0.313	0.342	0.389	0.429	0.440	0.451	0.312	0.341	0.388	0.428	0.439	0.450	0.309	0.339	0.386	0.426	0.436	0.448
Solid swine manure	0.386	0.499	0.698	0.500	0.595	0.759	0.384	0.498	0.697	0.499	0.594	0.758	0.380	0.493	0.692	0.495	0.589	0.753
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.712	0.656	0.546	0.825	0.751	0.607
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.806	0.762	0.701	0.702	0.695	0.825	0.806	0.761	0.698	0.700	0.693	0.822	0.803	0.759
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.362	0.067	0.151	0.301	0.179	0.245	0.361	0.064	0.148	0.298	0.176	0.242	0.357

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.77 (column 5) | g) (7) = Table 31 (column 11) + Table A.77 (column 10)  | m) (13) = Table 31 (column 11) + Table A.77 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.77 (column 5) | h) (8) = Table 31 (column 12) + Table A.77 (column 10)  | n) (14) = Table 31 (column 12) + Table A.77 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.77 (column 5) | i) (9) = Table 31 (column 13) + Table A.77 (column 10)  | o) (15) = Table 31 (column 13) + Table A.77 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.77 (column 5) | j) (10) = Table 31 (column 14) + Table A.77 (column 10) | p) (16) = Table 31 (column 14) + Table A.77 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.77 (column 5) | k) (11) = Table 31 (column 15) + Table A.77 (column 10) | q) (17) = Table 31 (column 15) + Table A.77 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.77 (column 5) | l) (12) = Table 31 (column 16) + Table A.77 (column 10) | r) (18) = Table 31 (column 16) + Table A.77 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.90: Revised Total Net Avoided GHG Emissions, 2050, Scenario *Min 1***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.000	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.493	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.262	0.008
Solid cattle manure	0.312	0.342	0.389	0.429	0.440	0.451	0.311	0.341	0.388	0.428	0.439	0.450	0.308	0.338	0.384	0.425	0.435	0.447
Solid swine manure	0.385	0.499	0.698	0.500	0.594	0.759	0.384	0.497	0.696	0.499	0.593	0.757	0.378	0.491	0.690	0.493	0.587	0.752
Solid poultry manure	0.714	0.658	0.548	0.827	0.753	0.608	0.713	0.658	0.548	0.826	0.752	0.608	0.711	0.656	0.546	0.824	0.750	0.606
Commercial and industrial waste	0.701	0.703	0.696	0.825	0.806	0.762	0.700	0.702	0.695	0.824	0.805	0.761	0.697	0.699	0.692	0.821	0.802	0.758
Organic municipal solid waste	0.068	0.152	0.302	0.180	0.246	0.361	0.067	0.151	0.300	0.179	0.245	0.360	0.062	0.147	0.296	0.175	0.241	0.356

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

Sources:

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.78 (column 5) | g) (7) = Table 31 (column 11) + Table A.78 (column 10)  | m) (13) = Table 31 (column 11) + Table A.78 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.78 (column 5) | h) (8) = Table 31 (column 12) + Table A.78 (column 10)  | n) (14) = Table 31 (column 12) + Table A.78 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.78 (column 5) | i) (9) = Table 31 (column 13) + Table A.78 (column 10)  | o) (15) = Table 31 (column 13) + Table A.78 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.78 (column 5) | j) (10) = Table 31 (column 14) + Table A.78 (column 10) | p) (16) = Table 31 (column 14) + Table A.78 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.78 (column 5) | k) (11) = Table 31 (column 15) + Table A.78 (column 10) | q) (17) = Table 31 (column 15) + Table A.78 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.78 (column 5) | l) (12) = Table 31 (column 16) + Table A.78 (column 10) | r) (18) = Table 31 (column 16) + Table A.78 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.91: Revised Total Net Avoided GHG Emissions, 2050, Scenario Max 2**

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.879	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.952	0.863	0.688	1.079	0.969	0.756	0.950	0.861	0.687	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.074	-0.291	-0.143	0.142
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.385	1.171	1.366	1.277	1.102	1.493	1.384	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.807	0.634
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.285	1.095	1.256	1.179	1.028	1.381	1.284	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.259	0.010	-0.528	-0.366	-0.058	-0.400	-0.260	0.010	-0.529	-0.367	-0.059	-0.401	-0.261	0.009

