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

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IMPRESSUM

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# Technical Greenhouse-Gas Mitigation Potentials of Biochar Soil Incorporation in Germany: Data Documentation[1]

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## Contents



## List of Tables

## List of Abbreviations

| | |
|---|---|
| a | Year |
| ad | Air dry |
| ap | As pyrolyzed |
| $B_o$ | Maximum methane producing capacity |
| C | Carbon |
| cal | Calorie |
| $CH_4$ | Methane |
| $CO_2$ | Carbon dioxide |
| $CO_2e$ | Carbon-dioxide equivalent |
| d | Day |
| D | Digestates |
| daf | Dry ash-free basis |
| db | Dry base |
| DDGS | Dry distiller's grains with solubles |
| DM | Dry mass |
| EF | Emission factor |
| FM | Fresh mass |
| FW | Fresh weight |
| g | Gram |
| GHG | Greenhouse gas |
| 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 |
| $m^3$ | Cubic meter |
| MCF | Methane conversion factor |
| min | Minute |
| MJ | Megajoule |
| mm | Millimeter |
| N | Nitrogen |
| n.a. | Not available |
| $N_2O$ | Nitrous oxide |
| $NH_3$ | Ammonia |
| $Nm^3$ | Standard cubic meter |
| $NO_x$ | Nitric oxides |
| oDM | Organic dry mass |
| P | Phosphorus |
| Pa | Pascal |
| PJ | Petajoule |
| psi | Pound-force per square inch |
| RW | Reaction water |
| t | Tonne |
| TJ | Terajoule |
| $T_{max}$ | Peak temperature |
| VM | Volatile matter |
| VS | Volatile solids |
| wt% | Weight percent |
| °C | Degree centigrade |
| - | Not applicable |

# 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)[2] 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.[3] This accompanying data documentation contains *(i)* the derivation and

[2] Any section without the leading "A." refers to Teichmann (2014).

[3] 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 digestable 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)[4] 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).[5] 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 digestable 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 digestable 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

[4] All tables numbered without the leading "A." refer to Teichmann (2014).

[5] 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.

digestable 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 perfomed 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).[6] 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.[7] 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)[8] 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).[9] 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).[10]

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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[6] 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 digestable energy crops (FNR 2012b).

[7] 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).

[8] 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).

[9] However, Knappe et al. (2007) use a different scenario from Fritsche et al. (2004a) than Teichmann (2014).

[10] The endorsement by SRU (2007) is based on the scenarios' respect of environmental policies and objectives.

generally described.[11] 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),[12] 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.[13] 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 digestable 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 digestable 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 digestable biomass residues are used directly for biochar production and for the case when only the solid biomass residues are used directly and the digestable biomass residues enter biochar production as digestates.[14]

[11] 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.
[12] Sometimes, it is even not stated whether the data refer to fresh weights or dry weights.
[13] The respective acreages in Zeddies et al. (2012) range from 0.9-9.4 million ha.
[14] 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

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

a) Fritsche et al. (2004a, "Umwelt" scenario).
b) Nitsch et al. (2004, "NaturschutzPlus" scenario).
c) Own calculation, based on the corresponding primary energy content, LHV and (**) water content.
d) Fritsche et al. (2004b).
e) 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.
f) Own calculation, based on 500,000 $t_{FW}$/a, 350,000 $t_{FW}$/a and 3,000,000 $t_{FW}$/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/$t_{DM}$ (at a water content of 30%).
s) Own calculation, based on the corresponding primary energy content and the LHV of 0.0000176 PJ/$t_{DM}$ used by Fritsche et al. (2004a).
t) Own calculation, based on the primary energy contents and the FW values of 2,610,600 $t_{FW}$/a (2010), 2,569,200 $t_{FW}$/a (2020) and 2,477,400 $t_{FW}$/a (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: Digestable Residues (Initial Feedstocks)

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

Table will be continued on the next page.

## Table A.2 continued

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

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) $Mt_{DM}$/a 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 $t_{DM}$/a of sewage sludge from the food and tobacco industries and 1/3 of the 375,000 $t_{DM}$/a 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 $t_{oDM}$/a) of the total sewage sludge from the food and tobacco industries (47,000 $t_{DM}$/a or 32,900 $t_{oDM}$/a) and 1/3 (87,500 $t_{oDM}$/a) of the total sewage sludge from the paper, publishing and printing industry (375,000 $t_{DM}$/a or 262,500 $t_{oDM}$/a) (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 $kt_{oDM}$/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: Digestable Residues (Digestates)

| Feedstocks* | Biogas[a] | | | | | Digestates: Dry mass[b] (Digestates: Organic dry mass)[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | 2050 | 2010 | 2020 | 2030 | 2040 | 2050 |
| | $t_{DM}/a$ | | | | | $kt_{DM}/a$ ($kt_{oDM}/a$) | | | | |
| **Sewage sludge** | **296,528** | **345,139** | **369,444** | **369,444** | **369,444** | **522 (277)** | **576 (300)** | **595 (306)** | **595 (306)** | **595 (306)** |
| 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) |
| **Solid manure** | **1,391,263** | **1,429,490** | **1,420,190** | **1,439,921** | **1,439,921** | **5,392 (4,001)** | **5,501 (4,077)** | **5,422 (4,013)** | **5,507 (4,077)** | **5,507 (4,077)** |
| 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) |
| **Liquid manure** | **2,823,320** | **2,858,010** | **2,789,532** | **2,837,857** | **2,837,857** | **6,235 (4,498)** | **6,317 (4,558)** | **6,177 (4,458)** | **6,285 (4,536)** | **6,285 (4,536)** |
| 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) |
| **Sugar-beet leaf and potato haulm** | **413,194** | **412,222** | **402,500** | **402,500** | **402,500** | **489 (286)** | **490 (287)** | **482 (283)** | **482 (283)** | **482 (283)** |
| 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[a] | | | | | Digestates: Dry mass[b] (Digestates: Organic dry mass)[c] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | 2050 | 2010 | 2020 | 2030 | 2040 | 2050 |
| | $t_{DM}$/a | | | | | $kt_{DM}$/a ($kt_{oDM}$/a) | | | | |
| **Commercial and industrial waste** | **301,389** | **301,389** | **301,389** | **301,389** | **301,389** | **293 (219)** | **293 (219)** | **293 (219)** | **293 (219)** | **293 (219)** |
| 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) |
| **Organic municipal solid waste** | **753,472** | **865,278** | **904,167** | **972,222** | **1,020,833** | **1,160 (682)** | **1,332 (783)** | **1,392 (818)** | **1,497 (880)** | **1,572 (924)** |
| 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) |
| **Digestates** | - | - | - | - | - | **14,091** | **14,509** | **14,361** | **14,660** | **14,735** |

Values rounded.

*Sources:*

a) Own calculation, based on the energy contents from Table A.2, the biogas heating value of 21.6 MJ/$m^3$ (Fritsche et al. 2004a) and the average dry mass captured in biogas of 1.05 kg/$m^3$ (Reinhold 2005).
b) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in $t_{DM}$/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 $t_{DM}$/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 (PJ/a) | | | | | Acreage (Million ha) | | | | | Initial feedstocks: Dry mass (Initial feedstocks: Organic dry mass) ($kt_{DM}$/a ($kt_{oDM}$/a)) | | | | | Yield ($t_{DM}$/ha ($m^3/t_{oDM}$)) | oDM content (% DM) | DM content (% FW) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | 2050 | 2010 | 2020 | 2030 | 2040 | 2050 | 2010 | 2020 | 2030 | 2040 | 2050 | | | |
| **Total** | - | - | - | - | - | **2.1[c]** | **2.1[d]** | **2.1[d]** | **3.1[b]** | **4.2[a, b]** | - | - | - | - | - | - | - | - |
| Corn silage for biogas[**] | 113[h] | 113[h] | 113[h] | 125[h] | 125[a] | 0.9[c] | 0.9[e] | 0.9[e] | 1.0[f] | 1.0[a] | 9,082[k] (8,174[j]) | 9,082[k] (8,174[j]) | 9,082[k] (8,174[j]) | 10,047[k] (9,042[j]) | 10,047[k] (9,042[j]) | (640[i]) | 90[i] | 32.5[i] |
| Short-rotation coppice | n.a. | n.a. | n.a. | n.a. | 175[a] | 0.006[c] | n.a. | n.a. | n.a. | 0.9[a] | 60[g] | n.a. | n.a. | n.a. | 9,000[g] | 10[b] | n.a. | n.a. |
| (Mainly) Rape-seed for biofuels | n.a. | n.a. | n.a. | n.a. | 300[a] | 1.15[c] | n.a. | n.a. | n.a. | 2.3[a] | 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/$m^3$ (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 digestable energy crops.

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

| Feedstock | Biogas[a] ($t_{DM}$/a) | | | | | Digestates: Dry mass[b] (Digestates: Organic dry mass)[c] ($kt_{DM}$/a ($kt_{oDM}$/a)) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2010 | 2020 | 2030 | 2040 | 2050 | 2010 | 2020 | 2030 | 2040 | 2050 |
| 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/$m^3$ (Fritsche et al. 2004a) and the average dry mass captured in biogas of 1.05 kg/$m^3$ (Reinhold 2005).
b) Own calculation, based on the procedure given in Reinhold (2005), i.e. deducting the biogas in $t_{DM}$/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 $t_{DM}$/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 | | | | | % | | | | |
| *Nitsch et al. (2004, “NaturschutzPlus” scenario)* | | | | | | | | | | | |
| Total biomass residues[1] | | 677 | 696 | 705 | 715 | 724 | | | | | |
| Total biomas residues, adjusted[2] | (A) | 554 | 591.3 | 705 | 715 | 724 | | | | | |
| Actual 2010 energy provision[3] | (B) | 500 | 500 | 500 | 500 | 500 | | | | | |
| Remaining biomass residues, i.e. (C) = (A) – (B) | (C) | **54** | **91.3** | **205** | **215** | **224** | ➔ Assumed maximum biomass potentials for biochar | | | | |
| *Teichmann (2014)* | | | | | | | | | | | |
| Solid biomass residues[4] | (D) | 298.9 | 335.4 | 463.5 | 471.8 | 478.8 | **18.07** | **27.22** | **44.23** | **45.57** | **46.78** |
| Digestable biomass residues[5] | (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 | **12.80** | **19.71** | **34.70** | **35.72** | **36.73** |

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,[15] without ash removal from the initial biomass and without activation of the biochars.[16] 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.[17] 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 deducted 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),[18] 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.

