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The carbon dioxide emission factor for combustion of Swedish peat

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The carbon dioxide emission factor for combustion of Swedish peat.

Sammanfattning/Summary

The Swedish carbon dioxide emission factor for combustion of energy peat has been reviewed. Three-year-old peat analyses from two Swedish peat producers indicated a notably lower emission factor than 107.3 g CO_2/MJ which is the value used in Sweden's National Emission Inventory Report 2003 submitted under the United Nations Convention on Climate Change. New calculations based on both the old analyses and complementing data were performed in order to calculate an emission factor representative to the entire Swedish production of energy peat. Assuming a water content of 45-50 % (good estimate for moisture content of Swedish energy peat) the calculated emission factor was approximately 105 -108 g CO_2/MJ (standard deviation: 4.8 g CO_2/MJ). Hence it could not be concluded that the emission factor is notably lower than the value used in Sweden's National Emission Inventory Report 2003. However, since the emission factor is dependent on the moisture content, peat with a significantly lower moisture content should also be associated with a lower emission factor.

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Abstract

In Sweden's National Emission Inventory Report 2003 submitted under the United Nations Convention on Climate Change the carbon dioxide emission factor used for peat consumption in electricity-, gas- and heating plants is 107.3 g CO_2 /MJ. Recent analyses of peat from HMAB and Råsjö Torv Ltd indicated that the carbon and energy content of the peat might correspond to a lower emission factor. The objective of this study was to review the already available peat analyses and the calculation methods used when calculating the lower emissions factor. If necessary the data should be complemented so that the total data set would be representative to the entire Swedish production of energy peat.

The CO_2 emission factor was determined by the carbon content and the net calorific value of the peat. The net calorific value was calculated according to the Swedish standard method, ISO 1928:1995.

The HMAB peat analyses had been made on peat bricks with a wood content of 30%. These values were replaced by analyses of pure peat from producers all over Sweden. The results show that the emission factor on dry basis is approximately 95.0 g CO_2/MJ (standard deviation 3.9 g CO_2/MJ). With a water content of 45-50 % the emission factor will be approximately 105-108 g CO_2/MJ (standard deviation 4.8 g CO_2/MJ). No complete compilation of moisture content on combusted peat was made, but many peat producers approximated their mean water content to somewhere between 40-50%. Therefore it can be concluded that the emission factor is not notably lower than the value used in the Swedish National Emission Inventory. Since the emission factor is dependent on the moisture content, it would be appropriate to use a lower emission factor for combustion of peat with significantly lower moisture content.

The reviewed calculations indicating a lower emission factor had not been done according to the IPCC methodology used in this study.

Acknowledgements

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Sammanfattning

I Sveriges rapportering av emissioner av växthusgaser till FN:s Klimatkonvention (Fink m. fl. 2003) används emissionsfaktorn 107,3 g CO_2/MJ för förbränning av energitorv i el-, gas och värmeverk. Beräkningar gjorda på analyser av torv från HMAB och Råsjö Torv AB indikerade att energi- och kolinnehållet i torven motsvarade en betydligt lägre emissionsfaktor på 90-97 g CO_2/MJ. Syftet med denna studie var att granska representativiteten av torvproverna från HMAB och Råsjö Torv AB för svensk torvproduktion samt korrektheten i de beräkningsmetoder som använts för att beräkna den lägre emissionsfaktorn. I syftet ingick också att vid behov komplettera med data från ytterligare producenter för att få ett urval som är representativt för hela dagens svenska produktion av energitorv. Detta för att kunna beräkna en emissionsfaktor för förbränning av torv som kan sägas vara representativ för svensk energitorv.

Analyserna av torv från HMAB och Råsjö Torv AB var ungefär tre år gamla och var gjorda för f.d. Uppsala Energi (numera Vattenfall Uppsala Värme). Efterforskning visade att torven från HMAB vid denna tid utgjordes av torvbriketter med en fukthalt på ca 8-10% och med en inblandning av träflis på ca 30%. Eftersom torven från HMAB visade sig vara ett blandbränsle exkluderades dessa mätvärden i de nya beräkningarna av emissionsfaktorn. De analyser från Råsjö Torv som kom från täkter som idag fortfarande är aktiva fick utgöra en grund för de nya beräkningarna. Urvalet utökades med analyser från andra täkter och producenter så att det totala urvalet av torv kom från ett 20-tal aktiva torvtäkter.

