6

Peat

Contents

Strategic insight

1 Introduction

Peat is the surface organic layer of a soil, consisting of partially decomposed organic material, derived mostly from plants, that has accumulated under conditions of waterlogging, oxygen deficiency, acidity and nutrient deficiency. In temperate, boreal and sub-arctic regions, where low temperatures (below freezing for long periods during the winter) reduce the rate of decomposition, peat is formed from mosses, herbs, shrubs and small trees (Joosten & Clarke, 2002). In the humid tropics, it is formed from rain forest trees (leaves, branches, trunks and roots) under near constantly high temperature (Page et al., 1999).

Peatlands are areas of landscape, with or without vegetation, that have a naturally accumulated peat layer at the surface. (Figures 6-1 and 6-2). For land to be designated as peatland, the thickness of the peat layer must be at least 20 cm if drained, and 30 cm if undrained. Peatland reserves are most frequently quoted on an area basis because initial inventory normally arises through soil survey or remote sensing. Even where peat deposit thickness and total peat volumes are known, it is still not possible to quantify the reserves in energy terms because the energy content of in-situ peat depends on its moisture and ash content. The organic component of peat deposits has, however, a fairly constant anhydrous, ash-free calorific value of 20-22 MJ/kg and, if the total quantity of organic material is known, together with the average moisture and ash content, then the peat reserve can be expressed in standard energy units.

The Nature of Peatlands and Peat

Globally, peatlands are major stores of carbon. Peatlands are also vital environmental 'regulators'. Peat is accumulating on the ground all the time and the top layers of mires and

Figure 6-1
Cranberry Moss, a natural Peatland in the Midlands of England
Source: Jack Rieley

Figure 6-2
Undrained peat swamp forest in Central Kalimantan, Indonesia
Source: Jack Rieley

peatlands form complex ecosystems. Joosten and Clarke (2002) describe peatlands as analogous to living organisms because they grow, mature and may even die. Joosten and Clarke continue: peat is 'sedentarily accumulated material consisting of at least 30% (dry weight) of dead organic material'. Peat is the partly decomposed remains of the biomass that was produced, mostly by plants, on waterlogged substrates; it is mostly water saturated and therefore not compacted. The peat harvested today in the northern hemisphere was formed mostly during the Holocene epoch (the last 10 000 years), after the retreat of the glaciers that once covered most parts of the Northern Hemisphere. Those plant species, which formed the basal peat, are still forming peat today.

2. Technical and economic considerations

Resources

The estimation of peat resources on a global scale is difficult and data for many countries are imprecise or only partially ascertained. Never the less it is clear that the world possesses huge reserves of peat overall (Figure 6-3 overleaf). The total area of pre-disturbance peat-land, based on reports from WEC Member Committees and published sources notably, Immirzi et al. (1992) and Joosten & Clarke (2002), is about (4 million km^2, equivalent to 3% of the world's land surface (Table 8-1). Most of the world's peatland is in North America and the northern parts of Asia with large areas in northern and central Europe and in Southeast Asia, whilst some are in tropical Africa, Latin America and the Caribbean (Table 8-2). 85% of the global peatland area is in only four countries, Russia, Canada, USA and Indonesia. Large areas of peatland in Europe, totalling 450 000 km^2 (11 % from the total global area), have been utilised for centuries for agriculture and forestry (Figure 8-4). According to Immirzi et al. (1992), 40% of the peatland area in Europe and 5% overall in the rest of the world has been used in these ways although, since their assessment was published, large areas of peatland in Indonesia and Malaysia have been deforested, drained and converted to agriculture for arable crops and plantations. A relatively small area (5 000 km^2 or only 0.1 % of the total peatland area) has been used to extract peat for energy, horticulture and a range of other industrial and medical uses (Figure 6-4).

Figure 6-3
Global distribution of mires
Source: International Peat Society

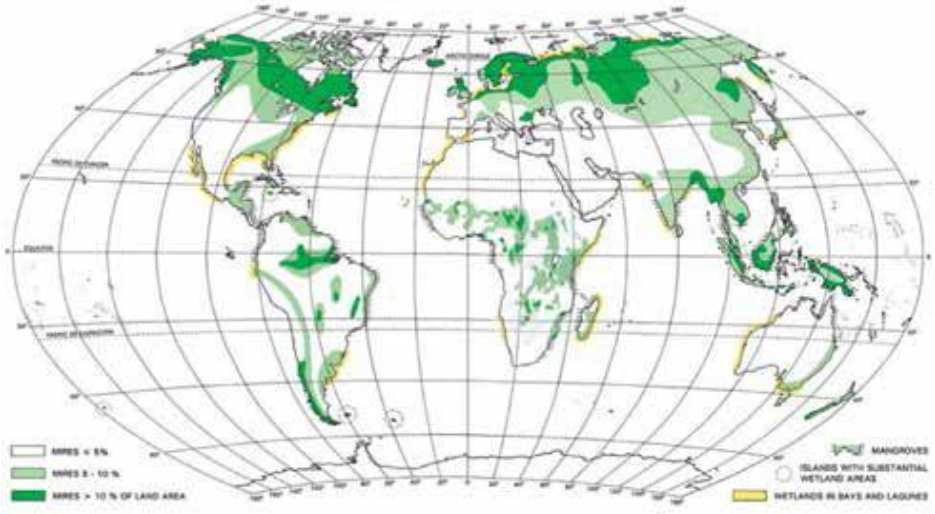
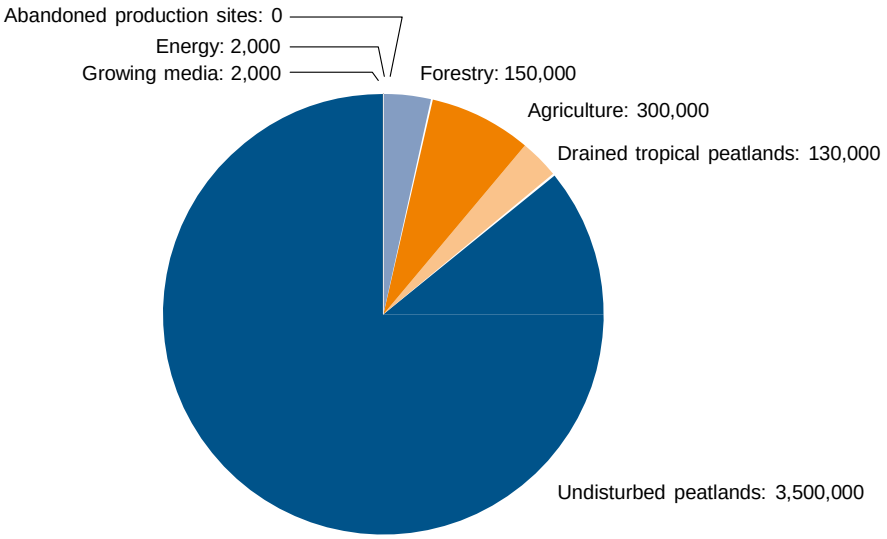