[15] With some exceptions when elevated pressures did not have apparent impacts on the results (cp. Table A.7).
[16] 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).
[17] 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).
[18] 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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Wa-ter | HHV | $T_{max}$ | Resi-dence time** | Heating rate | Char | Li-quid | Gas | Fixed C | Ash | C | N | P | K | HHV | C reco-very | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| ***CEREAL STRAW*** | | | | | | | | | | | | | | | | | | | | | | |
| 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$_{daf}$ (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. | 14.44 MJ/Nm$^3$ (LHV) | n.a. | b |
| | | | | | | 500 | | | ~34 | ~13.5 | ~52.5 | | | | | | | | | n.a. | | |
| | | | | | | 550 | | | ~32 | ~5.5 | ~62.5 | | 16.17 | 75.08 | 0.81 | | 2.17 | | 50.4 | n.a. | | |
| | | | | | | 600 | | | ~32.5 | ~5.0 | ~62.5 | | n.a. | n.a. | n.a. | | n.a. | | n.a. | 14.97 MJ/Nm$^3$ (LHV) | | |
| Wheat straw (*Triticum aestivum*) | 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. | 50.5 | n.a. | n.a. | c |
| | | | | | | 460 | | | n.a. | | | | 12.0 | 72.4 | 1.07 | | | | n.a. | | | |
| | | | | | | 525 | | | | | | | 12.7 | 74.4 | 1.04 | | | | | | | |
| 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. | d |
| Wheat straw (Danish) | 43.6 | 0.3 | 5.25 | 6.54¿ 7%$_{DM}$ | 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. | e |
| | | | | | | ~500 | | | ~31 | ~44 | ~21 | | | | | | | | | | | |
| | | | | | | ~575 | | | ~28 | ~44 | ~24 | | | 64.27 | 0.48 | | | | 41.3 | | | |
| | | | | | | ~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. | f |
| | 45.4 | 0.33 | 7.1 | 9.4 | 18.5 | | | | | | | | | | | | | | | | | |
| Wheat straw | 56.2£ 52.9$_{FW}$ | 0.43£ 0.4$_{FW}$ | 7.3£ 6.9$_{FW}$ | 5.9 | 19.7$_{FW}$ | 400 | ≥30 | 7 | n.a. ~28.5$_{daf}$ | Oil: ~14.8§ ~16.0$_{daf}$ | ~31.1§ ~33.5$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 30.88 | i |
| | | | | | | 500 | | | n.a. ~26.5$_{daf}$ | Oil: 17.7§ 19.1$_{daf}$ | ~28.7§ ~31$_{daf}$ | | | | | | | | | | 32.69 | |
| | | | | | | 600 | | | n.a. ~25.0$_{daf}$ | Oil: ~16.7§ ~18.0$_{daf}$ | ~30.1§ ~32.5$_{daf}$ | | | | | | | | | | 32.74 | |
| | | | | | | 700 | | | n.a. ~23.0$_{daf}$ | Oil: ~13.9§ ~15.0$_{daf}$ | ~36.2§ ~39.0$_{daf}$ | | | | | | | | | | 33.19 | |

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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m³ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Wheat straw | 40.8 | 0.178 | n.a. | n.a. | 16.24 | 500 | ~125 | 12 | 32[#] | 11[#] | 57[#] | n.a. | n.a. | 71.18[#] | 0.250[#] | n.a. | n.a. | 24.67[#] | 55.8[#] | 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[£] $48.5_{FW}$ | 0.43[£] $0.4_{FW}$ | 18.5[£] $17.3_{FW}$ | 6.7 | $17.0_{FW}$ | 400 | ≥30 | 7 | n.a. $\sim30_{daf}$ | Oil: ~12.6[§] $\sim15.5_{daf}$ | ~24.5[§] $\sim30_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 26.13 | i |
| | | | | | | 500 | | | n.a. $\sim27_{daf}$ | Oil: ~15.5[§] $\sim19.0_{daf}$ | ~25.3[§] $\sim31_{daf}$ | | | | | | | | | | 26.94 | |
| | | | | | | 600 | | | n.a. $\sim25_{daf}$ | Oil: 16.5[§] $20.3_{daf}$ | ~26.1[§] $\sim32_{daf}$ | | | | | | | | | | 27.09 | |
| | | | | | | 700 | | | n.a. $\sim24_{daf}$ | Oil: ~13.9[§] $\sim17.0_{daf}$ | ~28.5[§] $\sim35_{daf}$ | | | | | | | | | | 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 |
| **Mean*****, 1** | **46.6** | **0.47** | **6.9** | **7.9** | **17.92** | **520** | **-** | **-** | **33.8** | **20.8** | **38.9** | **n.a.** | **13.8** | **70.3** | **0.65** | **n.a.** | **2.17** | **24.67** | **49.5** | **n.a.** | **29.57** | **-** |
| ***FORESTRY RESIDUES*** | | | | | | | | | | | | | | | | | | | | | | |
| 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 (*Quercus spec*) | 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 (*Quercus robur*) | 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. | l |
| | | | | | | 600 | | | 17.6 | | | | | 90.0 | | | | | 34.4 | | | |
| Oak wood (*Quercus spp*) | 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. | 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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$**** | $MJ/m^3$ | 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 (*Fagus sylvatica*) | 46.1 | 0.00 | 0.72 | ~10 | 18.42 | 350 | 32 | n.a. | 36.3¶ | 40.3¶ | 11.9¶ | 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¶¶ | 53.3¶¶ | 12.1¶¶ | | | | | | | | | | | |
| | | | | | | Stages<br>1: 280<br>2: 350 | Stages<br>1: 32<br>2: 32 | n.a. | 47.5¶ | 36.4¶ | 15.2¶ | | | | | | | | | | | |
| | | | | | | Stages<br>1: 200<br>2: 280<br>3: 350 | Stages<br>1: 60<br>2: 60<br>3: 30 | Stages<br>1: -<br>2: 4<br>3: 2 | 30.6¶¶ | 49.6¶¶ | 12.2¶¶ | | | | | | | | | | | |
| 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 (*Picea abies*) | 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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$**** | $MJ/m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Spruce wood (*Picea abies*) | 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 (*Picea abies*) | 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. | 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 (*Pinus silvestrus*) | 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§ 48.2$_{daf}$ | 0.1§ 0.1$_{daf}$ | 0.86£ 0.8$_{FW}$ | 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 | | | | | | | | | | | |

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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/$m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Pine wood (*Pinus ponderosa*) | 50.9§ 51.2$_{daf}$ | n.a. | 0.54 | n.a. | n.a. | 350 | 60 | n.a. | 26.8 | n.a. | n.a. | n.a. | n.a. | 76.2$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | o |
| | | | | | | | 480 | | 21.1 | | | | | 69.8$_{daf}$ | | | | | | | | |
| | | | | | | 400 | 60 | | 22.5 | | | | | 77.4$_{daf}$ | | | | | | | | |
| | | | | | | | 480 | | 13.9 | | | | | 79.4$_{daf}$ | | | | | | | | |
| | | | | | | 500 | 60 | | 11.2 | | | | | 84.0$_{daf}$ | | | | | | | | |
| 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. | 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. | |
| 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 | 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 | | | | | |
| 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§ 77.85$_{daf}$ | 1.13§ 1.16$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | q |
| | | | | | | 500 | | | 26.1 | | | | 2.80 | 79.4§ 81.67$_{daf}$ | 1.08§ 1.11$_{daf}$ | | | | | | | |
| | | | | | | 600 | | | 20.4 | | | | 2.76 | 83.0§ 85.36$_{daf}$ | 0.95§ 0.98$_{daf}$ | | | | | | | |
| | | | | | | 700 | | | 14.0 | | | | 2.20 | 84.6§ 86.51$_{daf}$ | 1.1§ 1.13$_{daf}$ | | | | | | | |

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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time$^{**}$ | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%$^{*}$ | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$$^{***, ****}$ | | | wt%$^{****}$ | | | | | | MJ/kg$^{****}$ | %$_{db}$$^{****}$ | MJ/m$^{3}$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Pine needles (*Pinus ponderosa*) | n.a. | n.a. | n.a. | n.a. | 21.54$^{\$}$ | 400 | 10 | 200 | 37.0 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 27.58$^{\$}$ | n.a. | 17.99$^{\$}$ MJ/kg | | r |
| Pine bark (*Pinus ponderosa*) | 49.6$^{\S}$ 51.3$_{daf}$ | n.a. | 3.23 | n.a. | n.a. | 350 | 60 | n.a. | 44.5 | n.a. | n.a. | n.a. | n.a. | 68.3$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | o |
| | | | | | | | 480 | | 33.3 | | | | | 68.5$_{daf}$ | | | | | | | | |
| | | | | | | 400 | 480 | | 28.7 | | | | | 80.8$_{daf}$ | | | | | | | | |
| **Mean$^{*****, 2}$** | **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** | **-** |
| ***ADDITIONAL FORESTRY RESIDUES FROM HISTORICAL-FOREST FORMATION*** | | | | | | | | | | | | | | | | | | | | | | |
| Oak wood (*Quercus spec*) | 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 (*Quercus robur*) | 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. | l |
| | | | | | | 600 | | | 17.6 | | | | | 90.0 | | | | | 34.4 | | | |
| Oak wood (*Quercus spp*) | 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. | 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. | 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 | | | |

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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$**** | $MJ/m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Beech wood (*Fagus sylvatica*) | 46.1 | 0.00 | 0.72 | ~10 | 18.42 | 350 | 32 | n.a. | 36.3¶ | 40.3¶ | 11.9¶ | 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¶¶ | 53.3¶¶ | 12.1¶¶ | | | | | | | | | | | |
| | | | | | | Stages 1: 280 2: 350 | Stages 1: 32 2: 32 | n.a. | 47.5¶ | 36.4¶ | 15.2¶ | | | | | | | | | | | |
| | | | | | | Stages 1: 200 2: 280 3: 350 | Stages 1: 60 2: 60 3: 30 | Stages 1: - 2: 4 3: 2 | 30.6¶¶ | 49.6¶¶ | 12.2¶¶ | | | | | | | | | | | |
| 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 (*Alnus incana*) | 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 (*Betula pubescens*) | 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 | | | | | | | | | |
| **Mean*****, 3** | **47.9** | **0.18** | **0.6** | **10** | **19.06** | **460** | **-** | **-** | **29.2** | **42.7** | **24.4** | **71.7** | **1.5** | **82.9** | **0.18** | **0.002** | **0.16** | **30.68** | **41.8** | **n.a.** | **n.a.** | **-** |
| ***OPEN-COUNTRY BIOMASS RESIDUES*** | | | | | | | | | | | | | | | | | | | | | | |
| *Herbaceous biomass*[4] | 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. | - |
| *Woody biomass*[5] | 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 | - |
| **Mean**[6] | **46.5** | **0.74** | **4.6** | **7.8** | **18.73** | **472** | **-** | **-** | **31.5** | **46.6** | **23.3** | **66.5** | **12.4** | **69.3** | **0.68** | **0.002** | **0.13** | **29.76** | **45.5** | **n.a.** | **23.00** | **-** |
| ***INDUSTRIAL WOOD WASTE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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: Elements C | Feedstock characteristics: Elements N | Feedstock characteristics: Ash | Feedstock characteristics: Water | Feedstock characteristics: HHV | Process conditions: $T_{max}$ | Process conditions: Residence time** | Process conditions: Heating rate | Product distribution: Char | Product distribution: Liquid | Product distribution: Gas | Biochar characteristics: Fixed C | Biochar characteristics: Ash | Biochar characteristics: Elements C | Biochar characteristics: Elements N | Biochar characteristics: Elements P | Biochar characteristics: Elements K | Biochar characteristics: HHV | Biochar characteristics: C recovery | Gas: Energy content | Bio-oil: HHV | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$**** | $MJ/m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Oak wood (*Quercus spec*) | 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 (*Quercus robur*) | 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. | l |
| | | | | | | 600 | | | 17.6 | | | | | 90.0 | | | | | 34.4 | | | |
| Oak wood (*Quercus spp*) | 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. | 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. | 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 sawdust | 45.7§ $45.9_{daf}$ | 0.2§ $0.2_{daf}$ | 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. | 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. | 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 (*Fagus sylvatica*) | 46.1 | 0.00 | 0.72 | ~10 | 18.42 | 350 | 32 | n.a. | 36.3¶ | 40.3¶ | 11.9¶ | 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¶¶ | 53.3¶¶ | 12.1¶¶ | | | | | | | | | | | |
| | | | | | | Stages 1: 280 2: 350 | Stages 1: 32 2: 32 | n.a. | 47.5¶ | 36.4¶ | 15.2¶ | | | | | | | | | | | |
| | | | | | | Stages 1: 200 2: 280 3: 350 | Stages 1: 60 2: 60 3: 30 | Stages 1: - 2: 4 3: 2 | 30.6¶¶ | 49.6¶¶ | 12.2¶¶ | | | | | | | | | | | |