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.79 (column 5) | g) (7) = Table 31 (column 11) + Table A.79 (column 10)  | m) (13) = Table 31 (column 11) + Table A.79 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.79 (column 5) | h) (8) = Table 31 (column 12) + Table A.79 (column 10)  | n) (14) = Table 31 (column 12) + Table A.79 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.79 (column 5) | i) (9) = Table 31 (column 13) + Table A.79 (column 10)  | o) (15) = Table 31 (column 13) + Table A.79 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.79 (column 5) | j) (10) = Table 31 (column 14) + Table A.79 (column 10) | p) (16) = Table 31 (column 14) + Table A.79 (column 15) |
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| f) (6) = Table 31 (column 16) + Table A.79 (column 5) | l) (12) = Table 31 (column 16) + Table A.79 (column 10) | r) (18) = Table 31 (column 16) + Table A.79 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.92: Revised Total Net Avoided GHG Emissions, 2050, Scenario *Med 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.905	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.800	0.647	1.001	0.903	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.755
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.419	-0.250	0.073	-0.291	-0.143	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.172	1.367	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.102	1.493	1.383	1.170
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.774	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.807	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.381	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.261	0.008

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.80 (column 5) | g) (7) = Table 31 (column 11) + Table A.80 (column 10)  | m) (13) = Table 31 (column 11) + Table A.80 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.80 (column 5) | h) (8) = Table 31 (column 12) + Table A.80 (column 10)  | n) (14) = Table 31 (column 12) + Table A.80 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.80 (column 5) | i) (9) = Table 31 (column 13) + Table A.80 (column 10)  | o) (15) = Table 31 (column 13) + Table A.80 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.80 (column 5) | j) (10) = Table 31 (column 14) + Table A.80 (column 10) | p) (16) = Table 31 (column 14) + Table A.80 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.80 (column 5) | k) (11) = Table 31 (column 15) + Table A.80 (column 10) | q) (17) = Table 31 (column 15) + Table A.80 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.80 (column 5) | l) (12) = Table 31 (column 16) + Table A.80 (column 10) | r) (18) = Table 31 (column 16) + Table A.80 (column 15) |

Note that tables numbered without the leading "A." refer to Teichmann (2014).



**Table A.93: Revised Total Net Avoided GHG Emissions, 2050, Scenario *Min 2***

Feedstocks	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock						t CO <sub>2</sub> e/t <sub>DM</sub> feedstock					
(1) <sup>a</sup>	(2) <sup>b</sup>	(3) <sup>c</sup>	(4) <sup>d</sup>	(5) <sup>e</sup>	(6) <sup>f</sup>	(7) <sup>g</sup>	(8) <sup>h</sup>	(9) <sup>i</sup>	(10) <sup>j</sup>	(11) <sup>k</sup>	(12) <sup>l</sup>	(13) <sup>m</sup>	(14) <sup>n</sup>	(15) <sup>o</sup>	(16) <sup>p</sup>	(17) <sup>q</sup>	(18) <sup>r</sup>	
Cereal straw	0.879	0.801	0.649	1.002	0.904	0.715	0.878	0.801	0.648	1.002	0.904	0.714	0.877	0.799	0.647	1.000	0.902	0.713
Forestry residues	0.952	0.863	0.688	1.080	0.970	0.756	0.951	0.862	0.688	1.079	0.969	0.756	0.950	0.861	0.686	1.078	0.968	0.754
Open-country biomass residues	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Industrial wood waste	-0.418	-0.249	0.075	-0.290	-0.142	0.143	-0.418	-0.249	0.074	-0.290	-0.142	0.143	-0.420	-0.251	0.073	-0.292	-0.144	0.141
Wood in municipal solid waste	1.367	1.278	1.103	1.495	1.385	1.171	1.366	1.278	1.103	1.494	1.384	1.171	1.365	1.276	1.101	1.493	1.383	1.169
Green waste: Compensation areas	0.774	0.705	0.569	0.898	0.808	0.635	0.773	0.704	0.568	0.897	0.808	0.634	0.772	0.703	0.567	0.896	0.806	0.633
Biomass: Habitat-connectivity areas	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Green waste: Extensive grassland	1.257	1.180	1.029	1.382	1.285	1.096	1.257	1.180	1.029	1.382	1.284	1.095	1.255	1.178	1.027	1.380	1.283	1.094
Short-rotation coppice: Erosion areas	-0.527	-0.366	-0.058	-0.400	-0.260	0.010	-0.528	-0.367	-0.058	-0.400	-0.260	0.010	-0.529	-0.368	-0.060	-0.402	-0.262	0.008

GHG emissions are indicated by a negative sign, C removals or avoided emissions are displayed as positive values. Negative total net avoided GHG emissions are highlighted by grey color. Values rounded.