För att vara säker på att beräkningarna av emissionsfaktorn skall kunna betraktas som representativ för dagens svenska torvproduktion kontrollerades att urvalet av torvtäkter representerade samtliga torvproducerande regioner. Emissionsfaktorn beräknades för varje enskild täkt och vägdes sedan samman till ett medelvärde genom att vikta mot produktionen år 2002. Beräkningarna av emissionsfaktorn grundades på den generella ekvation som anges för bestämning av en specifik CO_2 emissionsfaktor för förbränning och industriella processer i EEA (2003). Enligt denna ekvation bestäms emissionsfaktorn i huvudsak av kolhalten och det effektiva värmevärde hos bränslet. Ekvationen är också i överensstämmelse med IPCCs (Houghton m. fl. 1996, Penman m. fl. 2000) metoder som i mycket stämmer helt överens med metoderna i EEA (2003). Det effektiva värmevärdet beräknades enligt svensk standard ISO (1996). De tidigare genomförda beräkningarna på emissionsfaktorn var inte gjorda enligt de ovan beskrivna standardmetoderna.

Beräkningarna av emissionsfaktorn resulterade i värdet 105,2 g CO_2/MJ, med standardavvikelsen 4,6 g CO_2/MJ, vid en fukthalt på 45% samt värdet 107,8 g CO_2/MJ,

med en standard avvikelse på 4,8g CO_2/MJ, vid en fukthalt på 50%. Det betyder att emissionsfaktorn vid dessa fukthalter inte skiljer sig signifikant (inte mer än 2%) från varken den i Houghton m. fl. (1996) rekommenderade på 105,9 g CO_2/MJ, eller den som idag används vid den svenska rapporteringen i Fink m.fl. (2003) på 107,3 g CO_2/MJ. Fukthalten har dock stor betydelse för emissionsfaktorn och även om en fukthalt på 45-50% stämmer väl överens med vad de flesta producenter uppgav så finns det undantag. Ett undantag är industriellt torkade torvbriketter som kan ha en fukthalt på 6-10%. Idag används både svensktillverkade och importerade torvbriketter vid förbränning i en inte oväsentlig omfattning.

Slutsatserna av denna studie är att emissionsfaktorn för förbränning av svensk energitorv ligger mycket nära den rekommenderade av IPCC samt den som idag används vi den svenska rapporteringen. Detta förutsatt att torvens fukthalt ligger runt 45-50%. För t. ex. torvbriketter med en väsentligt lägre vattenhalt kan det vara lämpligt att använda en lägre emissionsfaktor.

1 Introduction

In Sweden's National Emission Inventory Report 2003, submitted under the United Nations Convention on Climate Change (UNFCCC) the emissions from stationary combustion in connection to energy production and heating are determined as the product of fuel consumption, fuel thermal value and emission factors (Fink et al. 2003). The carbon dioxide emission factor used for peat consumption in electricity-, gas- and heating plants is 107.3 g CO_2/MJ. The default value for this emission factor recommended by in Houghton et al. (1996) is 105.9 g CO_2/MJ. However, three-year-old analyses of carbon and energy content of energy peat from HMAB and Råsjö Torv Ltd indicated that the emission factor might be significantly lower than both of these values. Based on the data from the HMAB and Råsjö Torv Ltd peat analyses, the emission factor had been (prior to this study) calculated to 91-96 g CO_2/MJ depending on moisture content (6-50%) (Uppenberg et al., 2001, pers. comm. Lars Åstrand, 2003).

2 Objective of the study

The objective of this study was to review the representativity of the HMAB and Råsjö Torv Ltd peat samples and the accuracy of the calculation methodologies indicating the lower emission factor. An emission factor for combustion of energy peat that would be representative to the current production of Swedish energy peat should be calculated.

3 Methodology

In order to calculate an emission factor valid for the total Swedish production of energy peat, analytical data from peat samples representative for the whole country should be used. Further, the calculations of the emission factor should follow acknowledged standard methodologies.