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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***,**** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | 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 (*Picea abies*) | 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 (*Picea abies*) | 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 (*Pinus ponderosa*) | 50.9§ 51.2$_{daf}$ | n.a. | 0.54 | n.a. | n.a. | 350 | 60 | n.a. | 26.8 | n.a. | n.a. | n.a. | n.a. | 76.2$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | o |
| | | | | | | | 480 | | 21.1 | | | | | 69.8$_{daf}$ | | | | | | | | |
| | | | | | | 400 | 60 | | 22.5 | | | | | 77.4$_{daf}$ | | | | | | | | |
| | | | | | | | 480 | | 13.9 | | | | | 79.4$_{daf}$ | | | | | | | | |
| | | | | | | 500 | 60 | | 11.2 | | | | | 84.0$_{daf}$ | | | | | | | | |
| 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. | 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 | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements | | | | HHV | C recovery | Energy content | HHV | |
| | C | N | | | | | | | | | | | | C | N | P | K | | | | | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Pine wood (*Pinus silvestrus*) | 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§ 48.2$_{daf}$ | 0.1§ 0.1$_{daf}$ | 0.86£ 0.8$_{FW}$ | 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: Elements C | Elements N | Ash | Water | HHV | Process conditions: $T_{max}$ | Residence time** | Heating rate | Product distribution: Char | Liquid | Gas | Biochar characteristics: Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Gas: Energy content | Bio-oil: HHV | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | wt%db | | | wt%* | MJ/kgdb | °C | min | °C/min | wt%db***, **** | | | wt%**** | | | | | | MJ/kg**** | %db**** | $MJ/m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Pine bark (*Pinus ponderosa*) | 49.6§<br>51.3 (daf) | n.a. | 3.23 | n.a. | n.a. | 350 | 60 | n.a. | 44.5 | n.a. | n.a. | n.a. | n.a. | 68.3 (daf) | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | o |
| | | | | | | | 480 | | 33.3 | | | | | 68.5 (daf) | | | | | | | | |
| | | | | | | 400 | 480 | | 28.7 | | | | | 80.8 (daf) | | | | | | | | |
| **Mean*****, 7** | **48.5** | **0.13** | **0.8** | **8.1** | **19.34** | **463** | **-** | **-** | **29.1** | **46.3** | **23.6** | **69.2** | **2.0** | **82.5** | **0.16** | **0.002** | **0.13** | **30.30** | **46.5** | **n.a.** | **23.00** | **-** |
| ***WOOD IN MUNICIPAL SOLID WASTE*** | | | | | | | | | | | | | | | | | | | | | | |
| **Mean5** | **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** | **-** |
| ***GREEN WASTE: COMPENSATION AREAS*** | | | | | | | | | | | | | | | | | | | | | | |
| 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 (*Lolium perenne*) | 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 leaves8 | 41.7§<br>44.5 (daf) | 1.4§<br>1.54 (daf) | ~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 (*Festuca arundinacea*) | 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§<br>77.3 (daf) | 1.04§<br>1.24 (daf) | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | w |
| | | | | | | 500 | | | 31.4 | | | 64.3 | 15.4 | 69.5§<br>82.2 (daf) | 0.92§<br>1.09 (daf) | | | | | | | |
| | | | | | | 600 | | | 29.8 | | | 67.6 | 18.9 | 72.2§<br>89.0 (daf) | 0.80§<br>0.99 (daf) | | | | | | | |
| | | | | | | 700 | | | 28.8 | | | 71.6 | 19.3 | 76.0§<br>94.2 (daf) | 0.56§<br>0.70 (daf) | | | | | | | |
| **Mean*****, 9** | **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.** | **-** |

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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| ***BIOMASS: HABITAT-CONNECTIVITY AREAS*** | | | | | | | | | | | | | | | | | | | | | | |
| *Woody*[5] | 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*[4] | 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. | - |
| **Mean[10]** | **46.5** | **0.74** | **4.6** | **7.8** | **18.73** | **472** | **-** | **-** | **31.5** | **46.6** | **23.3** | **66.5** | **12.4** | **69.3** | **0.68** | **0.002** | **0.13** | **29.76** | **45.5** | **n.a.** | **23.00** | **-** |
| ***GREEN WASTE: EXTENSIVE GRASSLAND*** | | | | | | | | | | | | | | | | | | | | | | |
| **Mean[11]** | **46.5** | **0.74** | **4.6** | **7.8** | **18.73** | **472** | **-** | **-** | **31.5** | **46.6** | **23.3** | **66.5** | **12.4** | **69.3** | **0.68** | **0.002** | **0.13** | **29.76** | **45.5** | **n.a.** | **23.00** | **-** |
| ***SHORT-ROTATION COPPICE: EROSION AREAS*** | | | | | | | | | | | | | | | | | | | | | | |
| 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§<br>47.8$_{daf}$ | 0.30§<br>0.30$_{daf}$ | 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 (*Populus tremula*) | 46.1 | 0.64 | 1.1 | 28 | n.a. | 400<br>460<br>525 | 600 | 8 K/min | 32<br>n.a. | n.a. | n.a. | n.a. | 3.5<br>5.7<br>6.8 | 67.3<br>70.0<br>77.9 | 0.78<br>0.95<br>1.07 | n.a. | n.a. | n.a. | 46.7<br>n.a. | n.a. | n.a. | c |
| Poplar wood (*Populus ssp*) | n.a. | n.a. | n.a. | n.a. | 19.33$ | 400 | 10 | 200 | 21.7 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | 29.83$ | n.a. | 16.42$ MJ/kg | | r |
| Poplar wood | 49.6§<br>49.9$_{daf}$ | n.a. | 0.53 | n.a. | n.a. | 350<br><br>400<br>500 | 60<br>480<br>60<br>60 | n.a. | 27.1<br>20.4<br>22.9<br>16.0 | n.a. | n.a. | n.a. | n.a. | 76.2$_{daf}$<br>75.6$_{daf}$<br>79.1$_{daf}$<br>86.6$_{daf}$ | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | x |
| Poplar wood (*Populus alba*) | 47.4 | 0.00 | 1.05 | ~54 (fresh) | 18.815 | Stages<br>1: 280<br>2: 335 | Stages<br>1: 30<br>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 |
| **Mean*****, 12** | **47.5** | **0.38** | **1.3** | **17.9** | **19.30** | **421** | **-** | **-** | **25.1** | **n.a.** | **n.a.** | **n.a.** | **5.3** | **71.7** | **0.93** | **n.a.** | **n.a.** | **29.83** | **46.7** | **16.42** | | **-** |

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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| ***DIGESTATES*** | | | | | | | | | | | | | | | | | | | | | | |
| 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. | cc |
| | | | | | | 400 | | | 28.5 | | | | | n.a. | n.a. | | | | n.a. | | | |
| | | | | | | 500 | | | 27.3 | | | | | 9.8 | 2.1 | | | | 7.1 | | | |
| | | | | | | 400 | 60 | | 25.5 | | | | | n.a. | n.a. | | | | n.a. | | | |
| | | | | | | 500 | | | 27.0 | | | | | | | | | | | | | |
| | | | | | | 400 | 90 | | 27.5 | | | | | | | | | | | | | |
| | | | | | | 500 | | | 31.0 | | | | | | | | | | | | | |
| 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$^F$ VM$_{db}$: 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$^F$ VM$_{db}$: 18.4 | 58.0 | 29.9 | 3.2 | n.a. | n.a. | 11.533 | 38.9 | ~17.5 | 28.054 (organic fraction) | |
| | | | | | | 650 | n.a. | 5 | ~45 | ~40.5 (organic fraction: ~2/3) | ~14.5 | 27.8$^F$ VM$_{db}$: 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$^F$ VM$_{db}$: 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 (dewa-tered) | 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) (anaerobially digested) | n.a. | n.a. | n.a. | 70 (dewa-tered) | 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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| Sewage sludge (urban) (anaerobically digested) | 35.0$^{£}$ 32.3$_{ad}$ | 3.54$^{£}$ 3.27$_{ad}$ | 36.8$^{£}$ 34$_{ad}$ | 7.6 (ad) | n.a. | 400 | n.a. | 10 | 68.9$^{£}$ 63.7$_{ad}$ | n.a. | n.a. | 7.1$^{¥}$ 6.8$_{FM}$ | 66.1$^{¥}$ 63.3$_{FM}$ | 21.1$^{¥}$ 20.2$_{FM}$ | 2.51$^{¥}$ 2.40$_{FM}$ | n.a. | n.a. | n.a. | 41.5 | n.a. | n.a. | ee |
| | | | | | | 500 | | | 62.7$^{£}$ 57.9$_{ad}$ | | | 7.9$^{¥}$ 7.6$_{FM}$ | 70.7$^{¥}$ 68.2$_{FM}$ | 21.0$^{¥}$ 20.3$_{FM}$ | 2.21$^{¥}$ 2.13$_{FM}$ | | | | 37.6 | | | |
| | | | | | | 700 | | | 56.7$^{£}$ 52.4$_{ad}$ | | | 8.6$^{¥}$ 8.3$_{FM}$ | 75.1$^{¥}$ 72.5$_{FM}$ | 21.1$^{¥}$ 20.4$_{FM}$ | 1.24$^{¥}$ 1.20$_{FM}$ | | | | 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 | | | | | |
| **Mean*****, 13** | **36.8** | **5.59** | **28.6** | **85.3** | **16.78** | **491** | **-** | **-** | **49.4** | **32.9** | **9.5** | **28.2** | **38.8** | **42.3** | **2.57** | **0.68** | **1.04** | **11.60** | **28.9** | **21.13** | **31.85** | **-** |
| ***SEWAGE SLUDGE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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‡ 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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$**** | $MJ/m^3$ | 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 | | | |
| **Mean*****, 14** | **35.5** | **3.97** | **33.7** | **79.5** | **17.02** | **491** | **-** | **-** | **49.3** | **32.3** | **9.7** | **24.3** | **40.3** | **34.9** | **4.40** | **5.60** | **n.a.** | **17.50** | **45.8** | **n.a.** | **33.50** | **-** |
| ***SOLID CATTLE MANURE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | |
| **Mean*****, 15** | **40.3** | **2.42** | **16.9** | **63.6** | **17.33** | **488** | **-** | **-** | **46.7** | **n.a.** | **n.a.** | **33.6** | **34.7** | **50.9** | **1.82** | **0.87** | **3.58** | **18.81** | **55.4** | **n.a.** | **n.a.** | **-** |
| ***SOLID SWINE MANURE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | Elements | | | | | | | | |
| | C | N | Ash | Water | HHV | $T_{max}$ | Residence time[**] | Heating rate | Char | Liquid | Gas | Fixed C | Ash | C | N | P | K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%[*] | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$[***, ****] | | | wt%[****] | | | | | | MJ/kg[****] | $\%_{db}$[****] | $MJ/m^3$ | 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[†] | n.a. | n.a. | 41.2 | 44.7 | 50.7 | 3.26 | 7.15 | 2.56 | 18.3 | ~48 | 29.5 MJ/S $m^3$ | n.a. | u |
| **Mean[*****, 15]** | **47.4** | **4.35** | **19.7** | **78.5** | **19.45** | **573** | **-** | **-** | **47.2** | **n.a.** | **n.a.** | **33.5** | **43.7** | **49.2** | **3.17** | **6.02** | **2.37** | **18.20** | **49.4** | **29.50** | **n.a.** | **-** |
| ***SOLID POULTRY MANURE*** | | | | | | | | | | | | | | | | | | | | | | |
| Chicken litter | 34.4 | 3.27 | 30.6 | 10.2 | 13.0 | 620 | 120 | 13 | ~46[†] | n.a. | n.a. | 30.8 | 53.2 | 41.5 | 2.77 | 1.72 | 6.77 | 13.5 | ~56 | 15.0 MJ/S $m^3$ | n.a. | u |
| Pelletized poultry litter (*Gallus domesticus*) | 36.2 | 4.1 | 24.4 | n.a. | n.a. | 350 | 60-180 | n.a. | 57 | n.a. | n.a. | 27.4[F] $VM_{db}$: 36.7 | 35.9 | 46.1 | 4.9 | 2.94 | n.a. | n.a. | 72.6 | n.a. | n.a. | jj |
| | | | | | | 700 | | | 36 | | | 33.5[F] $VM_{db}$: 14.1 | 52.4 | 44.0 | 2.8 | 4.28 | | | 43.8 | | | |
| Poultry litter (*Gallus domesticus*) | 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. | kk |
| | | | | | | 500 | | | ~29 | | | | | 39.2 | 3.09 | 3.59 | 5.86 | | 34.9 | | | |
| 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. | 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. | n.a. | 42.3 | 4.2 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | ll |
| Poultry litter | n.a. | 3.07 | 28.5 | 7.7 | n.a. | 350 | ~266[¢] | ~20 | 56.17 | 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[¢] | | 51.52 | | | | 56.62 | | 2.63 | 2.63 | 8.12 | | | | | |
| | | | | | | 450 | ~190[¢] | | 48.69 | | | | 58.66 | | 2.23 | 2.66 | 8.57 | | | | | |
| | | | | | | 500 | ~163[¢] | | 47.57 | | | | 60.58 | | 1.21 | 2.79 | 8.79 | | | | | |
| | | | | | | 550 | ~135[¢] | | 46.62 | | | | 60.65 | | 0.31 | 2.98 | 8.97 | | | | | |
| | | | | | | 600 | ~113[¢] | | 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 | 2.07 | 3.12 | 7.40 | 14.75 | 40.0 | | | |