*Sources:*

- |   |   |   |
|---|---|---|
| a) (1) = Table 31 (column 11) + Table A.81 (column 5) | g) (7) = Table 31 (column 11) + Table A.81 (column 10)  | m) (13) = Table 31 (column 11) + Table A.81 (column 15) |
| b) (2) = Table 31 (column 12) + Table A.81 (column 5) | h) (8) = Table 31 (column 12) + Table A.81 (column 10)  | n) (14) = Table 31 (column 12) + Table A.81 (column 15) |
| c) (3) = Table 31 (column 13) + Table A.81 (column 5) | i) (9) = Table 31 (column 13) + Table A.81 (column 10)  | o) (15) = Table 31 (column 13) + Table A.81 (column 15) |
| d) (4) = Table 31 (column 14) + Table A.81 (column 5) | j) (10) = Table 31 (column 14) + Table A.81 (column 10) | p) (16) = Table 31 (column 14) + Table A.81 (column 15) |
| e) (5) = Table 31 (column 15) + Table A.81 (column 5) | k) (11) = Table 31 (column 15) + Table A.81 (column 10) | q) (17) = Table 31 (column 15) + Table A.81 (column 15) |
| f) (6) = Table 31 (column 16) + Table A.81 (column 5) | l) (12) = Table 31 (column 16) + Table A.81 (column 10) | r) (18) = Table 31 (column 16) + Table A.81 (column 15) |

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

## A.11 Technical GHG Mitigation Potentials of Biochar

Tables A.94-A.102 contain supplementary results tables for the technical GHG mitigation potentials of biochar referred to and discussed in Section 6 of Teichmann (2014). That is, they display the technical GHG mitigation potentials for the biomass scenarios *Med 1*, *Med 2* and *Min 2* in 2030 and all the biomass scenarios in 2050.

**Table A.94: GHG Mitigation Potentials, 2030, Scenario *Med 1***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
Feedstocks	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	653	595	482	745	672	531	652	595	482	744	672	530	651	594	480	743	671	529
Forestry residues	2,269	2,056	1,640	2,573	2,311	1,802	2,268	2,056	1,639	2,572	2,310	1,801	2,264	2,052	1,636	2,569	2,307	1,798
Open-country biomass residues	397	373	325	437	406	346	397	373	325	437	406	346	397	372	325	436	405	346
Industrial wood waste	-	-	58	-	-	111	-	-	58	-	-	111	-	-	57	-	-	109
Wood in municipal solid waste	419	391	338	458	424	359	419	391	338	458	424	359	418	391	337	457	424	358
Green waste: Compensation areas	110	100	81	128	115	90	110	100	81	128	115	90	110	100	81	128	115	90
Biomass: Habitat-connectivity areas	346	325	283	380	353	301	346	324	283	380	353	301	345	324	283	380	353	301
Green waste: Extensive grassland	512	481	419	563	524	447	512	481	419	563	523	446	512	480	419	563	523	446
Short-rotation coppice: Erosion areas	-	-	-	-	-	14	-	-	-	-	-	13	-	-	-	-	-	11
<b>Solid biomass residues</b>	<b>4,705</b>	<b>4,322</b>	<b>3,626</b>	<b>5,284</b>	<b>4,805</b>	<b>4,001</b>	<b>4,704</b>	<b>4,320</b>	<b>3,624</b>	<b>5,282</b>	<b>4,803</b>	<b>3,999</b>	<b>4,697</b>	<b>4,314</b>	<b>3,617</b>	<b>5,276</b>	<b>4,797</b>	<b>3,989</b>
Solid cattle manure	371	407	462	510	522	536	370	406	461	509	521	535	367	402	457	505	518	531
Solid swine manure	123	159	223	160	190	242	123	159	222	159	189	242	121	157	221	158	188	240
Solid poultry manure	145	134	112	168	153	124	145	134	111	168	153	124	145	134	111	168	153	123
Commercial and industrial waste	104	105	104	123	120	113	104	104	103	123	120	113	104	104	103	122	119	113
Organic municipal solid waste	39	88	173	103	141	208	38	87	173	103	141	207	36	85	171	101	139	205
<b>Digestible biomass residues</b>	<b>783</b>	<b>892</b>	<b>1,073</b>	<b>1,064</b>	<b>1,127</b>	<b>1,223</b>	<b>781</b>	<b>889</b>	<b>1,071</b>	<b>1,062</b>	<b>1,125</b>	<b>1,221</b>	<b>772</b>	<b>881</b>	<b>1,063</b>	<b>1,054</b>	<b>1,116</b>	<b>1,212</b>
<b>TOTAL</b>	<b>5,488</b>	<b>5,213</b>	<b>4,700</b>	<b>6,348</b>	<b>5,932</b>	<b>5,224</b>	<b>5,484</b>	<b>5,210</b>	<b>4,695</b>	<b>6,344</b>	<b>5,928</b>	<b>5,219</b>	<b>5,470</b>	<b>5,195</b>	<b>4,680</b>	<b>6,329</b>	<b>5,913</b>	<b>5,202</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.82 by the respective feedstock-specific biomass potential from Table 35, column 8. Values rounded.