To ensure that the data used in the calculations of the emission factor was representative for the whole country the origin of the data was investigated. All peat producing regions in Sweden had to be represented, preferably in a way that reflected the relative contribution to the total production. The already available data from HMAB and Råsjö Torv Ltd was therefor supplemented with measurements from other peat producers and other regions.

The emission factor for each production site was calculated and a national mean value was obtained by using the annual production (in 2002) at each of the selected sites as weight factor.

3.1 CO_2 emission factor

The CO_2 emission factor is determined by the carbon content and the calorific value of the fuel. According to the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Houghton et al. 1996) there is currently two approaches to draw up and present national emission inventories in comparable form:

- The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (Houghton et al. 1996).
- The joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (EEA, 2003).

The methods which both follow the same basic principles are currently being harmonised. According to the EMEP/CORINAIR (EEA, 2003) emission factors for the energy sector (energy and transformation industries) are calculated according to Equation 3.1

Equation 3.1: The CO_2 emission factor.

$$EF_{R_{CO2}} = \frac{M_{CO_2}}{M_C} \cdot C_{C_{FUEL}} \cdot \varepsilon \cdot \frac{1}{NCV} \cdot 10^6$$

Where EF_{RCO2} = specified emission factor [g/GJ]

C_{CFUEL} = carbon content of fuel (in mass C/mass fuel [kg/kg])

ε = fraction of carbon oxidised

NCV = lower heating value / net calorific value of fuel [MJ/kg]

M_{CO2} = Molar mass of carbon dioxide [g/mol]

M_C = Molar mass of carbon [g/mol]

In the IPCC methodology the fraction of unoxidised carbon is accounted for separately, i.e. it is not included in the emission factor. Since the Swedish Environmental Protection Agency follow the IPCC methodology when reporting to the UNFCCC, the calculations of the emission factor in this report have been based on Equation 3.2.

Equation 3.2: The emission factor according to IPCC methodology.

$$EF_{R_{CO2}} = \frac{M_{CO_2}}{M_C} \cdot C_{C_{FUEL}} \cdot \frac{1}{NCV} \cdot 10^6$$

The denotations are the same as in Equation 3.1.

3.2 Calorific value

3.2.1 Definitions

The concept of calorific value is rather complicated and often causes misunderstandings. It is very important to distinguish between net and gross calorific values:

Net calorific values (NCVs) measure the specific heat of combustion for the complete combustion of a unit volume or mass of a fuel, assuming the water resulting from combustion remains as vapour and the heat of the vapour is not recovered.

Gross calorific values (GCVs) are estimated assuming that the water vapour is completely condensed.

3.2.2 Calculation of net calorific values

According to the Swedish standard, ISO (1996) Equation 3.3 should be used to calculate the net calorific value from the gross calorific value.

Equation 3.3: Net calorific value according to standard method

$$NCV_F = \{GCV_D - 212 \cdot H - 0.8[O + N]\} \cdot (1 - 0.01 \cdot F) - 24.4 \cdot F$$

Where: NCV_F = the net calorific value at constant pressure, in joules per gram, of the fuel with moisture content F;[1]

GCV_D = the gross calorific value at constant volume, in joules per gram, of the dry fuel.

H = the hydrogen content, in percentage by mass, of the moisture free (dry) fuel (including the hydrogen from the water of hydration of the mineral matter as well as the hydrogen in the coal substance.

O = the oxygen content, in percentage by mass, of the dry fuel.

N = the nitrogen content, in percentage by mass, of the dry fuel.

F = the total moisture content, in percentage by mass, for which the calculation is required.

[1] For a strict definition of NCV and GCV see the Swedish Standard SS ISO 1928:1995 (E), 1996.

3.2.3 Normalisation of data

The net calorific value on dry basis was either given from the producer or calculated according to Equation 3.3. If the calorific value was to be calculated according to Equation 3.3 the C, H, O, N, S and ash contents were first normalised according to Equation 3.4.

Equation 3.4: Normalisation

$$C_t = \frac{C_d}{C_d + H_d + N_d + O_d + S_d + Ash_d} \cdot 100$$

Where the d-index indicates that it is the content on dry basis and the t- index indicate that it is the normalised content on dry basis.

Since the emission factor was calculated for different moisture contents, *F*, the corresponding carbon content, *C,* had to be calculated. This was done according to Equation 3.5.