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 | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements | | | | HHV | C recovery | Energy content | HHV | |
| | C | N | | | | | | | | | | | | C | N | P | K | | | | | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/$m^3$ | 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 | | | |
| **Mean[*****, 15]** | **35.6** | **3.59** | **21.9** | **13.4** | **14.53** | **500** | **-** | **-** | **44.1** | **38.6** | **18.8** | **24.2** | **42.9** | **46.1** | **3.12** | **2.76** | **5.85** | **15.42** | **57.3** | **15.0** | **n.a.** | **-** |
| ***LIQUID CATTLE AND SWINE MANURE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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[F] $VM_{db}$: 46.2 | 32.3 | 50.8 | 3.74 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | ll |
| **Mean[*****, 16]** | **45.8** | **3.13** | **14.8** | **90.2** | **17.62** | **444** | **-** | **-** | **45.0** | **n.a.** | **n.a.** | **28.5** | **41.6** | **43.9** | **2.31** | **0.89** | **2.26** | **19.94** | **54.2** | **n.a.** | **n.a.** | **-** |
| ***SUGAR-BEET LEAF AND POTATO HAULM*** | | | | | | | | | | | | | | | | | | | | | | |
| 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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | wt%$_{db}$ | | | wt%* | MJ/kg$_{db}$ | °C | min | °C/min | wt%$_{db}$***, **** | | | wt%**** | | | | | | MJ/kg**** | %$_{db}$**** | MJ/m$^3$ | 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 |
| **Mean******* | **43.0** | **1.33** | **25.0** | **84.0** | **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.** | **-** |
| ***COMMERCIAL AND INDUSTRIAL WASTE*** | | | | | | | | | | | | | | | | | | | | | | |
| 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$_{db}$: 43.9 | 11.3 | 67.4 | 7.4 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | ll |
| | | | | | | 400 | | | | | | 51.4 VM$_{db}$: 36.9 | 11.7 | 68.1 | 7.3 | | | | | | | |
| DDGS (from bioethanol production, from wheat, corn and triticale, pelletized) | 49.0 | 1.00 | 6.28 | 6.5 | 22.84 MJ/kg$_{daf}$ (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. | 3.66 MJ/Nm$^3$ (LHV) | n.a. | b |
| | | | | | | 500 | | | ~40 | ~21.5 | ~18.5 | | | | | | | | | n.a. | | |
| | | | | | | 550 | | | ~31 | ~17 | ~52 | | 23.6 | 64.39 | 1.00 | | 2.05 | | 40.7 | 3.84 MJ/Nm$^3$ (LHV) | | |
| 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. | 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. | qq |
| **Mean*****, 17** | **49.8** | **3.07** | **6.28** | **61.3** | **n.a.** | **438** | **-** | **-** | **37.0** | **20.3** | **29.3** | **48.1** | **17.6** | **66.1** | **4.18** | **n.a.** | **2.05** | **n.a.** | **40.7** | **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 C | Elements N | Ash | Water | HHV | $T_{max}$ | Residence time** | Heating rate | Char | Liquid | Gas | Fixed C | Ash | Elements C | Elements N | Elements P | Elements K | HHV | C recovery | Energy content | HHV | |
| | $wt\%_{db}$ | | | wt%* | $MJ/kg_{db}$ | °C | min | °C/min | $wt\%_{db}$ ***, **** | | | wt%**** | | | | | | MJ/kg**** | $\%_{db}$ **** | $MJ/m^3$ | MJ/kg | |
| | (3) | | | | | | | | (1) | | | | | (2) | | | | | (1)*(2)/(3) | | | |
| ***ORGANIC MUNICIPAL SOLID WASTE*** | | | | | | | | | | | | | | | | | | | | | | |
| Organic waste | n.a. | ~1.5& | 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. | 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. | 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. | 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. | 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. | 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. | n.a. | hh |
| Greenwaste | n.a. | ~1.2& | 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. | 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. | 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. | 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. | 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. | 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. | n.a. | ss |
| **Mean*****, 17** | **31.1** | **1.67** | **23.1** | **70.9** | **15.2** | **490** | **-** | **-** | **n.a.** | **n.a.** | **n.a.** | **44.6** | **23.0** | **63.3** | **2.14** | **0.53** | **2.36** | **n.a.** | **n.a.** | **n.a.** | **n.a.** | **-** |

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


*Notes:*

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

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 beddding.
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),[19] 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)[a] | (A) | 11.03 | 11.03 | 11.03 | 11.03 | 11.03 | 11.03 |
| Acreage balances[a] | (B) | - | 0.52 | 1.57 | 2.39 | 3.39[l] | 4.49[l] |
| Set-aside land | (C) | - | 0.25[b] | 0.25[c] | 0.25[c] | 0.25[c] | 0.25[c] |
| Correction[d] | (D) | - | 0.51 | - | - | - | - |
| **Arable land for food crops[e]** | (E) | **-** | **9.5[f]** | **9.21** | **8.39** | **7.39[f]** | **6.29[f]** |
| **Arable land for energy crops[g]** | (F) | **-** | **2.1** | **2.1** | **2.1** | **3.1** | **4.2** |
| **Set-aside land** | (G) | **-** | **0.25[b]** | **0.25[c]** | **0.25[c]** | **0.25[c]** | **0.25[c]** |
| **Erosion areas (short-rotation coppice)[h]** | (H) | **-** | **0[i]** | **0[i]** | **0.55** | **0.55** | **0.55** |
| **TOTAL[j]** | (I) | **-** | **11.85[b]** | **11.56** | **11.29** | **11.29[k]** | **11.29[k]** |

Values rounded.

*Sources:*

a) 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.
b) Statistisches Bundesamt (2013).
c) Own assumption, based on the 2010 value.
d) 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 (*).
e) Own calculation, (E) = (A) – (B) – (C) – (D).
f) Own calculation, (E) = (I) – (H) – (G) – (F).
g) See Table A.4.
h) 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.
i) Own assumption, see Table A.1, comment (*).
j) Own calculation, (I) = (E) + (F) + (G) + (H).
k) Own assumption, based on the 2030 value.
l) Own calculation, (B) = (A) – (C) – (D) – (E).

* The 2010 values will be used for 2015.

[19] 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 $CH_4$ and $N_2O$ 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 $CH_4$ emissions from manure management, Tables A.9-A.11 contain the data and calculations for the transformation of the $CH_4$ emissions per animal and year deductable from Dong et al. (2006) and UBA (2013) (Table A.10, column 6) into the $CH_4$ 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 $CO_2$ emissions from manure management necessary to calculate the carbon contents of the manures prior to soil addition.

Turning to the $N_2O$ emissions from manure management displayed in Teichmann (2014: Table 16), Table A.15 outlines the derivation of the emission factors for the direct $N_2O$ emissions and Table A.16 the derivation of the default fractions of manure N volatilizing as $NH_3$ and $NO_x$ required to calculate the indirect $N_2O$ emissions from manure management.

Finally, to derive the $N_2O$ 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 $N_2O$ 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**

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

Values rounded.

*Sources:*

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

## Table A.10: Annual $CH_4$ Emission Factors from Manure Management per Animal

| Feedstocks | Conventional feedstock management (see Teichmann 2014: Table 12) | Daily VS excretions[a] | | $B_o$[c] | MCF | | Annual EF per animal[h] |
|---|---|---|---|---|---|---|---|
| | | kg $VS_{oDM}$ animal$^{-1}$ d$^{-1}$ | | m$^3$ $CH_4$/kg $VS_{oDM}$ | % of $B_o$ | | kg $CH_4$ animal$^{-1}$ a$^{-1}$ |
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| Solid cattle manure | Solid storage, land spread | Dairy cattle: 3.99<br>Other cattle: 1.47 | 3.01[b] | 0.23 | Dairy cattle: 2.0[e]<br>Other cattle: 7.7[e] | 4.2[b] | **7.11** |
| Solid swine manure | Solid storage, land spread | 0.26 | | 0.30 | 8.0[e] | | **1.53** |
| Solid poultry manure | Solid storage, land spread | 0.026 | | 0.368[d] | 1.5[f] | | **0.04** |
| Liquid cattle manure | Liquid storage, land spread | Dairy cattle: 3.99<br>Other cattle: 1.47 | 3.01[b] | 0.23 | Dairy cattle: 14.4[g]<br>Other cattle: 13.6[g] | 14.1[b] | **23.87** |
| Liquid swine manure | Liquid storage, land spread | 0.26 | | 0.30 | 21.7[g] | | **4.14** |

Values rounded. VS = volatile solids (animal-specific). $B_o$ = 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 $EF = (VS \cdot 365 \text{ d/a}) (B_o \cdot 0.67 \text{ kg/m}^3 \cdot MCF/100)$ 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 $CH_4$ 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: $CH_4$ Emissions from Manure Management per Dry Tonne of Feedstock in Germany in 2000

| Feedstocks | Energy content of biogas[a] | Feedstock dry mass[a] | Total livestock population for energy production[b] | Manure per animal[c] | Total livestock population for energy production (split)[d] | Annual average livestock population for energy production[e] | Annual $CH_4$ emission factor per animal[f] | Total annual $CH_4$ emissions[g] | $CH_4$ emissions per $t_{DM}$ of feedstock[h] |
|---|---|---|---|---|---|---|---|---|---|
| | PJ/a | $kt_{DM}$/a | Million animals/a | $t_{DM}$/animal | Million animals/a | Million animals/a | kg $CH_4$ animal$^{-1}$ a$^{-1}$ | t $CH_4$/a | t $CH_4$/$t_{DM}$ feedstock |
| | (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 | **0.004** |
| Solid swine manure | 5.9 | 1,243 | 39.8 | 0.031 | 17.9 | 17.9 | 1.53 | 27,387 | **0.022** |
| Solid poultry manure | 7.2 | 1,028 | 527.3 | 0.002 | 527.3 | 96.6 | 0.04 | 3,864 | **0.004** |
| Liquid cattle manure | 44.5 | 7,482 | 6.6 | 1.134 | 4.0 | 4.0 | 23.87 | 95,480 | **0.013** |
| Liquid swine manure | 12.9 | 1,505 | 39.8 | 0.038 | 21.9 | 21.9 | 4.14 | 90,666 | **0.060** |

Values rounded. Note that the $CH_4$ emissions per $t_{DM}$ 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:*

a) Derivation as for the corresponding 2010-2030 values in Table A.2.

b) Table A.9 (column 3). Note that the total cattle (swine) population is entered for both solid and liquid manure.

c) Own calculation, based on the formula (4) = (2) · 1,000/((3) · 1,000,000).

d) 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 $t_{DM}$ (= 0.726 + 1.134) of solid and liquid manure is produced by a cow and 0.069 $t_{DM}$ (= 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.

e) 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.

f) Table A.10 (column 6).

g) Calculated as (8) = (6) · (7) · 1,000, i.e. adapted from equation 10.22 of Dong et al. (2006).

h) Own calculation, based on the formula (9) = (8)/((2) · 1,000).

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

| Feedstocks | Storage condition | $CH_4$ emissions | | $CO_2$ emissions | $CO_2:CH_4$ ratio[c] | Average $CO_2:CH_4$ ratio[d] |
|---|---|---|---|---|---|---|
| | | g $CH_4$/$kg_{DM}$ feedstock[a] | g $CO_2e$/$kg_{DM}$ feedstock[b] | g $CO_2$/$kg_{DM}$ feedstock[a] | | |
| | | (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:*

a) Pattey et al. (2005: Table 5).
b) Own calculation, multiplying the $CH_4$ emissions (column 1) by their 100-year GWP of 25 (Forster et al. 2007).
c) Own calculation, (4) = (3)/(2).
d) 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 | $CH_4$ emissions[a] | $CO_2$ emissions[b] | $CO_2:CH_4$ ratio[c] | |
|---|---|---|---|---|---|
| | | g $CO_2e$/(d · kg animal) | g $CO_2$/(d · kg animal) | | |
| | | (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:*

a) Laguë et al. (2005: Table 4); average $CH_4$ emissions; however, based on the 100-year GWP of 25 (Forster et al. 2007) instead of 21 as used by Laguë et al. (2005).
b) Laguë et al. (2005: Table 4); average $CO_2$ emissions.
c) Own calculation, where (3) = (2)/(1) and (4) gives the simple average over the values in column 3.