Note that tables numbered without the leading "A." refer to Teichmann (2014).

**Table A.95: GHG Mitigation Potentials, 2030, Scenario *Med 2***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	783	714	578	893	806	637	783	714	578	893	806	637	782	712	576	892	804	635
Forestry residues	2,722	2,468	1,968	3,088	2,773	2,163	2,721	2,467	1,967	3,087	2,772	2,162	2,717	2,462	1,963	3,082	2,768	2,157
Open-country biomass residues	477	448	390	524	487	416	477	447	390	524	487	415	476	447	390	523	487	415
Industrial wood waste	-	-	70	-	-	133	-	-	69	-	-	133	-	-	68	-	-	131
Wood in municipal solid waste	502	470	406	549	509	431	502	470	405	549	509	430	502	469	405	549	508	430
Green waste: Compensation areas	132	121	97	154	138	109	132	120	97	153	138	108	132	120	97	153	138	108
Biomass: Habitat-connectivity areas	415	389	340	456	424	362	415	389	339	456	424	361	414	389	339	456	423	361
Green waste: Extensive grassland	615	577	503	676	628	536	615	577	503	676	628	536	614	576	502	675	627	535
Short-rotation coppice: Erosion areas	-	-	-	-	-	17	-	-	-	-	-	16	-	-	-	-	-	13
<b>Solid biomass residues = TOTAL</b>	<b>5,646</b>	<b>5,186</b>	<b>4,352</b>	<b>6,340</b>	<b>5,766</b>	<b>4,801</b>	<b>5,644</b>	<b>5,184</b>	<b>4,349</b>	<b>6,338</b>	<b>5,764</b>	<b>4,798</b>	<b>5,636</b>	<b>5,176</b>	<b>4,340</b>	<b>6,330</b>	<b>5,756</b>	<b>4,786</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.84 by the respective feedstock-specific biomass potential from Table 36, column 8. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.96: GHG Mitigation Potentials, 2030, Scenario *Min 2***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
<b>Feedstocks</b>																		
Cereal straw	522	476	385	596	537	425	522	476	385	595	537	424	521	475	384	594	536	423
Forestry residues	1,815	1,645	1,312	2,058	1,849	1,442	1,814	1,644	1,311	2,058	1,848	1,441	1,810	1,641	1,308	2,054	1,844	1,437
Open-country biomass residues	318	298	260	349	325	277	318	298	260	349	325	277	317	298	260	349	324	276
Industrial wood waste	-	-	46	-	-	89	-	-	46	-	-	88	-	-	45	-	-	87
Wood in municipal solid waste	335	313	270	366	339	287	335	313	270	366	339	287	334	313	270	366	339	286
Green waste: Compensation areas	88	80	65	102	92	72	88	80	65	102	92	72	88	80	65	102	92	72
Biomass: Habitat-connectivity areas	277	260	226	304	283	241	276	260	226	304	283	241	276	259	226	304	282	241
Green waste: Extensive grassland	410	385	335	451	419	357	410	385	335	450	419	357	409	384	335	450	418	356
Short-rotation coppice: Erosion areas	-	-	-	-	-	11	-	-	-	-	-	10	-	-	-	-	-	8
<b>Solid biomass residues = TOTAL</b>	<b>3,764</b>	<b>3,457</b>	<b>2,901</b>	<b>4,227</b>	<b>3,844</b>	<b>3,201</b>	<b>3,762</b>	<b>3,455</b>	<b>2,899</b>	<b>4,225</b>	<b>3,842</b>	<b>3,198</b>	<b>3,756</b>	<b>3,449</b>	<b>2,891</b>	<b>4,218</b>	<b>3,836</b>	<b>3,188</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.85 by the respective feedstock-specific biomass potential from Table 36, column 13. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.97: GHG Mitigation Potentials, 2050, Scenario *Max 1***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	1,083	987	800	1,235	1,115	881	1,083	987	799	1,235	1,114	880	1,082	986	798	1,234	1,113	879
Forestry residues	3,922	3,555	2,835	4,448	3,995	3,116	3,921	3,554	2,834	4,447	3,994	3,115	3,917	3,550	2,830	4,443	3,990	3,111
Open-country biomass residues	636	597	520	699	650	554	635	597	520	699	649	554	635	596	520	698	649	553
Industrial wood waste	-	-	93	-	-	177	-	-	93	-	-	177	-	-	91	-	-	176
Wood in municipal solid waste	683	639	552	747	692	586	683	639	552	747	692	586	683	638	551	747	692	585
Green waste: Compensation areas	176	161	130	205	184	145	176	161	130	205	184	145	176	160	129	204	184	144
Biomass: Habitat-connectivity areas	553	519	453	608	565	482	553	519	453	608	565	482	553	519	452	608	565	482
Green waste: Extensive grassland	820	769	671	901	838	714	819	769	671	901	838	714	819	769	670	900	837	714
Short-rotation coppice: Erosion areas	-	-	-	-	-	22	-	-	-	-	-	22	-	-	-	-	-	19
<b>Solid biomass residues</b>	<b>7,873</b>	<b>7,227</b>	<b>6,053</b>	<b>8,844</b>	<b>8,039</b>	<b>6,677</b>	<b>7,871</b>	<b>7,225</b>	<b>6,051</b>	<b>8,842</b>	<b>8,037</b>	<b>6,674</b>	<b>7,864</b>	<b>7,218</b>	<b>6,042</b>	<b>8,835</b>	<b>8,030</b>	<b>6,663</b>
Solid cattle manure	605	662	753	831	851	873	604	661	752	829	850	872	600	657	748	825	846	868
Solid swine manure	200	259	362	259	308	394	199	258	361	259	308	393	198	256	360	257	306	391
Solid poultry manure	232	214	178	269	245	198	232	214	178	269	245	198	232	214	178	269	245	198
Commercial and industrial waste	167	167	166	196	192	181	167	167	165	196	192	181	166	167	165	196	191	181
Organic municipal solid waste	70	158	313	187	255	375	70	157	312	186	255	374	67	155	310	183	252	372
<b>Digestible biomass residues</b>	<b>1,275</b>	<b>1,461</b>	<b>1,772</b>	<b>1,743</b>	<b>1,852</b>	<b>2,021</b>	<b>1,272</b>	<b>1,458</b>	<b>1,769</b>	<b>1,740</b>	<b>1,849</b>	<b>2,018</b>	<b>1,262</b>	<b>1,448</b>	<b>1,760</b>	<b>1,730</b>	<b>1,840</b>	<b>2,009</b>