Figure 6-4
Uses of peatland
Source: International Peat Society



The average thickness of the peat layer is difficult to determine precisely owing to a lack of data for most countries. This makes it virtually impossible to determine accurately the overall volume of peat and therefore the amount of carbon it contains. Immirzi et al., (1992) used an estimated global mean thickness of 1.5 metres while Gorham (1991) used 2.3 for boreal and subarctic peatlands. The thickness of tropical peatland is likely to be greater. An indicative estimate of the total volume of peat in situ is in the order of 6,000 to 13,800 billion m^3, containing 300 to 695 billion tonnes (109) of carbon. According to Strack (2008) the global peat carbon pool is in the region of 500 billion tonnes. The peat reserve base in major extraction (mainly for energy and horticulture) countries (including 'reserves currently under active cultivation or economically recoverable under current market conditions') has been assessed (Couch, 1993) as 5,267 million tonnes (air-dried).

Production Methods

Peat is either extracted as sods (traditionally hand-cut, nowadays predominantly harvested mechanically) or as fine granules (using a mechanical miller to disturb and grind the top layer of the peat bog surface)) (Figures 6-5 and 6-6). Peat in situ contains

Figure 6-5
Peat milling machine. A 25-40 mm layer is removed from the surface of the peat production site and dried in the sun
Source: Association of Finnish Peat Industries

Figure 6-6
After milling peat is turned 3-5 times to speed up the drying process.
Source: Association of Finnish Peat Industries

around 90% water; some of which is removed by drainage and most of the remainder by drying in the sun and wind. The resulting 'air-dried' peat has a moisture content of 40-50%. The bulk of peat production for energy use is obtained by milling and used in electricity or heat generation. A proportion of the milled peat is converted into briquettes, which provide a convenient household fuel. The main countries producing and using fuel peat are Belarus, Estonia, Finland, Indonesia, Ireland, Russian Federation and Sweden (Table 6-3).

3. Market trends and outlook

Uses of Peat

Peat has a large number of uses, which may be classified under three headings:

- Energy (as fuel for electricity/heat generation, and directly as a source of heat for industrial, residential and other purposes) (Figures 6-7 and 6-8 – see page 5);
- Horticultural and agricultural (e.g. as growing medium, soil improver, cowshed/stable litter, compost ingredient);
- Other (e.g. as a source of organic and chemical products such as activated carbon, resins and waxes, medicinal products such as steroids and antibiotics, and therapeutic applications such as peat baths and preparations).

The report: "Fuel Peat industry in EU" (Paappanen, Leinonen and Hillebrand, 2006) summaries fuel peat utilization in European Union fuel peat countries as follows (Table 6-4):

> *"The total annual peat use during the 2000´s has been 3 370 ktoe. The three largest users are Finland (59 % of total use), Ireland (29%) and Sweden (11%), corresponding to 99% of the total use. Peat is used in central heating power plants (CH) (45% of the total use), in condensing power generation (CP) (38%), district heating (DH) (10%) and residential heating (RH) (8%). The total number of power plants is 125. The approximate number of people receiving heating energy from peat is 1.94 million.*

Figure 6-7
Greenhouses in Finland heated with sod peat
Source: Association of Finnish Peat Industries

Figure 6-8
Forssan Energia, Finland, uses both peat and wood-based fuels in combined heat and power production.
Source: Association of Finnish Peat Industries

Figure 6-9
Drained and burned peat swamp forest in Central Kalimantan, Indonesia.
Source: Jack Rieley

The total annual value of fuel peat sales is 390 million Euros. The total employment effect of peat production and use is 13 100 – 16 100 man years, including direct and indirect employment.

The total primary energy consumption in the six EU countries mentioned in the Report is approximately 120 Mtoe of which about 3.8 Mtoe is produced with peat. Therefore the overall share of peat of primary energy consumption is 3% in these countries.

In Finland and in Ireland about 5–7% of primary energy consumption relies on peat. In Estonia and Sweden this share is 1.9% and 0.7% respectively. In Latvia and Lithuania peat makes a smaller contribution to primary energy consumption.

The importance of peat at national level is most significant in Finland, where over 22% of all fuel used by CH plants is peat. In DH plants this share is 19%, and 8% for CP generation. The use of peat and wood is bound together. Owing to technical and economic reasons peat cannot be replaced fully with wood or other renewable or recyclable fuels. Peat also decreases the dependence of energy production on imported fuels. The only alternative to peat is coal, which cannot replace all of the peat, because of the technical characteristics of boilers.