## Table A.14: $CO_2$ Emissions from Manure Management

| Feedstocks | Conventional feedstock management (Teichmann 2014: Table 12) | $CH_4$ emissions | | $CO_2$ emissions |
|---|---|---|---|---|
| | | t $CH_4$/$t_{DM}$ feedstock[a] | t $CO_2e$/$t_{DM}$ feedstock[c] | t $CO_2e$/$t_{DM}$ feedstock |
| | | (1) | (2) | (3) |
| Solid cattle manure | Solid storage, land spread | 0.004 | 0.100 | 0.332[d] |
| Solid swine manure | Solid storage, land spread | 0.022 | 0.550 | 0.332[f] |
| Solid poultry manure | Solid storage, land spread | 0.004 | 0.100 | 0.332[f] |
| Liquid cattle and swine manure | Liquid storage, land spread | 0.021[b] | 0.525 | 0.281[e] |

Values rounded.

*Sources:*

a) Table A.11 (column 9).
b) 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.
c) Own calculation, multiplying the $CH_4$ emissions (column 1) by their 100-year GWP of 25 (Forster et al. 2007).
d) Own calculation, using the average ratio of $CO_2$-to-$CH_4$ emissions from cattle manure under stockpile – 3.32 (Table A.12, column 5) –, i.e. (3) = (2) · 3.32.
e) Own calculation, using the weighted average of the average ratio of $CO_2$-to-$CH_4$ emissions from cattle manure under slurry storage – 0.54 (see Table A.12, column 5) – and the average ratio of $CO_2$-to-$CH_4$ 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).
f) Due to the lack of data for $CO_2$ emissions from solid swine and poultry manure, the same $CO_2$ emission factor was used as for solid cattle manure.

## Table A.15: Emission Factors for Direct $N_2O$ Emissions from Manure Management

| Feedstocks | Conventional feedstock management (see Teichmann 2014: Table 12) | Emission factor | | |
|---|---|---|---|---|
| | | kg $N_2O$-N/kg N | | kg $N_2O$/kg N[i] |
| | | (1) | (2) | (3) |
| Solid cattle manure | Solid storage, land spread | Dairy cattle: 0.01215[a]<br>Other cattle: 0.01202[b] | 0.0121[c] | 0.0190 |
| Solid swine manure | Solid storage, land spread | 0.01204[d] | | 0.0189 |
| Solid poultry manure | Solid storage, land spread | 0.001[e] | | 0.0016 |
| Liquid cattle manure | Liquid storage, land spread | Dairy cattle: 0.00303[f]<br>Other cattle: 0.00355[g] | 0.00323[c] | 0.0051 |
| Liquid swine manure | Liquid storage, land spread | 0.00322[h] | | 0.0051 |

Values rounded.

*Sources:*

a) 2009-2011 average from UBA (2013: Table 202, straw-based).
b) 2009-2011 average from UBA (2013: Table 203, straw-based).
c) 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.
d) 2009-2011 average from UBA (2013: Table 204, straw-based).
e) UBA (2013: Table 201).
f) 2009-2011 average from UBA (2013: Table 202, slurry-based).
g) 2009-2011 average from UBA (2013: Table 203, slurry-based).
h) 2009-2011 average from UBA (2013: Table 204, slurry-based).
i) Own calculation, transforming the values in column 2 using $N_2O = N_2O\text{-}N \cdot 44/28$ 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 $NH_3$ and $NO_x$

| Feedstocks | Conventional feedstock management (see Teichmann 2014: Table 12) | Manure-management system used as reference[a] | Fraction[a] | |
|---|---|---|---|---|
| | | | % | |
| 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[b] |
| Liquid swine manure | Liquid storage, land spread | Swine, liquid/slurry | 48 | |

Values rounded.

*Sources:*

a) Dong et al. (2006: Table 10.22).
b) 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* |
|---|---|---|
| | | % |
| 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 $N_2O$-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 $NH_3$ and $NO_x$ from Table A.16.

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

The study by Teichmann (2014) considers $CO_2$ 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 $CO_2$ 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 $CO_2$ 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 $CO_2$ 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 $CO_2$ 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**

| Biomass scenarios | | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | | km | | | | | km | | | | | km | | | | |
| Scenario *Max 1* | (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 *Med 1* | (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 *Min 1* | (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 *Max 2* | (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 *Med 2* | (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 *Min 2* | (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 $1/2 \cdot (348{,}672\ km^2/PU_{its})^{1/2}$. 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 |
|---|---|---|---|---|---|---|---|---|
| **Diesel fuel efficiency in goods traffic by trucks**[a] | Index | (A) | 0.94 | 0.87 | 0.83 | 0.71 | 0.67 | 0.63 |
| **Diesel fuel consumption - Trucks** | l/100 km[c] | (B) | 35.6[b] | 32.9 | 31.4 | 26.9 | 25.4 | 23.9 |
| | l/km[d] | (C) | 0.356 | 0.329 | 0.314 | 0.269 | 0.254 | 0.239 |
| | l/(t · km)[e] | (D) | **0.020** | **0.018** | **0.017** | **0.015** | **0.014** | **0.013** |
| **Diesel fuel consumption - Tractors** | l/100 km[g] | (E) | 30.1[f] | 27.9 | 26.6 | 22.7 | 21.5 | 20.2 |
| | l/km[h] | (F) | 0.301 | 0.279 | 0.266 | 0.227 | 0.215 | 0.202 |
| | l/(t · km)[i] | (G) | **0.050** | **0.046** | **0.044** | **0.038** | **0.036** | **0.034** |

Values rounded.

*Sources:*

a) 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.

b) 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).

c) 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).

d) Own calculation, (C) = (B)/100.

e) 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 $m^3$ 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 $m^3$ might be violated at 18 t for freight densities below 0.225 $t/m^3$. 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.

f) Kunert and Radke (2013: Table 3), referring to average diesel consumption by *remaining tractors* in Germany, which include agricultural tractors.

g) 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).

h) Own calculation, (F) = (E)/100.

i) 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: $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units

| | $CO_2$ emissions | | | | |
|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/($t_{DM}$ feedstock · km) | | | | |
| **Feedstocks** | (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 $CO_2$ emission factor for diesel fuel of 74.0 t $CO_2$/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: $CO_2$ Emissions from the Transportation of Biochar to the Farms

| Feedstocks | $CO_2$ emissions | | | | |
|---|---|---|---|---|---|
| | 2015 | 2020 | 2030 | 2040 | 2050 |
| | t $CO_2$/($t_{DM}$ 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 $CO_2$ emission factor for diesel fuel of 74.0 t $CO_2$/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: $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 1*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 1***

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 2*

| Feedstocks | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ 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: $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 2*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 1*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 1*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 2*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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: $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 2*

| Feedstocks | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ 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[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ 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*

| | **Small-scale pyrolysis units**[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units**[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units**[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | **Small-scale pyrolysis units**[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units**[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units**[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | Small-scale pyrolysis units[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | **Small-scale pyrolysis units[a]** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units[b]** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units[c]** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ 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 digestable 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
n) (14) = Table 31 (column 12) + Table A.31 (column 13)
o) (15) = Table 31 (column 13) + Table A.31 (column 13)
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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
i) (9) = Table 31 (column 13) + Table A.32 (column 8)
j) (10) = Table 31 (column 14) + Table A.32 (column 8)
k) (11) = Table 31 (column 15) + Table A.32 (column 8)
l) (12) = Table 31 (column 16) + Table A.32 (column 8)
m) (13) = Table 31 (column 11) + Table A.32 (column 13)
n) (14) = Table 31 (column 12) + Table A.32 (column 13)
o) (15) = Table 31 (column 13) + Table A.32 (column 13)
p) (16) = Table 31 (column 14) + Table A.32 (column 13)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.34 (column 3)
c) (3) = Table 31 (column 13) + Table A.34 (column 3)
d) (4) = Table 31 (column 14) + Table A.34 (column 3)
e) (5) = Table 31 (column 15) + Table A.34 (column 3)
f) (6) = Table 31 (column 16) + Table A.34 (column 3)
g) (7) = Table 31 (column 11) + Table A.34 (column 8)
h) (8) = Table 31 (column 12) + Table A.34 (column 8)
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o) (15) = Table 31 (column 13) + Table A.34 (column 13)
p) (16) = Table 31 (column 14) + Table A.34 (column 13)
q) (17) = Table 31 (column 15) + Table A.34 (column 13)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.35 (column 3)
c) (3) = Table 31 (column 13) + Table A.35 (column 3)
d) (4) = Table 31 (column 14) + Table A.35 (column 3)
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q) (17) = Table 31 (column 15) + Table A.35 (column 13)
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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.30 (column 1)
c) (3) = Table 31 (column 13) + Table A.30 (column 1)
d) (4) = Table 31 (column 14) + Table A.30 (column 1)
e) (5) = Table 31 (column 15) + Table A.30 (column 1)
f) (6) = Table 31 (column 16) + Table A.30 (column 1)
g) (7) = Table 31 (column 11) + Table A.30 (column 6)
h) (8) = Table 31 (column 12) + Table A.30 (column 6)
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p) (16) = Table 31 (column 14) + Table A.30 (column 11)
q) (17) = Table 31 (column 15) + Table A.30 (column 11)
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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
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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*

| | 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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.32 (column 1)
c) (3) = Table 31 (column 13) + Table A.32 (column 1)
d) (4) = Table 31 (column 14) + Table A.32 (column 1)
e) (5) = Table 31 (column 15) + Table A.32 (column 1)
f) (6) = Table 31 (column 16) + Table A.32 (column 1)
g) (7) = Table 31 (column 11) + Table A.32 (column 6)
h) (8) = Table 31 (column 12) + Table A.32 (column 6)
i) (9) = Table 31 (column 13) + Table A.32 (column 6)
j) (10) = Table 31 (column 14) + Table A.32 (column 6)
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n) (14) = Table 31 (column 12) + Table A.32 (column 11)
o) (15) = Table 31 (column 13) + Table A.32 (column 11)
p) (16) = Table 31 (column 14) + Table A.32 (column 11)
q) (17) = Table 31 (column 15) + Table A.32 (column 11)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.33 (column 1)
c) (3) = Table 31 (column 13) + Table A.33 (column 1)
d) (4) = Table 31 (column 14) + Table A.33 (column 1)
e) (5) = Table 31 (column 15) + Table A.33 (column 1)
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l) (12) = Table 31 (column 16) + Table A.33 (column 6)
m) (13) = Table 31 (column 11) + Table A.33 (column 11)
n) (14) = Table 31 (column 12) + Table A.33 (column 11)
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p) (16) = Table 31 (column 14) + Table A.33 (column 11)
q) (17) = Table 31 (column 15) + Table A.33 (column 11)
r) (18) = Table 31 (column 16) + Table A.33 (column 11)

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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table 31 (column 11) + Table A.34 (column 1)
b) (2) = Table 31 (column 12) + Table A.34 (column 1)
c) (3) = Table 31 (column 13) + Table A.34 (column 1)
d) (4) = Table 31 (column 14) + Table A.34 (column 1)
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q) (17) = Table 31 (column 15) + Table A.34 (column 11)
r) (18) = Table 31 (column 16) + Table A.34 (column 11)