<b>TOTAL</b>	<b>9,147</b>	<b>8,688</b>	<b>7,825</b>	<b>10,587</b>	<b>9,891</b>	<b>8,698</b>	<b>9,143</b>	<b>8,683</b>	<b>7,820</b>	<b>10,582</b>	<b>9,887</b>	<b>8,693</b>	<b>9,126</b>	<b>8,667</b>	<b>7,802</b>	<b>10,565</b>	<b>9,870</b>	<b>8,672</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.88 by the respective feedstock-specific biomass potential from Table 35, column 3. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.98: GHG Mitigation Potentials, 2050, Scenario *Med 1***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	677	617	500	772	697	550	677	617	499	772	696	550	676	616	498	771	696	549
Forestry residues	2,451	2,222	1,772	2,780	2,497	1,947	2,450	2,221	1,771	2,779	2,496	1,946	2,447	2,218	1,768	2,776	2,493	1,943
Open-country biomass residues	397	373	325	437	406	346	397	373	325	437	406	346	397	372	325	436	406	346
Industrial wood waste	-	-	58	-	-	111	-	-	58	-	-	111	-	-	57	-	-	110
Wood in municipal solid waste	427	399	345	467	433	366	427	399	345	467	433	366	427	399	344	467	432	366
Green waste: Compensation areas	110	100	81	128	115	90	110	100	81	128	115	90	110	100	81	128	115	90
Biomass: Habitat-connectivity areas	346	325	283	380	353	301	346	324	283	380	353	301	345	324	283	380	353	301
Green waste: Extensive grassland	512	481	419	563	524	447	512	481	419	563	523	446	512	480	419	563	523	446
Short-rotation coppice: Erosion areas	-	-	-	-	-	14	-	-	-	-	-	13	-	-	-	-	-	12
<b>Solid biomass residues</b>	<b>4,920</b>	<b>4,517</b>	<b>3,783</b>	<b>5,527</b>	<b>5,024</b>	<b>4,173</b>	<b>4,919</b>	<b>4,515</b>	<b>3,781</b>	<b>5,526</b>	<b>5,023</b>	<b>4,171</b>	<b>4,913</b>	<b>4,510</b>	<b>3,774</b>	<b>5,520</b>	<b>5,017</b>	<b>4,162</b>
Solid cattle manure	378	414	470	519	532	546	377	413	470	518	531	545	374	410	466	515	528	541
Solid swine manure	125	162	226	162	193	246	125	161	226	162	192	246	123	160	224	160	191	244
Solid poultry manure	145	134	112	168	153	124	145	134	111	168	153	124	145	134	111	168	153	123
Commercial and industrial waste	104	105	103	123	120	113	104	104	103	123	120	113	104	104	103	122	119	113
Organic municipal solid waste	44	99	196	117	160	234	43	98	195	116	159	234	41	96	193	114	157	232
<b>Digestible biomass residues</b>	<b>796</b>	<b>913</b>	<b>1,107</b>	<b>1,089</b>	<b>1,157</b>	<b>1,263</b>	<b>794</b>	<b>911</b>	<b>1,105</b>	<b>1,087</b>	<b>1,155</b>	<b>1,261</b>	<b>787</b>	<b>903</b>	<b>1,098</b>	<b>1,079</b>	<b>1,148</b>	<b>1,253</b>
<b>TOTAL</b>	<b>5,717</b>	<b>5,430</b>	<b>4,890</b>	<b>6,616</b>	<b>6,182</b>	<b>5,436</b>	<b>5,713</b>	<b>5,426</b>	<b>4,886</b>	<b>6,613</b>	<b>6,178</b>	<b>5,431</b>	<b>5,700</b>	<b>5,413</b>	<b>4,872</b>	<b>6,599</b>	<b>6,165</b>	<b>5,416</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.89 by the respective feedstock-specific biomass potential from Table 35, column 8. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.99: GHG Mitigation Potentials, 2050, Scenario *Min 1***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	406	370	300	463	418	330	406	370	300	463	418	330	405	369	299	462	417	329
Forestry residues	1,470	1,333	1,063	1,668	1,498	1,168	1,470	1,332	1,062	1,667	1,497	1,168	1,467	1,330	1,060	1,665	1,495	1,165
Open-country biomass residues	238	224	195	262	244	208	238	224	195	262	244	208	238	223	195	262	243	207
Industrial wood waste	-	-	35	-	-	66	-	-	35	-	-	66	-	-	34	-	-	66
Wood in municipal solid waste	256	240	207	280	260	220	256	240	207	280	260	220	256	239	207	280	259	219
Green waste: Compensation areas	66	60	49	77	69	54	66	60	49	77	69	54	66	60	48	77	69	54
Biomass: Habitat-connectivity areas	207	195	170	228	212	181	207	195	170	228	212	181	207	194	169	228	212	180
Green waste: Extensive grassland	307	289	252	338	314	268	307	288	251	338	314	268	307	288	251	337	314	267
Short-rotation coppice: Erosion areas	-	-	-	-	-	8	-	-	-	-	-	8	-	-	-	-	-	7
<b>Solid biomass residues</b>	<b>2,952</b>	<b>2,710</b>	<b>2,270</b>	<b>3,316</b>	<b>3,015</b>	<b>2,503</b>	<b>2,951</b>	<b>2,709</b>	<b>2,268</b>	<b>3,315</b>	<b>3,013</b>	<b>2,502</b>	<b>2,946</b>	<b>2,704</b>	<b>2,263</b>	<b>3,311</b>	<b>3,009</b>	<b>2,495</b>
Solid cattle manure	227	248	282	311	319	327	226	248	281	311	318	327	223	245	279	308	316	324
Solid swine manure	75	97	136	97	116	148	75	97	135	97	115	147	74	96	134	96	114	146
Solid poultry manure	87	80	67	101	92	74	87	80	67	101	92	74	87	80	67	101	92	74
Commercial and industrial waste	63	63	62	74	72	68	63	63	62	74	72	68	62	62	62	73	72	68
Organic municipal solid waste	26	59	117	70	96	141	26	59	117	70	95	140	24	57	115	68	94	138
<b>Digestible biomass residues</b>	<b>478</b>	<b>547</b>	<b>664</b>	<b>653</b>	<b>694</b>	<b>758</b>	<b>476</b>	<b>546</b>	<b>662</b>	<b>652</b>	<b>693</b>	<b>756</b>	<b>470</b>	<b>540</b>	<b>657</b>	<b>646</b>	<b>687</b>	<b>750</b>
<b>TOTAL</b>	<b>3,430</b>	<b>3,257</b>	<b>2,934</b>	<b>3,969</b>	<b>3,709</b>	<b>3,261</b>	<b>3,427</b>	<b>3,255</b>	<b>2,931</b>	<b>3,967</b>	<b>3,706</b>	<b>3,258</b>	<b>3,417</b>	<b>3,244</b>	<b>2,920</b>	<b>3,956</b>	<b>3,696</b>	<b>3,245</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.90 by the respective feedstock-specific biomass potential from Table 35, column 13. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.100: GHG Mitigation Potentials, 2050, Scenario Max 2**