Equation 3.5: Carbon content

$$C = C_t \cdot \left(\frac{100 - F}{100} \right)$$

The denotations are the same as in Equation 3.4.

3.3 Selection of production sites

In order to make the results of this study representative for the total Swedish production of energy peat, the data used in the calculations had to be taken from a representative sample of the Swedish peat production sites. Today there are approximately 125 active production sites of energy peat spread all over Sweden (SGU, 2002). In this study the country was divided into the five regions acknowledged by the Swedish National Forest Inventory originally statistically designed to give a uniform precision of estimates on forest variables. The peat production sites were selected in order to get good representability of the production in each region as well as in the whole country. **Table 3.1** shows the production of energy peat by region divided on peat types. Both the production at the selected sites and the total production in the region are shown. The table also shows the percentage of the total production in each region that the selected production sites represents. The last column tells the contribution of each region to the total Swedish production of energy peat.

Table 3.1: Production of Energy peat by region 2002

	C-peat (kind of sod peat)	Sod peat	Milled peat	Total	Total production in region compared to total Swedish production [%]
Region 1					
Total production [m^3]	0	65 736	239 846	305 582	10,6
Our samples represents [m^3]	0	0	153 659	153 659	
Our samples represents [%]	-	0	64,1	50,3	
Region 2					
Total production [m^3]	202 007	183 830	770 218	1 156 055	40,3
Our samples represents [m^3]	19 626	45 580	237 297	302 503	
Our samples represents [%]	9,7	24,8	30,8	26,2	
Region 3					
Total production [m^3]	4785	172 723	98 157	275 665	9,6
Our samples represents [m^3]	0	103 163	47 782	150 945	
Our samples represents [%]	0	59,7	48,7	54,8	
Region 4					
Total production [m^3]	0	652 883	463 525	1 116 408	38,9
Our samples represents [m^3]	0	152 243	103 395	255 638	
Our samples represents [%]	-	23,3	22,3	22,9	
Region 5					
Total production [m^3]	0	0	15 800	15 800	0,6
Our samples represents [m^3]	0	0	0	0	
Our samples represents [%]	-	-	0	0	
Sweden					
Total production [m^3]	206 792	1 751 172	1 587 546	2 869 510	100
Our samples represents [m^3]	19 626	300 986	542 133	862 745	
Our samples represents [%]	9,5	28,0	34,2	30,1	

Region 1 = The inland of northern Norrland

Region 2 = The middle part of the inland of Norrland and the northern Norrland coast.

Region 3 = The counties of Värmland, Gävleborg and most parts of Dalarna (not Älvdalen)

Region 4 = The rest of Svealand and most parts of Götaland.

Region 5 = The counties of Skåne, Halland and the coastal regions of Västra Götaland.

The source of production quantities is SGU, 2002.

In region 5 there was only one active production area for energy peat, Smörmyren. The producer was contacted but did unfortunately not have any of the required measurements (pers comm. Mats Nilsson, 2003).

4 Assumptions, Limitations and Uncertainties

Since mires are very heterogeneous there might be variation in peat characteristics within a single production site. In this study many of the peat analyses from the different mires consisted of one or two composite samples, where peat samples from different depths in the mire are mixed. The reason for depth variation of peat characteristics in a mire is mainly due to the different stages of decomposition and age. Therefore the analyses on composite samples (i.e. analyses on a mixture of peat samples from different depths) might reflect the entire production from a site better than a sample taken from harvested peat (which only reflects one level in the mire). If measurements reflecting one level only are used, possible losses through oxidation during the drainage stage and harvest handling will not be included. However, when comparing analyses on composite samples with those of harvested peat from the same production site, the differences in carbon and energy content have shown to be small.

The water content of the peat is of great importance to the net calorific value and hence the emission factor. No complete compilation of moisture content of combusted peat was made. Data on water content from the producers fell, with one exception, in the interval 40-50 %. The exception is peat produced by HMAB, which consists of peat bricks with a very low water content and are sometimes mixed with wood. No analyses of these peat bricks were included in this study, still analyses of pure peat from some of the HMAB production sites were available and was used. Instead of making distinguished assumptions on the water contents of the peat from each specific production site, the emission factor was calculated for a number of different water contents.