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

## Table A.45: Total Net Avoided GHG Emissions, 2015, 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.35 (column 1)
c) (3) = Table 31 (column 13) + Table A.35 (column 1)
d) (4) = Table 31 (column 14) + Table A.35 (column 1)
e) (5) = Table 31 (column 15) + Table A.35 (column 1)
f) (6) = Table 31 (column 16) + Table A.35 (column 1)
g) (7) = Table 31 (column 11) + Table A.35 (column 6)
h) (8) = Table 31 (column 12) + Table A.35 (column 6)
i) (9) = Table 31 (column 13) + Table A.35 (column 6)
j) (10) = Table 31 (column 14) + Table A.35 (column 6)
k) (11) = Table 31 (column 15) + Table A.35 (column 6)
l) (12) = Table 31 (column 16) + Table A.35 (column 6)
m) (13) = Table 31 (column 11) + Table A.35 (column 11)
n) (14) = Table 31 (column 12) + Table A.35 (column 11)
o) (15) = Table 31 (column 13) + Table A.35 (column 11)
p) (16) = Table 31 (column 14) + Table A.35 (column 11)
q) (17) = Table 31 (column 15) + Table A.35 (column 11)
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*

| | 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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.30 (column 5)
c) (3) = Table 31 (column 13) + Table A.30 (column 5)
d) (4) = Table 31 (column 14) + Table A.30 (column 5)
e) (5) = Table 31 (column 15) + Table A.30 (column 5)
f) (6) = Table 31 (column 16) + Table A.30 (column 5)
g) (7) = Table 31 (column 11) + Table A.30 (column 10)
h) (8) = Table 31 (column 12) + Table A.30 (column 10)
i) (9) = Table 31 (column 13) + Table A.30 (column 10)
j) (10) = Table 31 (column 14) + Table A.30 (column 10)
k) (11) = Table 31 (column 15) + Table A.30 (column 10)
l) (12) = Table 31 (column 16) + Table A.30 (column 10)
m) (13) = Table 31 (column 11) + Table A.30 (column 15)
n) (14) = Table 31 (column 12) + Table A.30 (column 15)
o) (15) = Table 31 (column 13) + Table A.30 (column 15)
p) (16) = Table 31 (column 14) + Table A.30 (column 15)
q) (17) = Table 31 (column 15) + Table A.30 (column 15)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.31 (column 5)
c) (3) = Table 31 (column 13) + Table A.31 (column 5)
d) (4) = Table 31 (column 14) + Table A.31 (column 5)
e) (5) = Table 31 (column 15) + Table A.31 (column 5)
f) (6) = Table 31 (column 16) + Table A.31 (column 5)
g) (7) = Table 31 (column 11) + Table A.31 (column 10)
h) (8) = Table 31 (column 12) + Table A.31 (column 10)
i) (9) = Table 31 (column 13) + Table A.31 (column 10)
j) (10) = Table 31 (column 14) + Table A.31 (column 10)
k) (11) = Table 31 (column 15) + Table A.31 (column 10)
l) (12) = Table 31 (column 16) + Table A.31 (column 10)
m) (13) = Table 31 (column 11) + Table A.31 (column 15)
n) (14) = Table 31 (column 12) + Table A.31 (column 15)
o) (15) = Table 31 (column 13) + Table A.31 (column 15)
p) (16) = Table 31 (column 14) + Table A.31 (column 15)
q) (17) = Table 31 (column 15) + Table A.31 (column 15)
r) (18) = Table 31 (column 16) + Table A.31 (column 15)

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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | $t\ CO_2e/t_{DM}$ feedstock | | | | | | $t\ CO_2e/t_{DM}$ feedstock | | | | | | $t\ CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.32 (column 5)
c) (3) = Table 31 (column 13) + Table A.32 (column 5)
d) (4) = Table 31 (column 14) + Table A.32 (column 5)
e) (5) = Table 31 (column 15) + Table A.32 (column 5)
f) (6) = Table 31 (column 16) + Table A.32 (column 5)
g) (7) = Table 31 (column 11) + Table A.32 (column 10)
h) (8) = Table 31 (column 12) + Table A.32 (column 10)
i) (9) = Table 31 (column 13) + Table A.32 (column 10)
j) (10) = Table 31 (column 14) + Table A.32 (column 10)
k) (11) = Table 31 (column 15) + Table A.32 (column 10)
l) (12) = Table 31 (column 16) + Table A.32 (column 10)
m) (13) = Table 31 (column 11) + Table A.32 (column 15)
n) (14) = Table 31 (column 12) + Table A.32 (column 15)
o) (15) = Table 31 (column 13) + Table A.32 (column 15)
p) (16) = Table 31 (column 14) + Table A.32 (column 15)
q) (17) = Table 31 (column 15) + Table A.32 (column 15)
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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.33 (column 5)
c) (3) = Table 31 (column 13) + Table A.33 (column 5)
d) (4) = Table 31 (column 14) + Table A.33 (column 5)
e) (5) = Table 31 (column 15) + Table A.33 (column 5)
f) (6) = Table 31 (column 16) + Table A.33 (column 5)
g) (7) = Table 31 (column 11) + Table A.33 (column 10)
h) (8) = Table 31 (column 12) + Table A.33 (column 10)
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j) (10) = Table 31 (column 14) + Table A.33 (column 10)
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o) (15) = Table 31 (column 13) + Table A.33 (column 15)
p) (16) = Table 31 (column 14) + Table A.33 (column 15)
q) (17) = Table 31 (column 15) + Table A.33 (column 15)
r) (18) = Table 31 (column 16) + Table A.33 (column 15)

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

# Table A.50: Total Net Avoided GHG Emissions, 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table 31 (column 11) + Table A.34 (column 5)
b) (2) = Table 31 (column 12) + Table A.34 (column 5)
c) (3) = Table 31 (column 13) + Table A.34 (column 5)
d) (4) = Table 31 (column 14) + Table A.34 (column 5)
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q) (17) = Table 31 (column 15) + Table A.34 (column 15)
r) (18) = Table 31 (column 16) + Table A.34 (column 15)

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

# Table A.51: Total Net Avoided GHG Emissions, 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.35 (column 5)
c) (3) = Table 31 (column 13) + Table A.35 (column 5)
d) (4) = Table 31 (column 14) + Table A.35 (column 5)
e) (5) = Table 31 (column 15) + Table A.35 (column 5)
f) (6) = Table 31 (column 16) + Table A.35 (column 5)
g) (7) = Table 31 (column 11) + Table A.35 (column 10)
h) (8) = Table 31 (column 12) + Table A.35 (column 10)
i) (9) = Table 31 (column 13) + Table A.35 (column 10)
j) (10) = Table 31 (column 14) + Table A.35 (column 10)
k) (11) = Table 31 (column 15) + Table A.35 (column 10)
l) (12) = Table 31 (column 16) + Table A.35 (column 10)
m) (13) = Table 31 (column 11) + Table A.35 (column 15)
n) (14) = Table 31 (column 12) + Table A.35 (column 15)
o) (15) = Table 31 (column 13) + Table A.35 (column 15)
p) (16) = Table 31 (column 14) + Table A.35 (column 15)
q) (17) = Table 31 (column 15) + Table A.35 (column 15)
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

| | Emissions from biochar | | Emissions from conventional feedstock management | | | | | | Combustion of pyrolysis by-products | | | | Energy input for biochar production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Stable C[a] | $N_2O$[b] | $CH_4$[c] | $N_2O$[d] | Stable C[e] | Fossil-fuel substitution | | | $CH_4$, $N_2O$[i] | Fossil-fuel substitution | | | No process heat recovery | | | Process heat recovery | | |
| | t $CO_2e/t_{DM}$ feedstock | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1) | (2) | (3) | (4) | (5) | (6a)[f] | (6b)[g] | (6c)[h] | (7) | (8a)[j] | (8b)[k] | (8c)[l] | (9a)[m] | (9b)[n] | (9c)[o] | (10a)[p] | (10b)[q] | (10c)[r] |
| 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 $CO_2e/t_{DM}$ feedstock | | | | | |
| | (11)[s] | (12)[t] | (13)[u] | (14)[v] | (15)[w] | (16)[x] |
| 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
b) Table 17, column 9; shown as a negative value
c) Table 14, column 5
d) Table 16, column 13
e) Table 15, column 3; shown as a negative value
f) Table 18, column 4; shown as a negative value
g) Table 18, column 8; shown as a negative value
h) Table 18, column 12; shown as a negative value
i) Table 19, column 8; shown as a negative value
j) Table 20, column 4
k) Table 20, column 8
l) Table 20, column 12
m) Table 22, column 4; shown as a negative value
n) Table 22, column 8; shown as a negative value
o) Table 22, column 12; shown as a negative value
p) Table 23, column 4; shown as a negative value
q) Table 23, column 8; shown as a negative value
r) Table 23, column 12; shown as a negative value
s) (11) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (9a)
t) (12) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (9b)
u) (13) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (9c)
v) (14) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (10a)
w) (15) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (10b)
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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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

| | 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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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

| | 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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table A.52 (column 12) + Table A.33 (column 3)
c) (3) = Table A.52 (column 13) + Table A.33 (column 3)
d) (4) = Table A.52 (column 14) + Table A.33 (column 3)
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g) (7) = Table A.52 (column 11) + Table A.33 (column 8)
h) (8) = Table A.52 (column 12) + Table A.33 (column 8)
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p) (16) = Table A.52 (column 14) + Table A.33 (column 13)
q) (17) = Table A.52 (column 15) + Table A.33 (column 13)
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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table A.52 (column 11) + Table A.35 (column 3)
b) (2) = Table A.52 (column 12) + Table A.35 (column 3)
c) (3) = Table A.52 (column 13) + Table A.35 (column 3)
d) (4) = Table A.52 (column 14) + Table A.35 (column 3)
e) (5) = Table A.52 (column 15) + Table A.35 (column 3)
f) (6) = Table A.52 (column 16) + Table A.35 (column 3)
g) (7) = Table A.52 (column 11) + Table A.35 (column 8)
h) (8) = Table A.52 (column 12) + Table A.35 (column 8)
i) (9) = Table A.52 (column 13) + Table A.35 (column 8)
j) (10) = Table A.52 (column 14) + Table A.35 (column 8)
k) (11) = Table A.52 (column 15) + Table A.35 (column 8)
l) (12) = Table A.52 (column 16) + Table A.35 (column 8)
m) (13) = Table A.52 (column 11) + Table A.35 (column 13)
n) (14) = Table A.52 (column 12) + Table A.35 (column 13)
o) (15) = Table A.52 (column 13) + Table A.35 (column 13)
p) (16) = Table A.52 (column 14) + Table A.35 (column 13)
q) (17) = Table A.52 (column 15) + Table A.35 (column 13)
r) (18) = Table A.52 (column 16) + Table A.35 (column 13)

## Table A.59: Total Net Avoided GHG Emissions from Sections 4.1 to 4.3[*] – Zero Biomass Carbon Sequestration

| | **Emissions from biochar** | | **Emissions from conventional feedstock management** | | | | | | **Combustion of pyrolysis by-products** | | | | **Energy input for biochar production** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Stable C[a]** | **$N_2O$[b]** | **$CH_4$[c]** | **$N_2O$[d]** | **Stable C[e]** | **Fossil-fuel substitution** | | | **$CH_4$, $N_2O$[i]** | **Fossil-fuel substitution** | | | **No process heat recovery** | | | **Process heat recovery** | | |
| | t $CO_2e/t_{DM}$ feedstock | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1) | (2) | (3) | (4) | (5) | (6a)[f] | (6b)[g] | (6c)[h] | (7) | (8a)[j] | (8b)[k] | (8c)[l] | (9a)[m] | (9b)[n] | (9c)[o] | (10a)[p] | (10b)[q] | (10c)[r] |
| 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 $CO_2e/t_{DM}$ feedstock | | | | | |
| | (11)[s] | (12)[t] | (13)[u] | (14)[v] | (15)[w] | (16)[x] |
| 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
b) Table 17, column 9; shown as a negative value
c) Table 14, column 5
d) Table 16, column 13
e) Assumed zero biomass carbon sequestration
f) Table 18, column 4; shown as a negative value
g) Table 18, column 8; shown as a negative value
h) Table 18, column 12; shown as a negative value
i) Table 19, column 8; shown as a negative value
j) Table 20, column 4
k) Table 20, column 8
l) Table 20, column 12
m) Table 22, column 4; shown as a negative value
n) Table 22, column 8; shown as a negative value
o) Table 22, column 12; shown as a negative value
p) Table 23, column 4; shown as a negative value
q) Table 23, column 8; shown as a negative value
r) Table 23, column 12; shown as a negative value
s) (11) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (9a)
t) (12) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (9b)
u) (13) = (1) + (2) + (3) + (4) + (5) + (6c) + (7) + (8c) + (9c)
v) (14) = (1) + (2) + (3) + (4) + (5) + (6a) + (7) + (8a) + (10a)
w) (15) = (1) + (2) + (3) + (4) + (5) + (6b) + (7) + (8b) + (10b)
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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
j) (10) = Table A.59 (column 14) + Table A.30 (column 8)
k) (11) = Table A.59 (column 15) + Table A.30 (column 8)
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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
l) (12) = Table A.59 (column 16) + Table A.31 (column 8)
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p) (16) = Table A.59 (column 14) + Table A.31 (column 13)
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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table A.59 (column 12) + Table A.32 (column 3)
c) (3) = Table A.59 (column 13) + Table A.32 (column 3)
d) (4) = Table A.59 (column 14) + Table A.32 (column 3)
e) (5) = Table A.59 (column 15) + Table A.32 (column 3)
f) (6) = Table A.59 (column 16) + Table A.32 (column 3)
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h) (8) = Table A.59 (column 12) + 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table A.59 (column 11) + Table A.33 (column 3)
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q) (17) = Table A.59 (column 15) + Table A.33 (column 13)
r) (18) = Table A.59 (column 16) + Table A.33 (column 13)