In Ireland, that does not have any fossil fuel reserves, peat is an important source of domestic energy, and therefore it is included in the fuel mix. One of the principle energy sectors in Ireland is the electricity sector and of this peat contributes 8.5%. In Estonia about 4% of district heat is produced using peat. In Sweden the importance of peat at a national level is relatively low, 0.7% of primary energy consumption, but of CH and DH the peat share is 4% and 6%, respectively.

The regional benefits of peat production are mostly directed to rural areas, which suffer from migration of young people and from a workforce with a high average age, as well as from relatively low levels of income. Peat contractors usually also practice agriculture or forestry or some kind of contracting work. Therefore peat brings extra income to people and regions that are less developed economically.

Peat has both a short-term and a long-term role in security of energy supply. For example in Finland and Estonia the reserve supplies correspond to 7–17 months use, which can easily cover short-term interruptions in energy supply."

Peat from a Climate Impact Point of View

The Intergovernmental Panel on Climate Change (IPCC) changed the classification of peat from fossil fuel to a separate category between fossil and renewable fuels (25th session of IPCC, Port Louis, Mauritius, 2006). Peat now has its own category: 'peat'. The emission factor of peat is similar to fossil fuels.

Strategy for Responsible Peatland Management

In 2010, the International Peat Society (IPS) launched a globally applicable "Strategy for Responsible Peatland Management". The two-year development process for the Strategy included collaboration with a wide range of interested parties, including universities, the peat-producing and using industry and several non-government organisations.

The Strategy (SRPM) is now widely used in national policy development as well as a basis for several peatland certification schemes, such as Veriflora in Canada, the voluntary Code of Conduct of the European Peat and Growing Media Association (EPAGMA) and a special certification project for peat used in horticulture currently being planned in the Netherlands.

The main objective of the SRPM is to manage peatlands responsibly for their, environmental, social and economic values, according to the following priorities:

- Biodiversity
- Hydrology and water regulation
- Climate and climate change processes
- Economic activities
- After-use, rehabilitation and restoration
- Human and institutional capacity and information dissemination
- Engagement of local people
- Good governance

The Responsible Peatland Management Strategy encompasses all uses of peatlands and includes nature conservation and protection, various forms of economic use, as well as recreational and traditional uses. It sets out practical objectives for peatland management applicable at several levels (global, regional, national and sub-national) and identifies actions that will contribute to responsible management of peatlands.

By presenting commonly accepted principles, it provides a framework for the future development of a more detailed standard for peatland management to be used in voluntary certification. For more information, please visit www.peatsociety.org.

Balance of Peat Usage and Life-Cycle Analysis

The total production area for fuel peat in the EU amounts to 1 750 km^2 (0.34% of the total peatland area). The total annual use of fuel peat has amounted to 12 million delivered tonnes of peat (4 million tonnes of carbon) during recent years (Paappanen, Leinonen and Hillebrand, 2006). The world's annual peat harvest is equivalent, according to Joosten and Clarke (2002), to about 15 million tonnes of carbon.

The present sequestration rate of carbon in all mires of the World is estimated to be 100 million tonnes annually (Strack, 2008), thus exceeding the annual use of peat 3 to 6 times, although areas where peat is accumulating are not necessarily the same as those being used. Peat extraction and peat accumulation may be in global balance but this is not necessarily so on a country or regional basis.

Many peatlands globally, which were drained and used for agriculture and forestry in the past, are now sources of greenhouse gases, owing to degradation and oxidation of the unsaturated peat layer. If these areas are not significant sources of food or other income for local people, they could be used for peat production and afterwards transformed relatively easily into carbon sinks by rewetting them. They could be restored to peat-forming mires, reclaimed to forests or planted with energy crops. These new carbon sinks will be needed in coming decades. The possibility of reusing energy peat production sites as new carbon sinks constitutes another difference between peatlands and fossil fuel producing coal mines and oil wells.

Wise Use of Peat

The International Peat Society (IPS) joined with the International Mire Conservation Group (IMCG) to develop a procedure for the reasoned and wise use of peat and peatlands globally (Joosten and Clarke, 2002). This contains sound advice for the peat industry to adopt the 'Wise Use' approach and will mean that most of the remaining peat bogs in Europe and North America will not be utilised (less than 0.4% of the total peatland area in Europe is currently used in this way) and those that are will have after-use plans, to be implemented at the industry's expense once the extraction work has ended. In most cases, former extraction sites are destined to become CO_2 sinks once again.

In order to put CO_2 emissions into context, it is important to emphasise that most of the carbon released from peatland in the world today occurs in tropical Southeast Asia as a result of large scale land use change and fire (Figure 8-7). In 1997, between 0.87 and 2.57 billion tonnes of carbon (equivalent to 2.9-8.5 billion tonnes CO_2) were discharged into the environment as a result of forest and peat fires in Indonesia in just 4 months (Page, et al. 2002). Since then, it is estimated that an average of around 2 billion tonnes of CO_2 have been released every year from peatland in Southeast Asia, as a result of peatland deforestation, drainage, degradation and conversion to oil palm and paper pulp tree plantations (Figure 8-9). This is equivalent to about 30% of global CO_2 emissions from fossil fuels (Hooijer, et al., 2006). Developed countries should assist in the wise use of tropical peatlands in agriculture and forestry, in order to prevent thoughtless release of CO_2 into the atmosphere. From a climate-impact point of view peat is much more acceptable than fossil fuels and if peat can be used in a wise way this will be to the benefit of mankind now and in the future.