The weight factor used when calculating the national average emission factor from the individual emission factors of each of the selected production sites was the annual production in year 2002. The weather determines the harvesting possibilities and the variation between years could be significant. The early part of the harvesting season 2002 was quite wet (pers. comm. Larsson, 2003) and this could alter the relation between amount of harvested sod peat and harvested milled peat. However the impact on the national average emission factor should not be significant. The arithmetic mean of the emission factors from each production site only differs slightly (< 1%) from the weighted mean.

It is not uncommon to calculate the net calorific value of peat (and other fuels) on an ash free basis. This has not been done in this study. The reason is that according to the IPCC methodology on calculating emissions, a separate oxidation factor should be used. In the new guidelines on monitoring and reporting of greenhouse gas emissions given by the EU Commission for the reporting of emissions in the EU ETS (emission trading scheme) it is possible to use specific oxidation factors that are based on the coal content of the ashes and other by-products (Commission Decision 29/01/2004). According to Jirjis (pers. comm. 2003) and Burvall (pers. comm. 2003) to use a separate oxidation factor (separate form the emissions factor) is the most appropriate procedure since the ashes will always be included in the combustion, i.e. there is no way to separate it before the combustion. However, calculations of the emission factor performed on net calorific values on ash free basis show that the differences to the ones resulting from this study are small.

5 Data

In Table 5.1 the data used in the calculations of the emission factor is presented. For a more complete information of each of the chosen production sites, see Appendix.

Table 5.1 **Data from producers used in calculations**

Mire	C wt %[2]	H wt %[2]	O wt %[2]	N wt[2] %	Ash wt[2] %	S wt[2] %	GCV [MJ/kg ts[3]]	NCV [MJ/kg ts[3]]
Kaartivuoma	51,1							19,43
Skråttmyran	51,7	6,0	34	1.7	6.6	0.2	21.96	
Stomyran i Sidskogen	50.9	6.2	35	2.0	6.4	0.2	22.7	
Saltmyran A+C	53.6							20.87
Sjulsmur	55							19.76
Röjnoret 1B	56.7							20.90
Norrbomuren	54							20.87
Orrslätten	54.1	5.6	32.4	1.9	5.7	0.36	21.39	
Porlamossen	54.2	5.7	33.4	1.8	4.7	0.24	21.7	
Västkärr	53.2	5.4	31.1	2.4	7.5	0.40	21.14	
Espenäsmossen	56.1	5.3	34.2	1.2	2.9	0.28	22.65	21.49
Hällarydsmossen	54.6	5.9	38.0	1.0	1.0	0.13	21.57	
Rastamossen	54.1						20.77	
Stänges-Forellmossen	54.2	6.0	1.5				22.25	
Sickelmyren	53.9							21.06
Slåttkölen	54.4							21.96
Översjökölen	53.4							21.52
Rössjeflyet	53.07							21.45
Stackflon	53.71							21.00

[2] wt % is the percentage by weight on dry basis

[3] MJ/kg ts is the calorific value based on dry substance.

6 Results

6.1 Accuracy of old calculations and analyses

The old peat analyses that indicated a lower emission factor were performed on behalf of Vattenfall Värme Uppsala Ltd (former Uppsala Energi) on peat delivered from HMAB and Råsjö Torv Ltd. These measurements were done about three years ago and the peat from HMAB was actually peat bricks with a wood content of about 30% (pers. comm. Roland Forsberg, 2003). The analyses gave the gross calorific values, hence the net calorific values had to be calculated. The calculations of the emission factors had not been done according to the IPCC (Houghton et al. 1996) and EMEP/CORINAIR (EEA 2003) methodologies. One very important part of the calculations that differed from the IPCC (Houghton et al. 1996) and EMEP/CORINAIR (EEA 2003) methodologies was the consideration of the water content.

6.2 CO_2 emission factor according to new calculations

In Table 6.1 the results of the new calculations of the emission factor is presented. The mean values have been calculated by using annual production at each site as a weight factor. The results show that higher water content results in a higher emission factor (due to the lower net calorific value). The table also contains a compilation of the difference between the emission factors calculated in this study and the emission factor recommended by the IPCC, 105.9 g CO_2/MJ, and the one used by the Swedish Environmental Protection Agency in Sweden's National Emission Inventory Report, 107.3 g CO_2/MJ. A negative value mean that the calculated value is lower than the recommended value and a positive value mean that the calculated value is higher than the recommended.