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

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table A.59 (column 11) + Table A.34 (column 3)
b) (2) = Table A.59 (column 12) + Table A.34 (column 3)
c) (3) = Table A.59 (column 13) + Table A.34 (column 3)
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q) (17) = Table A.59 (column 15) + Table A.34 (column 13)
r) (18) = Table A.59 (column 16) + Table A.34 (column 13)

## 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 $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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:*

a) (1) = Table A.59 (column 11) + Table A.35 (column 3)
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p) (16) = Table A.59 (column 14) + Table A.35 (column 13)
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 digestable biomass residues are used directly for biochar production. Analoguously 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 | | | | | % | | | | |
| *Nitsch et al. (2004, “NaturschutzPlus” scenario)* | | | | | | | | | | | |
| Total biomass residues[1] | | 677 | 696 | 705 | 715 | 724 | | | | | |
| Total biomas residues, adjusted[2] | (A) | 554 | 591.3 | 705 | 715 | 724 | | | | | |
| Actual 2010 energy provision[3] | (B) | 500 | 500 | 500 | 500 | 500 | | | | | |
| Remaining biomass residues, i.e. (C) = (A) – (B) | (C) | **54** | **91.3** | **205** | **215** | **224** | ➔ Assumed maximum biomass potentials for biochar | | | | |
| *Teichmann (2014)* | | | | | | | | | | | |
| Solid biomass residues[4] | (D) | 298.9 | 335.4 | 463.5 | 471.8 | 478.8 | **18.07** | **27.22** | **44.23** | **45.57** | **46.78** |
| Revised digestable biomass residues[5] | (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 | **15.46** | **23.48** | **39.61** | **40.75** | **41.82** |

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 $CO_2$ 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 $CO_2$ 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 $CO_2$ 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 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| **Biomass scenarios** | | km | | | | | km | | | | | km | | | | |
| Scenario *Max 1* | (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 *Med 1* | (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 *Min 1* | (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 *Max 2* | (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 *Med 2* | (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 *Min 2* | (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*, $PU_{its}$, given in Table 39 of Teichmann (2014), i.e. calculated as $1/2 \cdot (348{,}672\ km^2/PU_{its})^{1/2}$. 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.68: Revised $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 1*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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 $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 1***

| Feedstocks | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ 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 $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Med 2*

| Feedstocks | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ 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 $CO_2$ Emissions from the Transportation of Biomass to the Pyrolysis Units, Germany, 2015-2050, Scenario *Min 2*

| Feedstocks | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ feedstock | | | | | t $CO_2/t_{DM}$ 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 $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 1*

| Feedstocks | Small-scale pyrolysis units (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ 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 $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 1*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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 $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Med 2*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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 $CO_2$ Emissions from the Transportation of Biochar to the Farms, Germany, 2015-2050, Scenario *Min 2*

| | **Small-scale pyrolysis units** (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units** (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units** (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | | t $CO_2$/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ 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*

| | Small-scale pyrolysis units[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | Small-scale pyrolysis units[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | Small-scale pyrolysis units[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | Medium-scale pyrolysis units[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | Large-scale pyrolysis units[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 | 2015 | 2020 | 2030 | 2040 | 2050 |
| | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | t $CO_2e/t_{DM}$ 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*

| | **Small-scale pyrolysis units**[a] (à 2,000 $t_{DM}$ feedstock/a) | | | | | **Medium-scale pyrolysis units**[b] (à 16,000 $t_{DM}$ feedstock/a) | | | | | **Large-scale pyrolysis units**[c] (à 184,800 $t_{DM}$ feedstock/a) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** | **2015** | **2020** | **2030** | **2040** | **2050** |
| | t $CO_2$e/$t_{DM}$ feedstock | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | |
| **Feedstocks** | (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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.77 (column 3)
c) (3) = Table 31 (column 13) + Table A.77 (column 3)
d) (4) = Table 31 (column 14) + Table A.77 (column 3)
e) (5) = Table 31 (column 15) + Table A.77 (column 3)
f) (6) = Table 31 (column 16) + Table A.77 (column 3)
g) (7) = Table 31 (column 11) + Table A.77 (column 8)
h) (8) = Table 31 (column 12) + Table A.77 (column 8)
i) (9) = Table 31 (column 13) + Table A.77 (column 8)
j) (10) = Table 31 (column 14) + Table A.77 (column 8)
k) (11) = Table 31 (column 15) + Table A.77 (column 8)
l) (12) = Table 31 (column 16) + Table A.77 (column 8)
m) (13) = Table 31 (column 11) + Table A.77 (column 13)
n) (14) = Table 31 (column 12) + Table A.77 (column 13)
o) (15) = Table 31 (column 13) + Table A.77 (column 13)
p) (16) = Table 31 (column 14) + Table A.77 (column 13)
q) (17) = Table 31 (column 15) + Table A.77 (column 13)
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*

| | **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** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.78 (column 3)
c) (3) = Table 31 (column 13) + Table A.78 (column 3)
d) (4) = Table 31 (column 14) + Table A.78 (column 3)
e) (5) = Table 31 (column 15) + Table A.78 (column 3)
f) (6) = Table 31 (column 16) + Table A.78 (column 3)
g) (7) = Table 31 (column 11) + Table A.78 (column 8)
h) (8) = Table 31 (column 12) + Table A.78 (column 8)
i) (9) = Table 31 (column 13) + Table A.78 (column 8)
j) (10) = Table 31 (column 14) + Table A.78 (column 8)
k) (11) = Table 31 (column 15) + Table A.78 (column 8)
l) (12) = Table 31 (column 16) + Table A.78 (column 8)
m) (13) = Table 31 (column 11) + Table A.78 (column 13)
n) (14) = Table 31 (column 12) + Table A.78 (column 13)
o) (15) = Table 31 (column 13) + Table A.78 (column 13)
p) (16) = Table 31 (column 14) + Table A.78 (column 13)
q) (17) = Table 31 (column 15) + Table A.78 (column 13)
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*

| | **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** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.80 (column 3)
c) (3) = Table 31 (column 13) + Table A.80 (column 3)
d) (4) = Table 31 (column 14) + Table A.80 (column 3)
e) (5) = Table 31 (column 15) + Table A.80 (column 3)
f) (6) = Table 31 (column 16) + Table A.80 (column 3)
g) (7) = Table 31 (column 11) + Table A.80 (column 8)
h) (8) = Table 31 (column 12) + Table A.80 (column 8)
i) (9) = Table 31 (column 13) + Table A.80 (column 8)
j) (10) = Table 31 (column 14) + Table A.80 (column 8)
k) (11) = Table 31 (column 15) + Table A.80 (column 8)
l) (12) = Table 31 (column 16) + Table A.80 (column 8)
m) (13) = Table 31 (column 11) + Table A.80 (column 13)
n) (14) = Table 31 (column 12) + Table A.80 (column 13)
o) (15) = Table 31 (column 13) + Table A.80 (column 13)
p) (16) = Table 31 (column 14) + Table A.80 (column 13)
q) (17) = Table 31 (column 15) + Table A.80 (column 13)
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*

| | 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 $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | | t $CO_2$e/$t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.81 (column 3)
c) (3) = Table 31 (column 13) + Table A.81 (column 3)
d) (4) = Table 31 (column 14) + Table A.81 (column 3)
e) (5) = Table 31 (column 15) + Table A.81 (column 3)
f) (6) = Table 31 (column 16) + Table A.81 (column 3)
g) (7) = Table 31 (column 11) + Table A.81 (column 8)
h) (8) = Table 31 (column 12) + Table A.81 (column 8)
i) (9) = Table 31 (column 13) + Table A.81 (column 8)
j) (10) = Table 31 (column 14) + Table A.81 (column 8)
k) (11) = Table 31 (column 15) + Table A.81 (column 8)
l) (12) = Table 31 (column 16) + Table A.81 (column 8)
m) (13) = Table 31 (column 11) + Table A.81 (column 13)
n) (14) = Table 31 (column 12) + Table A.81 (column 13)
o) (15) = Table 31 (column 13) + Table A.81 (column 13)
p) (16) = Table 31 (column 14) + Table A.81 (column 13)
q) (17) = Table 31 (column 15) + Table A.81 (column 13)
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**

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.76 (column 1)
c) (3) = Table 31 (column 13) + Table A.76 (column 1)
d) (4) = Table 31 (column 14) + Table A.76 (column 1)
e) (5) = Table 31 (column 15) + Table A.76 (column 1)
f) (6) = Table 31 (column 16) + Table A.76 (column 1)
g) (7) = Table 31 (column 11) + Table A.76 (column 6)
h) (8) = Table 31 (column 12) + Table A.76 (column 6)
i) (9) = Table 31 (column 13) + Table A.76 (column 6)
j) (10) = Table 31 (column 14) + Table A.76 (column 6)
k) (11) = Table 31 (column 15) + Table A.76 (column 6)
l) (12) = Table 31 (column 16) + Table A.76 (column 6)
m) (13) = Table 31 (column 11) + Table A.76 (column 11)
n) (14) = Table 31 (column 12) + Table A.76 (column 11)
o) (15) = Table 31 (column 13) + Table A.76 (column 11)
p) (16) = Table 31 (column 14) + Table A.76 (column 11)
q) (17) = Table 31 (column 15) + Table A.76 (column 11)
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**