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International Peat Society

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Web sites for further information

International Peat Society www.peatsociety.org
World Resources Institute www.wri.org

Global tables

Table 6.1
Peat: areas of peatland (square kilometres)

Russian Federation	1 390 000
Canada	1 113 280
United States of America	625 001
Indonesia	206 950
Finland	89 000
Sweden	66 000
China	53 120
Peru	50 000
Norway	28 010
United Kingdom	27 500
Malaysia	25 889
Brazil	23 875
Belarus	23 500
Germany	13 000
Poland	12 500
Zambia	12 201
Ireland	11 800
Falkland Islands	11 510
Papua New Guinea	10 986
Chile	10 472
Venezuela	10 000
Sudan	9 068
Estonia	9 020
Guyana	8 139
Iceland	8 000
Ukraine	8 000
Panama	7 870
Uganda	7 300
Cambodia	7 000
Latvia	6 600
Congo (Brazzaville)	6 220
Cuba	5 293
Colombia	5 043
Ecuador	5 001
Honduras	4 530
Nicaragua	3 710
New Zealand	3 610
Lithuania	3 520
Antarctica	3 000
Congo (Democratic Rep.)	2 800
Botswana	2 625
Kenya	2 440
Argentina	2 400

Japan	2 000
Guinea	1 952
Madagascar	1 920
French Guiana	1 620
Nigeria	1 600
France	1 500
Zimbabwe	1 400
Denmark	1 400
Korea (Democratic People's Rep.)	1 360
Australia	1 350
Myanmar (Burma)	1 228
Surinam	1 130
Cameroon	1 077
Mexico	1 000
Uruguay	1 000
Romania	1 000
Brunei	909
Rwanda	830
Belize	735
Côte d'Ivoire	725
Philippines	645
Thailand	638
Mozambique	575
Gabon	548
Vietnam	533
Bolivia	509
Malawi	492
Mali	400
India	400
Bangladesh	375
Costa Rica	370
Hungary	330
Burundi	323
South Africa	300
Italy	300
Serbia and Montenegro	300
Switzerland	300
Angola	264
Ethiopia	200
Georgia	200
Laos	200
Austria	200
Czech Republic	200
Albania	179
Belgium	160
Sri Lanka	158
Bosnia-Herzogovina	150
Jamaica	128
Liberia	120
Haiti	120
Afghanistan	120
Turkey	120
Benin	100

Central African Republic	100
Gambia	100
Tanzania	100
Puerto Rico	100
Paraguay	100
Kyrgyzstan	100
Pakistan	100
Slovenia	100
Iraq	100
El Salvador	90
St Helena	80
Greece	71
Mauritania	60
Spain	60
Ghana	59
Armenia	55
Kazakhstan	50
Mongolia	50
Egypt (Arab Rep.)	46
Israel	40
Fiji	40
Senegal	36
Micronesia	33
Niger	30
Faroe Islands	30
Macedonia (Rep.)	30
Slovakia	26
Bulgaria	25
Lesotho	20
Portugal	20
Algeria	10
Burkina Faso	10
Chad	10
Morocco	10
Namibia	10
Togo	10
Bahamas	10
Dominican Republic	10
Trinidad & Tobago	10
Azerbaijan	10
Moldova	10
Iran (Islamic Rep.)	10
Solomon Islands	10
Greenland	5
Korea (Republic)	5
Andorra	5
Luxembourg	3
Syria (Arab Rep.)	3
Guadeloupe	2
Kiribati	2
Mauritius	1
Réunion	1
Sierra Leone	1

Tunisia	1
Bermuda	1
Dominica	1
Martinique	1
St Kitts & Nevis	1
Guatemala	1
Bhutan	1
Cyprus	1
Maldives	1
Nepal	1
Singapore	1
Azores	1
Croatia	1
Liechtenstein	1
Jordan	1
Lebanon	1
Palau	1
Samoa	1
World Total	**3 973 503**

Table 6.2
Global peatland area by region

Sources: Immirzi et al. (1992); Joosten and Clarke (2002); www.carbopeat.org

Region	Peatland Area (km2)
Central and North America	1,762,267
Asia	1,490,361
Europe	525,668
South America	130,800
Africa	56,165
Antarctica, Oceania, Pacific	8,048
TOTAL	3,973,309
Tropical peatland	41,547

Table 6.3
Peat: production and consumption for fuel in 2008 (provisional)

	Source	Production (thousand tonnes)	Consumption (thousand tonnes)
Burundi	www	20	20
Total Africa		20	20
Falkland Islands	estimated	13	13
Total South America		13	13
Austria	IEA	1	1
Belarus	www / IEA (2007)	2 944	2 240
Estonia	Statistics Estonia	214	294
Finland	IEA	4 770	7 910
Germany	IEA		
Ireland	IEA	3 089	4 140
Latvia	Eurostat	11	11
Lithuania	Eurostat	58	36
Romania	IEA (2007)	1	25

Russian Federation	IEA (2007)	1 287	1 176
Sweden	IEA	701	1 065
Ukraine	IEA (2007)	395	383
United Kingdom	Estimated	20	20
Total Europe		13 491	17 301
TOTAL WORLD		**13 524**	**17 334**

Notes:

1. Data on production relate to peat produced for energy purposes; data on consumption (including imported peat) similarly relate only to fuel use
2. Tonnages are generally expressed in terms of air-dried peat (35%-55% moisture content)
3. Sources: *Energy Statistics of OECD Countries*, 2009 Edition, International Energy Agency; *Energy Statistics of Non-OECD Countries*, 2009 Edition, International Energy Agency; Eurostat; web sites; estimates by the Editors
4. Differences between production and consumption can be due to two factors: (i) import and export of peat and (ii) and peat may be stored between years since production can vary significantly between years as a result of differences in weather conditions during the harvesting season.