Table 6.1: The CO_2 emission factor

	Emission factor [g CO_2/MJ]		Difference between mean value and emission factor recommended/used by:	
Moisture Content	Mean (min – max)	Standard deviation	IPCC [%]	NIR [%]
0 % (dry)	95.0 (86.4-102.0)	3.9	-10.3	-11.4
6 %	95.8 (87.0-102.8)	3.9	-9.6	-10.8
40 %	103.2 (93.5-111.1)	4.4	-2.6	-3.9
45 %	105.2 (95.2-113.4)	4.6	-0.7	-2.0
50%	107.8 (97.5-116.4)	4.8	1.8	0.4

A negative sign of the difference mean that the value calculated in this study is lower than the recommended value and a positive value mean that the calculated value is higher than the recommended.

7 Discussion

According to Penman et al. (2000), national emission factors for fuels should be determined by selecting data from fuel suppliers/ fuel suppliers' organisations or plant operators. Then the calculated values should be compared to the default values given by Houghton et al. (1996). Only if the difference is significant, approximately more than 2%, one should bother to investigate the emission factor further. In the case of a significant difference one should ask fuel research laboratories to provide references and then try to find an explanation to the difference. If a good explanation is found one could use the new emission factor. In the case of this study the difference between the obtained value of the emission factor and the default value given by Houghton et al. (1996), was not significant for a moisture content of 45-50%. Neither was the difference, for a moisture content of 45-50%, between obtained value and the value used in Sweden's National Emission Inventory Report 2003 significant. If the actual moisture content is higher or lower, the difference between obtained value and default values will be significant. Therefore it is very important to know what the actual moisture content, i.e. the net calorific value, of the combusted peat is.

In Sweden's National Emission Inventory Report 2003 the thermal value (net calorific value) of the Swedish peat used for energy and heat production is reported to be 9.91 MJ/kg. With the characteristics of the peat obtained in this study that corresponds to a moisture content of ~ 45%. According to Fink et al. (2003), Statistics Sweden determines the thermal value. This is done by collecting data from peat consumers i.e. combustion plants (pers. comm. Olsson, 2003).

It is also important to be aware of the fact that peat may have water contents that differ significantly from 45-50%. HMAB produces peat bricks with a very low moisture content (6-10%). The peat is dried industrially and then mixed with wood. Today these peat bricks constitutes a significant amount of the combusted peat in Sweden (pers. comm. Larsson, 2003). There might be reasons to treat this mixed fuel separately but the question should be investigated further.

8 Conclusions

Assuming a moisture content of approximately 45 - 50%, the calculated CO_2 emission factor for peat combustion does not differ significantly from the emission factor used in Sweden's National Emission Inventory Report. Neither does the emission factor at that water content differ significantly from the value recommended by the IPCC. A moisture content of 45-50% is likely to be a good estimate for most peat producers. Therefore either the already used value of 107.3 g CO_2/MJ or the default value given by Houghton et al. (1996) could be used in Sweden's National Emission Inventory Report. However, the documentation about the currently used national emission factor is poor. There might be a reason to use the default value recommended by Houghton et al. (1996). The reason for this is also that a moisture content of 45% seem to be a good estimate of the actual average, both according to the data obtained in this study and the Statistics Sweden (see Section 7), which, according to this study corresponds to an emission factor of 105.2 g CO_2/MJ which is very close to the IPCC value of 105.9 g CO_2/MJ. There are reasons to treat the combustion of peat bricks with a significant wood content and significantly lower moisture content differently. The wood content should not be considered as a fossil fuel and the lower moisture content results in a lower emission factor.

9 Recommendations

The water content and the net calorific value of peat are of great importance to the emission factor. Peat bricks with very low moisture content (and sometimes also a significant wood content) which today represent a considerable amount of the total use of energy peat in Sweden could be ascribed a lower emission factor than the one used in the Swedish national emission inventory and the one recommended by the IPCC. One could argue that dried peat will cause extra use of energy and should therefore not have a lower emission factor. But if other energy sources are used to dry the peat, those should be associated with emission factors if they result in CO_2 emissions. Thus we recommend that when performing emission inventories, the possibility to classify peat according to moisture content and apply the most appropriate combustion emission factor to each class should be considered.