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	1,218	1,111	899	1,390	1,254	991	1,218	1,110	899	1,389	1,254	990	1,217	1,109	898	1,388	1,252	989
Forestry residues	4,412	3,999	3,189	5,004	4,494	3,505	4,410	3,998	3,188	5,003	4,493	3,504	4,406	3,993	3,183	4,998	4,488	3,499
Open-country biomass residues	715	671	585	786	731	623	715	671	585	786	731	623	714	671	585	785	730	623
Industrial wood waste	-	-	104	-	-	199	-	-	104	-	-	199	-	-	103	-	-	198
Wood in municipal solid waste	769	719	621	841	779	659	769	719	621	841	779	659	768	718	620	840	778	658
Green waste: Compensation areas	199	181	146	230	207	163	198	181	146	230	207	163	198	180	146	230	207	163
Biomass: Habitat-connectivity areas	622	584	509	684	636	542	622	584	509	684	636	542	622	584	509	684	635	542
Green waste: Extensive grassland	922	866	755	1,014	942	804	922	865	755	1,014	942	804	921	865	754	1,013	941	803
Short-rotation coppice: Erosion areas	-	-	-	-	-	25	-	-	-	-	-	24	-	-	-	-	-	21
<b>Solid biomass residues = TOTAL</b>	<b>8,857</b>	<b>8,131</b>	<b>6,809</b>	<b>9,949</b>	<b>9,044</b>	<b>7,511</b>	<b>8,854</b>	<b>8,128</b>	<b>6,807</b>	<b>9,947</b>	<b>9,042</b>	<b>7,508</b>	<b>8,845</b>	<b>8,119</b>	<b>6,796</b>	<b>9,938</b>	<b>9,033</b>	<b>7,495</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.91 by the respective feedstock-specific biomass potential from Table 36, column 3. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).