Table 6.4
Fuel Peat industry in the EU

Source: Paappanen et al., 2006

	Finland	Ireland	Sweden	Estonia	Latvia	Lithuania	Total
"Fuel peat resources, ktoe"	1,100,000	47,500	370,000	10,000	57,000	4,000	1,589,000
"Annual peat use, ktoe"	1980	984	372	28	0	4	3368
"Number of peat producers"	250	300	25	30	11	11	630
Number of machine and boiler manufacturers	22	1	9	9	0	0	41
"Number of peat-fired power plants"	55	3	20	40	0	7	125
"Number of people getting heating energy from peat"	480,000	1,000,000	390,000	65,000	0	0	1,940,000
"Value of domestic trade, million Euro"	204	153	27	2	0	3	390
"Value of international trade, million Euro"	0.5	0.0	16.9	7.1	0.3	0.2	17.9
"Employment, man-years"	7000	2300	1700	2100	0	0	13100

Country notes

The following Country Notes on Peat provide a brief account of countries with significant peat resources. They have been compiled by the Editors, drawing upon a wide variety of material, including information received from WEC Member Committees, national and international publications.

Argentina

Areas of peatland (square kilometres)	2 400
Production (thousand tonnes)	8

The main (about 95%) of peat deposits in Argentina are located on the Isla Grande de Tierra del Fuego in the South of the country. The remaining peat bogs can be found in the highland valleys of the Andean Cordillera and other areas. Production of peat is on a relatively small scale and nearly totally confined to Tierra del Fuego, where circa 3 000 m3 per annum are extracted. Consumption of peat for energy production is currently insignificant, and currently peat is mainly used is as a soil-improvement agent.

Proved recoverable reserves of peat are reported by the Argentinian Member Committee to be 80 million tonnes, within a total proved amount in place of some 90 million tonnes. A further 50 million tonnes of (unproved) resources is estimated to be present, of which some 15 million tonnes is deemed to be recoverable

Belarus

Areas of peatland (square kilometres)	23 500
Production (thousand tonnes)	2.2
Consumption (thousand tonnes)	2

Belarus has the largest peat lands in Eastern Europe (after Russian Federation), amounting to 23 500 km^2. The main areas of peat formation are located in the Pripyat Marshes in the South and in the central area around Minsk. Peat has been used in Belarus as a fuel for many years, with the peak consumption during the 1970's and 1980's. However, since 1986 peat has no longer been used as a fuel for power generation; and the largest part of output in recent years has been used for the production of peat briquettes, mainly for household use.

Out of a total fuel peat production of around 3 million tonnes per annum, briquetting plants account for about 2 million tonnes. heat plants for about 300 000 tpa, with the balance either being exported or consumed by a variety of small-scale consumers. Current annual output of peat briquettes is approximately 1.7 million tonnes, of which about 78% is consumed by residential users.

Brazil

Areas of peatland (square kilometres)	23 875
Production (thousand tonnes)	2500
Consumption (thousand tonnes)	

The total area of peat land in Brazil is estimated to be nearly 24 000 km^2, the second largest in South America after Peru. There are large peat deposits in the Middle Amazon and in a large marshy plain (Pantanal) near the Bolivian border. Smaller areas of peatland are located in coastal areas. Peat lands in the industrialised south-east of Brazil (in the states of Espírito Santo, Rio de Janeiro and São Paulo), and further north in Bahia state. These areas have recently attracted interest as potential sites for the production of peat for energy uses. Experts from the Irish peat authority Bord na Móna carried out preliminary surveys in Brazil in the early 1980s but no production of peat for fuel has yet been established.

The total amount of peat in situ has been estimated as 25 billion tonnes. According to the Ministry of Mines and Energy, 'measured/indicated/inventoried resources' of peat amount to just over 129 million tonnes, with an 'inferred/estimated' additional amount of 358 million tonnes.

Burundi

Areas of peatland (square kilometres)	323
Production (thousand tonnes)	11
Consumption (thousand tonnes)	6

The National Peat Office (ONATOUR) in the country has the mission to exploit and commercialise production and use of peat; primarily in industry and agriculture and conduct further research and studies of the peat potential. Peat has been known in Burundi since the time the country was under Belgian control. Exploitable reserves have been estimated at 57 million tonnes at 30% humidity in an area of around 150 km^2.

ONATOUR is the only enterprise in the Great Lakes region of Africa that mechanically produces peat sods. Since it was established in 1977, 300 000 tonnes, some 0.5% of reserves, have been processed. The major users of peat are military camps and prisons, which account for 90% of production. The remaining 10% is lost during handling or stockpiling. ONATOUR has sold nearly 225 000 tonnes of peat since its formation, with the army being the principal client. Following the acquisition of new production installations, production of peat is expected to increase.

Canada

Areas of peatland (square kilometres)	1 113 280
Production (thousand tonnes)	
Consumption (thousand tonnes)	

Canada's peatlands are estimated to exceed 1.1 million km^2, globally second only to those of the Russia Federation.

There have been a number of assessments of the potential use of peat as a fuel (including for power generation) but at present, peat is not used for energy purposes and it is unlikely

to change in the immediate future. Canada is, however, a major producer (and exporter) of peat for horticultural applications.

China

Areas of peatland (square kilometres)	53 120
Production (thousand tonnes)	
Consumption (thousand tonnes)	

China's peatlands total about 53 000 km^2 and are widely distributed across the country. However, peatlands occupy only about 0.5% of the country's land area, and thus are insignificant to the country's topography. The principal peat areas are located in the region of the Qingzang Plateau in the southwest, in the north-east mountains and in the lower Yangtze plain in the east.