10 References

10.1 Literature

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Appendix

The bold values given in the column with data collected from producers are the ones that have been used to calculate the emission factor.

Mire/ Production area	Fraction of sod peat (sp) & milled peat (mp)	Data collected	Method	Emission factor [g CO_2/MJ] at given MC
Kaartivuoma	sp = 61% mp = 39 %	Ash = 7.56 C = 51.1 H = 5.69 O = 32.8 N = 2.28 S = 0.33 GCV = - NCV = 19.43 MC = 35 (sp), 45 (mp)	The NCV is an average of measurements on the 2002 production. The NCV from the concession application is 20,31 MJ/kg. The producer expects that the ash content will decrease and the NCV will increase in the future. C, H, O, N, S are averages for the 2002 production. The MC values are the ones aimed for.	dry = 96.6 6% = 97.4 40% = 105.5 45% =107.7 50% = 110.5
Skråttmyran	sp = 45% mp = 55 %	Ash = 6.6 C = 51.7 H = 5.96 O = 34 N = 1.7 S = 0.2 GCV = 21.96 NCV = calculated MC = 40 (sp), 50 (mp)	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements. The MC's are estimated values from the producer and is general for their total production.	dry = 91.5 6% = 92.2 40% = 99.3 45% =101.3 50% =103.8
Stormyran i Sidskogen	sp = 100 % mp = 0 %	Ash = 6.4 C = 50.9 H = 6.2 O = 35 N = 2.0 S = 0.2 GCV = 22.78 NCV = calculated MC = 40 (sp), 50 (mp)	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements. The MC's are estimated values from the producer and is general for their total production.	dry = 86.4 6% = 87.0 40% = 93.5 45% =95.2 50% =97.5
Saltmyran A+C	sp = 0 % mp = 100	Ash = - C = 53.6 H = - O = - N = - S = - GCV = - NCV = 20.87 MC = -		dry = 94.1 6% = 94.8 40% = 102.1 45% = 104.1 50% =106.6
Sjulsmur	sp = 86 % mp = 14 %	Ash = 10.1 C = 55 H = 5.5 O = - N = - S = - GCV = 21.79 NCV = 19.76 MC = -	The carbon content is an estimate done by the producer. The produced peat at Sjulsmur is starrtorv and the mean value for carbon content is 55. The NCV is the mean value from measurements on 2002 production (24 measurements).	dry = 102.0 6% = 102.8 40% = 111.1 45% =113.5 50% =116.4
Röjnoret 1B	sp = 6 % mp = 94 %	Ash = 4.3 C = 56.7 H = 5.89 O = N = - S = 0.4 GCV = 22.90 NCV = - MC = -		dry = 101.8 6% = 102.6 40% = 110.6 45% =112.8 50% =115.6