**Table A.101: GHG Mitigation Potentials, 2050, Scenario *Med 2***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	812	741	600	927	836	660	812	740	599	926	836	660	811	739	598	925	835	659
Forestry residues	2,941	2,666	2,126	3,336	2,996	2,337	2,940	2,665	2,125	3,335	2,995	2,336	2,936	2,661	2,121	3,331	2,991	2,332
Open-country biomass residues	477	447	390	524	487	415	477	447	390	524	487	415	476	447	390	524	487	415
Industrial wood waste	-	-	70	-	-	133	-	-	69	-	-	133	-	-	68	-	-	131
Wood in municipal solid waste	513	479	414	561	519	439	512	479	414	560	519	439	512	479	413	560	519	439
Green waste: Compensation areas	132	121	97	154	138	109	132	120	97	153	138	108	132	120	97	153	138	108
Biomass: Habitat-connectivity areas	415	389	340	456	424	362	415	389	339	456	424	361	414	389	339	456	423	361
Green waste: Extensive grassland	615	577	503	676	628	536	615	577	503	676	628	536	614	576	502	675	627	535
Short-rotation coppice: Erosion areas	-	-	-	-	-	17	-	-	-	-	-	16	-	-	-	-	-	14
<b>Solid biomass residues = TOTAL</b>	<b>5,904</b>	<b>5,420</b>	<b>4,539</b>	<b>6,633</b>	<b>6,029</b>	<b>5,007</b>	<b>5,902</b>	<b>5,418</b>	<b>4,537</b>	<b>6,631</b>	<b>6,027</b>	<b>5,004</b>	<b>5,895</b>	<b>5,411</b>	<b>4,528</b>	<b>6,623</b>	<b>6,020</b>	<b>4,994</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.92 by the respective feedstock-specific biomass potential from Table 36, column 8. Values rounded.