Peat has been harvested since the 1970s for a variety of purposes, including fuel use. Some peat is used in industry (e.g. brick-making), but the major part of consumption is as a household fuel. Peat has been reported to be sometimes mixed with animal dung as input to biogas plants. No information is available on the current level of peat consumption for fuel.

Denmark

Areas of peatland (square kilometres)	1 400
Production (thousand tonnes)	300
Consumption (thousand tonnes)	

Human activities, mainly cultivation and drainage operations, have reduced Denmark's originally extensive areas of peatland from some 20-25% of its total land area to not much more than 3% today. Out of a total existing mire area of 1 400 km^2, freshwater peatland accounts for about 1 000 km^2; the remainder consists of salt marsh and coastal meadow. Commercial exploitation of peat resources is at a low level: in 1995 the area utilised was some 1 200 ha, producing about 100 000 tonnes per annum. Almost all the peat produced is used in horticulture.

Estonia

Areas of peatland (square kilometres)	9 020
Production (thousand tonnes)	
Consumption (thousand tonnes)	

Peatlands are a major feature of the topography in Estonia, occupying about 20% of its total territory. Peatlands are distributed throughout the country, with the largest mires being located on the plains. Estonia has a long history of peat utilisation: mechanised harvesting dates from 1861, whilst the first peat-fired power plant was operating in 1918 and peat briquetting began in 1939. Total peat resources are estimated to be 1.64 billion tonnes, of which active resources amount to 1.12 billion tonnes.

Annual use of peat for fuel has averaged about 350 000 tonnes in recent years but, as in other countries, tends to be highly variable. In thousands of tonnes, A considerable proportion of peat is used to produce briquettes, most of which are destined for export. In 2007,

briquette production totalled 128 000 tonnes, of which 75% was exported, the balance being very largely consumed in the residential sector. As a consequence of the low peat harvest in 2008, output of briquettes in that year was nearly halved. Exports of peat briquettes, however, fell by only 5 000 tonnes, whilst domestic consumption actually increased. This was possible through a substantial drawdown in stocks of briquettes, which fell by 40 000 tonnes.

Most of the consumption of un-briquetted peat is accounted for by district heating and electricity generation (mainly CHP). Some sod peat (27 000 tonnes in 2008) is exported, but annual amounts are highly variable.

Finland

Areas of peatland (square kilometres)	89 000
Production (thousand tonnes)	8.9
Consumption (thousand tonnes)	61

With their total area of some 89 000 km^2, the Finnish peatlands are some of the most important in Europe and indeed globally – Finland has the highest proportion of wetlands of any nation in the world. Peat deposits are found throughout Finland, with a greater density to the west and north of the country.

The area of peat potentially suitable for commercial extraction is 6 220 km^2, of which about 22% contains high-grade peat suitable for horticulture and soil improvement. The remaining 78% (together with other deposits from which the surface layers have been harvested for horticultural use) is suitable for fuel peat production. In 2009, the total area used for peat production was about 630 km^2. The energy content of peat technically suitable for extraction is about 12 800TWh, while the amount of fuel peat consumption has recently varied between 10 and 30TWh/yr.

According to the Association of Finnish Peat Industries, quoted by Statistics Finland, 2008 peat production in Finland – the latest available – rose by nearly 7%. However, 2007 peat production was 66% lower than in the previous year, whereas Finnish consumption of peat fuel grew by about 9% in 2007 over 2006. This apparent discrepancy between supply and demand is an excellent illustration of one of peat's special features. Owing to the vagaries of the weather, in particular the amount of sunshine, wind and rainfall during the peat harvesting, milling and drying season, annual production levels vary greatly. In order to cope with such circumstances, the principal peat-consuming countries maintain large buffer stocks, which enable them to smooth out supplies to power plants and other consumers.

In 2007, CHP plants accounted for almost 52%, and power stations for 30%, of the total national consumption of fuel peat; industrial users consumed 12%, the balance being used in heat plants (5%), and directly in the residential and agricultural sector (1%). The share of peat fuel was about 7% of total energy consumption.

The Keljonlahti hybrid CHP plant (200 MW heat, 210 MW electricity) has been brought into operation in Jyväskylä. The plant uses about 1 million tonnes of wood and peat each year.

Germany

Areas of peatland (square kilometres)	13 000
Production (thousand tonnes)	
Consumption (thousand tonnes)	

The majority of the peatlands are located in the north of Germany such as Lower Saxony, Mecklenburg-West Pomerania and Brandenburg. The German WEC Member Committee reports a total peatland area of some 14 000 km^2 and the proved amount of peat in place is 157 million tonnes, of which about 23% is considered to be recoverable.

Approximately 60% is farmed, with only a small proportion (less than 10%) used for peat production. Energy use of peat is reported to be very limited at present, virtually all production being destined for agricultural/horticultural uses or for the manufacture of activated carbon. A small amount of energy-grade peat is exported.

Greece

Areas of peatland (square kilometres)	71
Production (thousand tonnes)	
Consumption (thousand tonnes)	

Despite the drainage of large stretches of former fenland, and the loss of much peat through oxidation and self-ignition, peat resources in Greece are still quite considerable. The largest deposits are in the north of the country, at Philippi in eastern Macedonia and Nissi in western Macedonia. The Philippi peatland covers about 55 km^2 and is nearly 190 m deep – the thickest known peat deposit in the world.

Fuel Peat: World Resources and Utilisation quotes total reserves as 4 billion tonnes: the proportion of this amount that might be suitable for fuel use is indeterminate.

Peat resources in Greece have not so far been commercially exploited, either for use as fuel or for agricultural, horticultural or other purposes. Schemes for peat-fired electricity generation at Philippi and Nissi have been proposed in the past, but have subsequently been abandoned.