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.79 (column 1)
c) (3) = Table 31 (column 13) + Table A.79 (column 1)
d) (4) = Table 31 (column 14) + Table A.79 (column 1)
e) (5) = Table 31 (column 15) + Table A.79 (column 1)
f) (6) = Table 31 (column 16) + Table A.79 (column 1)
g) (7) = Table 31 (column 11) + Table A.79 (column 6)
h) (8) = Table 31 (column 12) + Table A.79 (column 6)
i) (9) = Table 31 (column 13) + Table A.79 (column 6)
j) (10) = Table 31 (column 14) + Table A.79 (column 6)
k) (11) = Table 31 (column 15) + Table A.79 (column 6)
l) (12) = Table 31 (column 16) + Table A.79 (column 6)
m) (13) = Table 31 (column 11) + Table A.79 (column 11)
n) (14) = Table 31 (column 12) + Table A.79 (column 11)
o) (15) = Table 31 (column 13) + Table A.79 (column 11)
p) (16) = Table 31 (column 14) + Table A.79 (column 11)
q) (17) = Table 31 (column 15) + Table A.79 (column 11)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.76 (column 5)
c) (3) = Table 31 (column 13) + Table A.76 (column 5)
d) (4) = Table 31 (column 14) + Table A.76 (column 5)
e) (5) = Table 31 (column 15) + Table A.76 (column 5)
f) (6) = Table 31 (column 16) + Table A.76 (column 5)
g) (7) = Table 31 (column 11) + Table A.76 (column 10)
h) (8) = Table 31 (column 12) + Table A.76 (column 10)
i) (9) = Table 31 (column 13) + Table A.76 (column 10)
j) (10) = Table 31 (column 14) + Table A.76 (column 10)
k) (11) = Table 31 (column 15) + Table A.76 (column 10)
l) (12) = Table 31 (column 16) + Table A.76 (column 10)
m) (13) = Table 31 (column 11) + Table A.76 (column 15)
n) (14) = Table 31 (column 12) + Table A.76 (column 15)
o) (15) = Table 31 (column 13) + Table A.76 (column 15)
p) (16) = Table 31 (column 14) + Table A.76 (column 15)
q) (17) = Table 31 (column 15) + Table A.76 (column 15)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.77 (column 5)
c) (3) = Table 31 (column 13) + Table A.77 (column 5)
d) (4) = Table 31 (column 14) + Table A.77 (column 5)
e) (5) = Table 31 (column 15) + Table A.77 (column 5)
f) (6) = Table 31 (column 16) + Table A.77 (column 5)
g) (7) = Table 31 (column 11) + Table A.77 (column 10)
h) (8) = Table 31 (column 12) + Table A.77 (column 10)
i) (9) = Table 31 (column 13) + Table A.77 (column 10)
j) (10) = Table 31 (column 14) + Table A.77 (column 10)
k) (11) = Table 31 (column 15) + Table A.77 (column 10)
l) (12) = Table 31 (column 16) + Table A.77 (column 10)
m) (13) = Table 31 (column 11) + Table A.77 (column 15)
n) (14) = Table 31 (column 12) + Table A.77 (column 15)
o) (15) = Table 31 (column 13) + Table A.77 (column 15)
p) (16) = Table 31 (column 14) + Table A.77 (column 15)
q) (17) = Table 31 (column 15) + Table A.77 (column 15)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.78 (column 5)
c) (3) = Table 31 (column 13) + Table A.78 (column 5)
d) (4) = Table 31 (column 14) + Table A.78 (column 5)
e) (5) = Table 31 (column 15) + Table A.78 (column 5)
f) (6) = Table 31 (column 16) + Table A.78 (column 5)
g) (7) = Table 31 (column 11) + Table A.78 (column 10)
h) (8) = Table 31 (column 12) + Table A.78 (column 10)
i) (9) = Table 31 (column 13) + Table A.78 (column 10)
j) (10) = Table 31 (column 14) + Table A.78 (column 10)
k) (11) = Table 31 (column 15) + Table A.78 (column 10)
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m) (13) = Table 31 (column 11) + Table A.78 (column 15)
n) (14) = Table 31 (column 12) + Table A.78 (column 15)
o) (15) = Table 31 (column 13) + Table A.78 (column 15)
p) (16) = Table 31 (column 14) + Table A.78 (column 15)
q) (17) = Table 31 (column 15) + Table A.78 (column 15)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.79 (column 5)
c) (3) = Table 31 (column 13) + Table A.79 (column 5)
d) (4) = Table 31 (column 14) + Table A.79 (column 5)
e) (5) = Table 31 (column 15) + Table A.79 (column 5)
f) (6) = Table 31 (column 16) + Table A.79 (column 5)
g) (7) = Table 31 (column 11) + Table A.79 (column 10)
h) (8) = Table 31 (column 12) + Table A.79 (column 10)
i) (9) = Table 31 (column 13) + Table A.79 (column 10)
j) (10) = Table 31 (column 14) + Table A.79 (column 10)
k) (11) = Table 31 (column 15) + Table A.79 (column 10)
l) (12) = Table 31 (column 16) + Table A.79 (column 10)
m) (13) = Table 31 (column 11) + Table A.79 (column 15)
n) (14) = Table 31 (column 12) + Table A.79 (column 15)
o) (15) = Table 31 (column 13) + Table A.79 (column 15)
p) (16) = Table 31 (column 14) + Table A.79 (column 15)
q) (17) = Table 31 (column 15) + Table A.79 (column 15)
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*

| | 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| **Feedstocks** | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.80 (column 5)
c) (3) = Table 31 (column 13) + Table A.80 (column 5)
d) (4) = Table 31 (column 14) + Table A.80 (column 5)
e) (5) = Table 31 (column 15) + Table A.80 (column 5)
f) (6) = Table 31 (column 16) + Table A.80 (column 5)
g) (7) = Table 31 (column 11) + Table A.80 (column 10)
h) (8) = Table 31 (column 12) + Table A.80 (column 10)
i) (9) = Table 31 (column 13) + Table A.80 (column 10)
j) (10) = Table 31 (column 14) + Table A.80 (column 10)
k) (11) = Table 31 (column 15) + Table A.80 (column 10)
l) (12) = Table 31 (column 16) + Table A.80 (column 10)
m) (13) = Table 31 (column 11) + Table A.80 (column 15)
n) (14) = Table 31 (column 12) + Table A.80 (column 15)
o) (15) = Table 31 (column 13) + Table A.80 (column 15)
p) (16) = Table 31 (column 14) + Table A.80 (column 15)
q) (17) = Table 31 (column 15) + Table A.80 (column 15)
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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | | t $CO_2e/t_{DM}$ feedstock | | | | | |
| | (1)[a] | (2)[b] | (3)[c] | (4)[d] | (5)[e] | (6)[f] | (7)[g] | (8)[h] | (9)[i] | (10)[j] | (11)[k] | (12)[l] | (13)[m] | (14)[n] | (15)[o] | (16)[p] | (17)[q] | (18)[r] |
| 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)
b) (2) = Table 31 (column 12) + Table A.81 (column 5)
c) (3) = Table 31 (column 13) + Table A.81 (column 5)
d) (4) = Table 31 (column 14) + Table A.81 (column 5)
e) (5) = Table 31 (column 15) + Table A.81 (column 5)
f) (6) = Table 31 (column 16) + Table A.81 (column 5)
g) (7) = Table 31 (column 11) + Table A.81 (column 10)
h) (8) = Table 31 (column 12) + Table A.81 (column 10)
i) (9) = Table 31 (column 13) + Table A.81 (column 10)
j) (10) = Table 31 (column 14) + Table A.81 (column 10)
k) (11) = Table 31 (column 15) + Table A.81 (column 10)
l) (12) = Table 31 (column 16) + Table A.81 (column 10)
m) (13) = Table 31 (column 11) + Table A.81 (column 15)
n) (14) = Table 31 (column 12) + Table A.81 (column 15)
o) (15) = Table 31 (column 13) + Table A.81 (column 15)
p) (16) = Table 31 (column 14) + Table A.81 (column 15)
q) (17) = Table 31 (column 15) + Table A.81 (column 15)
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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$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 |
| **Solid biomass residues** | **4,705** | **4,322** | **3,626** | **5,284** | **4,805** | **4,001** | **4,704** | **4,320** | **3,624** | **5,282** | **4,803** | **3,999** | **4,697** | **4,314** | **3,617** | **5,276** | **4,797** | **3,989** |
| 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 |
| **Digestable biomass residues** | **783** | **892** | **1,073** | **1,064** | **1,127** | **1,223** | **781** | **889** | **1,071** | **1,062** | **1,125** | **1,221** | **772** | **881** | **1,063** | **1,054** | **1,116** | **1,212** |
| **TOTAL** | **5,488** | **5,213** | **4,700** | **6,348** | **5,932** | **5,224** | **5,484** | **5,210** | **4,695** | **6,344** | **5,928** | **5,219** | **5,470** | **5,195** | **4,680** | **6,329** | **5,913** | **5,202** |

*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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| **Feedstocks** | (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 |
| **Solid biomass residues = TOTAL** | **5,646** | **5,186** | **4,352** | **6,340** | **5,766** | **4,801** | **5,644** | **5,184** | **4,349** | **6,338** | **5,764** | **4,798** | **5,636** | **5,176** | **4,340** | **6,330** | **5,756** | **4,786** |

*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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| **Feedstocks** | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) |
| 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 |
| **Solid biomass residues = TOTAL** | **3,764** | **3,457** | **2,901** | **4,227** | **3,844** | **3,201** | **3,762** | **3,455** | **2,899** | **4,225** | **3,842** | **3,198** | **3,756** | **3,449** | **2,891** | **4,218** | **3,836** | **3,188** |

*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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| **Feedstocks** | (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 |
| **Solid biomass residues** | **7,873** | **7,227** | **6,053** | **8,844** | **8,039** | **6,677** | **7,871** | **7,225** | **6,051** | **8,842** | **8,037** | **6,674** | **7,864** | **7,218** | **6,042** | **8,835** | **8,030** | **6,663** |
| 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 |
| **Digestable biomass residues** | **1,275** | **1,461** | **1,772** | **1,743** | **1,852** | **2,021** | **1,272** | **1,458** | **1,769** | **1,740** | **1,849** | **2,018** | **1,262** | **1,448** | **1,760** | **1,730** | **1,840** | **2,009** |
| **TOTAL** | **9,147** | **8,688** | **7,825** | **10,587** | **9,891** | **8,698** | **9,143** | **8,683** | **7,820** | **10,582** | **9,887** | **8,693** | **9,126** | **8,667** | **7,802** | **10,565** | **9,870** | **8,672** |

*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*

| 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| | (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 |
| **Solid biomass residues** | **4,920** | **4,517** | **3,783** | **5,527** | **5,024** | **4,173** | **4,919** | **4,515** | **3,781** | **5,526** | **5,023** | **4,171** | **4,913** | **4,510** | **3,774** | **5,520** | **5,017** | **4,162** |
| 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 |
| **Digestable biomass residues** | **796** | **913** | **1,107** | **1,089** | **1,157** | **1,263** | **794** | **911** | **1,105** | **1,087** | **1,155** | **1,261** | **787** | **903** | **1,098** | **1,079** | **1,148** | **1,253** |
| **TOTAL** | **5,717** | **5,430** | **4,890** | **6,616** | **6,182** | **5,436** | **5,713** | **5,426** | **4,886** | **6,613** | **6,178** | **5,431** | **5,700** | **5,413** | **4,872** | **6,599** | **6,165** | **5,416** |

*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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| **Feedstocks** | (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 |
| **Solid biomass residues** | **2,952** | **2,710** | **2,270** | **3,316** | **3,015** | **2,503** | **2,951** | **2,709** | **2,268** | **3,315** | **3,013** | **2,502** | **2,946** | **2,704** | **2,263** | **3,311** | **3,009** | **2,495** |
| 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 |
| **Digestable biomass residues** | **478** | **547** | **664** | **653** | **694** | **758** | **476** | **546** | **662** | **652** | **693** | **756** | **470** | **540** | **657** | **646** | **687** | **750** |
| **TOTAL** | **3,430** | **3,257** | **2,934** | **3,969** | **3,709** | **3,261** | **3,427** | **3,255** | **2,931** | **3,967** | **3,706** | **3,258** | **3,417** | **3,244** | **2,920** | **3,956** | **3,696** | **3,245** |

*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** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** | **Lignite** | **Hard coal** | **Natu-ral gas** |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| **Feedstocks** | (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 |
| **Solid biomass residues = TOTAL** | **8,857** | **8,131** | **6,809** | **9,949** | **9,044** | **7,511** | **8,854** | **8,128** | **6,807** | **9,947** | **9,042** | **7,508** | **8,845** | **8,119** | **6,796** | **9,938** | **9,033** | **7,495** |

*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*

| 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 | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas | Lignite | Hard coal | Natu-ral gas |
| | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | | kt $CO_2$e/a | | | | | |
| | (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 |
| **Solid biomass residues = TOTAL** | **5,904** | **5,420** | **4,539** | **6,633** | **6,029** | **5,007** | **5,902** | **5,418** | **4,537** | **6,631** | **6,027** | **5,004** | **5,895** | **5,411** | **4,528** | **6,623** | **6,020** | **4,994** |

*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*

| 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 |
| | kt $CO_2e/a$ | | | | | | kt $CO_2e/a$ | | | | | | kt $CO_2e/a$ | | | | | |
| | (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 |
| **Solid biomass residues = TOTAL** | **3,936** | **3,613** | **3,026** | **4,422** | **4,019** | **3,338** | **3,934** | **3,612** | **3,024** | **4,420** | **4,018** | **3,336** | **3,928** | **3,606** | **3,017** | **4,414** | **4,012** | **3,327** |

*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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