Note that tables numbered without the leading “A.” refer to Teichmann (2014).

**Table A.102: GHG Mitigation Potentials, 2050, Scenario *Min 2***

	Small-scale pyrolysis units						Medium-scale pyrolysis units						Large-scale pyrolysis units					
	No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery			No process heat recovery			Process heat recovery		
	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas	Lignite	Hard coal	Natural gas
	kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a						kt CO <sub>2</sub> e/a					
<b>Feedstocks</b>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Cereal straw	541	494	400	618	557	440	541	493	399	617	557	440	540	492	398	616	556	439
Forestry residues	1,961	1,777	1,417	2,224	1,997	1,558	1,960	1,776	1,417	2,223	1,997	1,557	1,956	1,773	1,413	2,220	1,993	1,554
Open-country biomass residues	318	298	260	349	325	277	318	298	260	349	325	277	317	298	260	349	324	276
Industrial wood waste	-	-	46	-	-	89	-	-	46	-	-	88	-	-	45	-	-	87
Wood in municipal solid waste	342	319	276	374	346	293	342	319	276	374	346	293	341	319	275	373	346	292
Green waste: Compensation areas	88	80	65	102	92	72	88	80	65	102	92	72	88	80	65	102	92	72
Biomass: Habitat-connectivity areas	277	260	226	304	283	241	276	260	226	304	283	241	276	259	226	304	282	241
Green waste: Extensive grassland	410	385	335	451	419	357	410	385	335	450	419	357	409	384	335	450	418	357
Short-rotation coppice: Erosion areas	-	-	-	-	-	11	-	-	-	-	-	10	-	-	-	-	-	9
<b>Solid biomass residues = TOTAL</b>	<b>3,936</b>	<b>3,613</b>	<b>3,026</b>	<b>4,422</b>	<b>4,019</b>	<b>3,338</b>	<b>3,934</b>	<b>3,612</b>	<b>3,024</b>	<b>4,420</b>	<b>4,018</b>	<b>3,336</b>	<b>3,928</b>	<b>3,606</b>	<b>3,017</b>	<b>4,414</b>	<b>4,012</b>	<b>3,327</b>

Sources: Own calculation, multiplying the total net avoided GHG emissions from Table A.93 by the respective feedstock-specific biomass potential from Table 36, column 13. Values rounded.

Note that tables numbered without the leading "A." refer to Teichmann (2014).

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