Iceland

Areas of peatland (square kilometres)	8 000
Production (thousand tonnes)	
Consumption (thousand tonnes)	

Peatlands cover 8 000 km^2 or about 8% of Iceland's surface area; the ash content of the peat is usually high (10-35%), owing to the frequent deposition of volcanic ash. Although peat has traditionally been used as a fuel in Iceland, present-day consumption is reported as zero. In the past, an important non-energy application of peat consisted of the use of 'peat bricks' in the construction of buildings.

Indonesia

Areas of peatland (square kilometres)	206 950
Production (thousand tonnes)	
Consumption (thousand tonnes)	

The peatlands are by far the most extensive in the tropical zone (estimated at 207 000 km^2) and rank as the fourth largest in the world: they are located largely in the sub-coastal low-lands of Kalimantan and Sumatra. A feasibility study was carried out between 1985 and 1989 regarding the use of peat for electricity generation in central Kalimantan; no project resulted, but a small peat-fired power plant has operated in southern Sumatra.

Ireland

Areas of peatland (square kilometres)	11 800
Production (thousand tonnes)	2.7
Consumption (thousand tonnes)	539

More than 17% of the republic's land surface is classified as peatland. Peat deposits totalling nearly 12 000 km^2 are widely distributed, being especially prominent along the western seaboard and across the Midland Plain in the centre of the island. Domestic consumption of peat for energy purposes in Ireland dates back to prehistoric times, with documentary evidence of its use from as early as the 8th century. After large stretches of the island's forests were cleared in the 17th century, peat (called 'turf' when cut) became the only fuel available to the majority of households.

Mechanical methods of extraction were adopted on a large scale following World War II, both for the production of milled peat (used as a power-plant fuel and in the manufacture of peat briquettes) and to replace manual cutting of sod peat for household use. Production of fuel peat in 2008 (as reported to the IEA) was about 3.1 million tonnes, with consumption of around 4.1 million tonnes.

Out of the total production of peat for energy purposes in 2007, nearly 67% was used for power generating and heat production, 14% was briquetted and 17% consisted of sod peat, used predominantly as a residential fuel. Peat briquettes are almost entirely used as household fuel.

Since its foundation in 1946, the Irish Peat Development Authority (Bord na Móna) has promoted the economic development of Ireland's peat resources. A number of power generating and briquetting plants have been built near peat deposits. A programme has been undertaken to replace five old peat-fired power plants with three more efficient and more environmentally-friendly peat-fired power plants. The first of the new stations, built by Edenderry Power Ltd near Clonbulloge, County Offaly, with a net output capacity of 120 MW, was commissioned in November 2000. It consumes approximately 1 million tonnes of milled peat per annum. The other new stations were constructed at Lough Ree (100 MW), replacing the existing Lanesboro station in December 2004, and West Offaly (150 MW), which replaced Shannonbridge in January 2005. The peat consumption rates of Lough Ree and West Offaly are 800 000 tpa and 1 245 000 tpa, respectively.

During the last five fiscal years, Bord na Móna's production of milled peat has ranged from 2.5 to 4.2 million tonnes, with an average annual level of just under 3.4 million tonnes. Sales of milled peat to power stations rose from just under 2 million tonnes in 2004/05 to nearly

3.1 million tonnes in 2008/09, in line with the input capacity (quoted above) of the three new peat-fired plants.

In 2008/09, 882 000 tonnes of milled peat were consigned to Bord na Móna's briquetting plants, which produced 217 000 tonnes of peat briquettes during the same period; these levels were close to the five-year averages of 903 000 and 219 000 tonnes respectively.

Italy

Areas of peatland (square kilometres)	300
Production (thousand tonnes)	
Consumption (thousand tonnes)	

There are significant resources of peat in Italy, mostly in the north of the country in areas such as Piedmont, Lombardia and Venezia. Fuel Peat: World Resources and Utilisation gives the estimated reserves as 2.5 billion tones, however the proportion of this that is usable is yet to be determined.

Although peat has been used for fuel during the past, notably in the context of wartime shortages of other sources of energy, no present-day usage has been reported.

Latvia

Areas of peatland (square kilometres)	6 600
Production (thousand tonnes)	25
Consumption (thousand tonnes)	1

Peatlands cover an estimated 6 600 km^2, or about 10% of Latvia's territory, with the major deposits located in the eastern plains and in the vicinity of Riga. Of the estimated total tonnage of peat resources (1 500 million tonnes), 230 million tonnes is suitable for fuel use.

Peat has been used in agriculture and as a fuel for several hundred years: output peaked in 1973, when fuel use amounted to 2 million tonnes. By 1990, the tonnage of peat extracted had fallen by 45% and fuel use was down to only about 300 000 tonnes. There has been a steep decline in consumption since then, with deliveries to the Riga CHP-1 plant coming to an end in 2004. The production of peat briquettes ceased in 2001. Currently, only minor tonnages of peat (less than 10 000 tpa) are consumed by heat plants and industrial users.

Lithuania

Areas of peatland (square kilometres)	3 520
Production (thousand tonnes)	53
Consumption (thousand tonnes)	5

Peatlands (totalling about 3 500 km^2) are widespread, with the larger accumulations tending to be in the west and south-east of the country. About 71% of the overall tonnage of peat resources is suitable for use as fuel. Energy use of peat fell from 1.5 million tonnes in 1960 to only about 0.1 million tonnes in 1985. Since then consumption has declined further to around 65 000 tonnes per year. The principal peat consumers are heat plants, producers of semi-briquettes, and households. They also account for virtually all of Lithuania's modest

consumption of locally-produced peat semi-briquettes, together with briquettes imported from Belarus (8 000 tonnes in 2007).