Mire/ Production area	Fraction of sod peat (sp) & milled peat (mp)	Data collected	Method	Emission factor [g CO_2/MJ] at given MC
Norrbomuren	sp = 100 % mp = 0 %	Ash = 2.4 C = 54 H = O = - N = - S = - GCV = NCV = 20.87 MC = - NCV =	The carbon content is an estimate done by the producer. The produced peat at Sjulsmur is vitmossetorv and the mean value for carbon content is 54%. The NCV is the mean value from measurements on 2001 and 2002 production (7 measurements). The mean NCV from the concession application (1982) is 20,0. The ash content is an average from the concession application.	dry = 94.8 6% = 95.5 40% = 102.8 45% =104.8 50% =107.4
Orrslätten	sp = 0 % mp = 100 %	Ash = 5.7 C = 54.1 H = 5.6 O = 32.4 N = 1.9 S = 0.36 GCV = 21.39 NCV = calculated MC = -	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements.	dry = 98.2 6% = 99.0 40% = 106.8 45% =109.0 50% =111.7
Porlamossen	sp = 0 % mp = 100 %	Ash = 4.7 C = 54.2 H = 5.7 O = 33.4 N = 1.8 S = 0.24 GCV = 21.76 NCV = calculated MC = -	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements.	dry = 96.7 6% = 97.5 40% = 105.1 45% =107.2 50% =109.8
Västkärr	sp = 25 % mp = 75 %	Ash = 7.5 C = 53.2 H = 5.4 O = 31.1 N = 2.0 S = 0.40 GCV = 21.14 NCV = calculated MC = -	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements.	dry = 98.0 6% = 98.8 40% = 106.7 45% =108.9 50% =111.7
Espenäsmossen	sp = 50 % mp = 50 %	Ash = 2.88 C = 56.06 H = 5.34 O = 34.24 N = 1.18 S = 0.28 GCV = 22.65 NCV = 21.49 MC = -	The measurements are performed on peat harvested during 1998. The NCV was calculated according to the SS-ISO 1928 standard. Measurements were made at five different locations on the mire. The moisture content of the peat generally is about 40% but at times it can be over 50%.	dry = 95.6 6% = 96.3 40% = 103.4 45% =105.4 50% =107.8
Hällarydsmossen	sp = 75% mp = 25 %	Ash = 1.0 C = 54.6 H = 5.9 O = 38.0 N = 1.0 S = 0.13 GCV = 21.57 NCV = calculated MC = -	The values are the results of measurements on peat performed at the combustion plant in Uppsala (Vattenfall Värme Uppsala). The NCV has been calculated from these measurements.	dry = 98.0 6% = 98.7 40% = 106.5 45% =108.6 50% =111.3

Mire/ Production area	Fraction of sod peat (sp) & milled peat (mp)	Data collected	Method	Emission factor [g CO_2/MJ] at given MC
Ryds mosse / Rasta mossen	sp = 100 % mp = 0 %	Ash = 1.47 C = 54.1 H = - O = - N = 1.23 S = 0.21 GCV = - NCV = 20.77 MC = -	The ash, S and NCV values are averages from 15 measurements. The N-value is an average of 3 measurements. The carbon content is measured on harvested peat.	dry = 95.4 6% = 96.2 40% = 103.5 45% =105.6 50% =108.1
Stänges-Forellmossen	sp = 100 % mp = 0 %	Ash = C = 54.2 H = O = N = S = GCV = NCV = 22.25 MC = -	The NCV value is an average from composite sample and the carbon content is measured on harvested peat.	dry = 94.8 6% = 95.5 40% = 102.8 45% =104.8 50% =107.3
Sickelmyren	sp = 0 % mp = 100 %	Ash = 3.53 C = 53.85 H = - O = - N = - S = - GCV = NCV = 21.06 MC = -		dry = 93.7 6% = 94.4 40% = 101.5 45% = 103.5 50% = 106.0
Slåttkölen	sp = 0 % mp = 100 %	Ash = 2.46 C = 54.39 H = - O = - N = - S = - GCV = NCV = 21.96 MC = -		dry = 90.8 6% = 91.4 40% = 98.0 45% = 99.8 50% =102.1
Översjökölen	sp = 0 % mp =100 %	Ash = 2.56 C = 53.4 H = - O = - N = - S = - GCV = NCV = 21.52 MC = -		dry = 90.9 6% = 91.6 40% = 98.4 45% = 100.2 50% =102.5
Rössjeflyet	sp = 0 % mp = 100 %	Ash = 4.39 C = 53.07 H = - O = - N = - S = - GCV = NCV = 21.45 MC = -		dry = 90.7 6% = 91.3 40% = 98.1 45% = 100.0 50% =102.3

Mire/ Production area	Fraction of sod peat (sp) & milled peat (mp)	Data collected	Method	Emission factor [g CO_2/MJ] at given MC
Stackflon	sp = 0 % mp = 100 %	Ash = 4.6 C = 53.71 H = - O = - N = - S = - GCV = NCV = 21.00 MC = -		dry = 93.7 6% = 94.4 40% = 101.6 45% = 103.6 50% =106.0

Used abbreviations:

Ash = ash content [% weight]

C = carbon content [% weight]

H = hydrogen content [% weight]

O = oxygen content [% weight]

N = nitrogen content [% weight]

S = sulphur content [% weight]

GCV = gross calorific value [MJ/kg dry substance]

NCV = net calorific value [MJ/kg dry substance]

MC = moisture content

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