Norway

Areas of peatland (square kilometres)	28 010
Production (thousand tonnes)	
Consumption (thousand tonnes)	

Although there are extensive areas of essentially undisturbed peatland, amounting to some 28000 km^2, peat extraction (almost all for horticultural purposes) has been at a relatively low level in recent years.

Peat had traditionally been used as a fuel in coastal parts of the country; unrestrained cutting led to considerable damage to the peatland, which in 1949 resulted in legislation to control extraction.

Poland

Areas of peatland (square kilometres)	12 500
Production (thousand tonnes)	
Consumption (thousand tonnes)	

The area of peatland is some 12500 km^2, with most deposits in the northern and eastern parts of the country.

Much use was made of peat as a fuel in the years immediately after World War II, with some production of peat briquettes and peat coke; by the mid-1960s fuel use had, however, considerably diminished. Current consumption of peat is virtually all for agricultural or horti-cultural purposes.

Romania

Areas of peatland (square kilometres)	1 000
Production (thousand tonnes)	9
Consumption (thousand tonnes)	

There are estimated to be 1000 km^2 of peatlands. Peat production for energy purposes has dwindled to a very low level; annual consumption of around 40 000 tonnes is largely met by imports.

Russian Federation

Areas of peatland (square kilometres)	1 390 000
Production (thousand tonnes)	910
Consumption (thousand tonnes)	10

The total area of peatlands in Russia has been estimated at some 1 390 000 km^2, of which 85% are located in Siberia.

The bulk of current peat production is used for agricultural/horticultural purposes. Peat deposits have been exploited in Russia as a source of industrial fuel for well over a hundred years. During the 1920s, the use of peat for power generation expanded rapidly, such that by 1928 over 40% of Soviet electric power was derived from peat. Peat's share of power generation has been in long-term decline, and since 1980 has amounted to less than 1%.

The main users are CHP plants and briquetting works; most of the residual consumption of peat, whether as such or in the form of briquettes, takes place in the rural residential sector.

Sweden

Areas of peatland (square kilometres)	66 000
Production (thousand tonnes)	702
Consumption (thousand tonnes)	

In Western Europe, the extent of Sweden's peatlands (66 000 km^2 with a peat layer thicker than 30 cm) is second only to Finland's: the deposits are distributed throughout the country, being particularly extensive in the far north.

The use of peat as a household fuel has never been of much significance in Sweden. Production of peat for industrial energy use began during the 19th century and, after reaching a peak level during World War II, declined to virtually zero by 1970. Use of peat as a fuel for power stations and district heating plants started in the mid-1980s and now constitutes by far the greater part of consumption. In 2007, CHP plants accounted for 73% of total consumption, heat plants for 23% and industrial users for the remainder.

Sweden's reliance on peat as a fuel is considerably lower than that of Finland or Ireland, and moreover it imports about a third of its requirements, chiefly from Belarus, Latvia and Estonia. The Swedish Peat Producers Association forecasts that over the longer term peat imports will tend to decrease, as the Baltic States will need to increase their use of indigenous fuels in the face of rising natural gas prices, particularly following the commissioning of the North Stream pipeline between Russia and Germany. The Association considers that Sweden needs to produce more of its own fuel peat, but reports that there are problems in obtaining licences, on account of a resistance to peat production. It states that its biggest problem is achieving greater public acceptance of peat as a fuel. The Government's energy and climate policy (February 2009) points out that 'under certain conditions and to a limited extent, peat can be used with a positive net climate impact'. It therefore considers that Sweden should take action to ensure that this point is taken into account by the IPCC and in the EU's regulatory framework

Ukraine

Areas of peatland (square kilometres)	8 000
Production (thousand tonnes)	449
Consumption (thousand tonnes)	8

There are estimated to be 10 000 km^2 of peatlands, more than half of which are located in Polesie, in the north of the country. The other main area for peat deposits is the valley of the Dnieper, in particular on the east side of the river. Peat production rose during the period of the communist regime, reaching 7.5 million tonnes in 1970, when 73% was used in agriculture and 27% for fuel. In recent years consumption of peat for fuel purposes has fallen to

less than 350 000 tonnes per annum, the bulk of which is consumed by households, either directly or in the form of peat briquettes

United Kingdom

Areas of peatland (square kilometres)	27 500
Production (thousand tonnes)	
Consumption (thousand tonnes)	

The peatlands of UK cover an area of some 17 500 km^2, most deposits being in the northern and western regions.

The total UK peatland area is more than twice that of Ireland, but the extraction of peat is on a very much smaller scale. Almost all peat industry output is for the horticultural market; there is, however, still quite extensive (but unquantified) extraction of peat for use as a domestic fuel in the rural parts of Scotland and Northern Ireland. Anecdotal evidence suggests that peat-cutting for fuel in Scotland has declined in recent years, having been replaced to some extent by purchases of peat briquettes imported from Ireland.

United States of America

Areas of peatland (square kilometres)	6 250 000
Production (thousand tonnes)	
Consumption (thousand tonnes)	

The area of peatlands in the USA has been estimated at some 625 000 km^2, the majority of which is located in Alaska. In the contiguous United States, the major areas of peat deposits are in the northern states of Minnesota, Michigan and Wisconsin, along the eastern seaboard from Maine to Florida and along the Gulf coastal region as far as Louisiana.

The potential uses of peat as fuel were evaluated during the 1970s; a Department of Energy study published in 1980 covered – in addition to direct combustion uses – the potential for producing liquid fuels from peat. Interest in developing the use of peat for energy purposes has diminished since 1980. A small (23 MW) power plant was constructed in 1990 in Maine, to be fuelled by local peat. Initial problems associated with the use of inappropriate harvesting equipment were overcome but it was then difficult to obtain further permits to exploit the larger bog area required; the boilers were subsequently fuelled mainly by wood chips.