UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/CONF.100/PC/32
2 March 1981

ORIGINAL: ENGLISH

PREPARATORY COMMITTEE FOR THE UNITED NATIONS CONFERENCE ON NEW AND RENEWABLE SOURCES OF ENERGY
Third session
30 March-17 April 1981
Item 2 of the provisional agenda

SUBSTANTIVE PREPARATIONS FOR THE CONFERENCE

Report on the use of peat for energy

Note by the Secretary-General

At its thirty-third session, the General Assembly, in its resolution 33/148 of 20 December 1978, identified peat as one of the new and renewable sources of energy within the scope of the Conference.

At its thirty-fourth session, the Assembly, in its resolution 34/190 of 18 December 1979, considered that "adequate arrangements should be made to ensure equally detailed consideration for those areas of new and renewable sources of energy for which no technical panels have been created, namely peat and draught animal power".

The Government of Finland undertook to prepare a study on the energy uses of peat for the Conference secretariat and provided an interim report on the subject (A/CONF.100/PC/21) to the Preparatory Committee at its second session.

The Government of Finland has now provided the final report on the use of peat for energy (see annex below) summarizing the situation with regard to:

(a) The potential of peat as an energy source;

(b) Technological status;

(c) Economic viability;

(d) Environmental impacts;

(e) Social and institutional aspects;

(f) Measures to overcome the constraints on the use of peat for energy.

Annex

REPORT ON THE USE OF PEAT FOR ENERGY*

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* Prepared by the Government of Finland.

PREFACE

In its resolution 33/148 of 20 December 1978, the General Assembly identified peat as one of the new and renewable sources of energy within the scope of the United Nations Conference on New and Renewable Sources of Energy.

The Government of Finland undertook to prepare a report on the energy uses of peat for the Conference secretariat. The Energy Department in the Ministry of Trade and Industry in Finland was responsible for drafting the present report and a preparatory committee was formed to carry out the work. EKONO Consulting Engineers, as subcontractors, did the co-ordinating and editing of the expert papers supplied by a number of Finnish specialists in the subject. (For a list of contributors, see appendix I below.)

While peat, as such, is not a renewable resource because of its slow formation process, it is nevertheless a new source of energy for many countries. Throughout the world, as a rule only the developed countries are using significant amounts of peat. The aim of this report is to give an over-all view of the various aspects of the exploration of peat resources, to discuss its fuel properties, to explain alternative production methods and the possibilities of implementing them, and also to discuss environmental and social considerations. Peat can be used at many different levels. Many traditional manual methods, for example, can be implemented at very moderate cost, although more labour is required; such methods should be especially suitable for developing countries with low capital reserves. Peat can also be used at a very high technical level and at rather high capital cost. Very much depends on the proper transfer of technology and on the training of local people, as well as on the receipt of financial support from the major development banks.

It is sincerely hoped that this report will give an over-all understanding of the status of peat utilization in the world and will also encourage developing countries to pursue further their own possibilities for using peat.

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SUMMARY

Peat is a realistic energy alternative. It is often a very local fuel and even, in some cases, the only alternative, especially in remote areas. It offers a viable alternative to scarce fuel wood for home cooking purposes in developing countries and can replace imported or limited sources of other fuels in generating heat or power or in other industrial fuel usage in a number of countries.

The current fuel usage of peat throughout the world amounts to 25 million tons of oil equivalent. The three principal users are the Union of Soviet Socialist Republics, Ireland and Finland. Several other developed and developing countries have started their own peat programmes.

The total amount of fuel-peat resources world-wide is estimated at 100,000 million tons of oil equivalent, which is close to 50 per cent of the known global natural gas resources. At least 40-50 countries are known to have peat resources and several other countries are also believed to possess such resources. Peat may be found in every continent.

Peat as such is not a renewable fuel, although it is formed by a slow formation process in swamps, bogs or marshes. Formation stops once fuel peat production has been started.

The conventional fuel-peat products are milled peat, sod peat, and their processed forms - briquettes or pellets - and finally, hand-cut peat. Gasification and liquefaction of peat is under research and development. In its natural state, the water content of peat exceeds 90 per cent and, after production, 10-55 per cent, depending on the production and processing method used.

The lower heating value varies from 8 to 18 megajoules per kilogramme. Reduction of the moisture content is the most demanding task in fuel-peat production.

Peat is already being used on both a small and a large scale, the size of plants varying from a few kilowatts to 600 megawatts, and in individual homes. Potential use throughout the world by the year 2000 has been estimated to be 30-40 million tons of oil equivalent in developed countries and 10-20 million tons of oil equivalent in developing countries, and the world total is estimated at 40-50 million tons of oil equivalent. The ultimate potential is still higher.

The economic viability of peat as a fuel depends on such local conditions as available fuel alternatives, labour and material costs, transportation distances, climatic conditions and operational scale.

Although perhaps not competitive in the beginning phase, peat utilization can have large socio-economic impacts on rural areas, by developing local skills and the growth of small industry, providing employment and clearing wetlands for later use for forestry and agriculture.

The most serious constraints on the use of peat for energy, especially in developing countries, have been:

(a) The lack of information on peat as an energy alternative and on adequate peat resources;

(b) The exclusion of peat from the energy development programmes of international organizations.

Recommended measures to promote the energy use of peat may be summarized as follows:

(a) In particular, developing countries with unexploited peat resources should seriously consider peat as an energy alternative, include it in their energy programmes, estimate their resources, strengthen their capability to adapt peat technology and promote international collaboration with peat-producing countries;

(b) Peat-producing countries should support developing countries with bilateral financing and scientific and technical assistance for planning, research and training;

(c) International organizations, particularly the United Nations system, with its relevant bodies and international development banks, should include peat energy in their development and lending programmes. The activities of the International Peat Society, as the major international non-governmental peat organization, should be supported by governmental and international funds.

I. POTENTIAL OF PEAT AS AN ENERGY SOURCE

A. Peat as an energy source

Many countries possess an untapped source of energy that they are not even aware of. It is peat. It is not a new form of energy, as it has been used in many countries for at least 2,000 years and on an industrial scale since before the First World War. As the availability of oil and gas in particular is declining and prices are on the rise, many countries are taking a new look at the prospects for using peat. This is especially the case when their other domestic fuel sources are limited. The three biggest fuel-peat users today are the USSR, Ireland and Finland.

The technology of peat production and utilization is well established. In commercial applications, the cost of equipment is in the same range as in systems using wood waste or coal. The price of fuel peat is considerably lower than the world market price for oil or natural gas.

Peat is indeed a realistic energy alternative; it can prove to be attractive or, in some cases, the only alternative. It is often a very local fuel and can be valuable in remote areas. It also offers a viable alternative to scarce fuel wood for home cooking purposes in rural areas of developing countries.

In addition to energy production, peat can also be used as a raw material for many other applications. Most important of these is the use of peat for substrate and many special products in horticulture. It can also be a source for fertilizers. For example, a Finnish company is now seriously investigating the possible production of ammonia from peat for fertilizing.

1. What is peat?

Peat is a heterogeneous mixture of partially decomposed organic matter (plant material) and inorganic minerals that have accumulated in a water-saturated environment. Its colour can vary from yellow to brownish black, depending upon the degree of biological decay, mechanical disintegration of the plant fibres, and the presence of sediment. A water-saturated environment inhibits active biological decomposition of the plant material and promotes the retention of carbon that would normally be released as gaseous products of the biological activity. Consequently, there is an accumulation of organic material. This is known as peat.

2. Peat formation

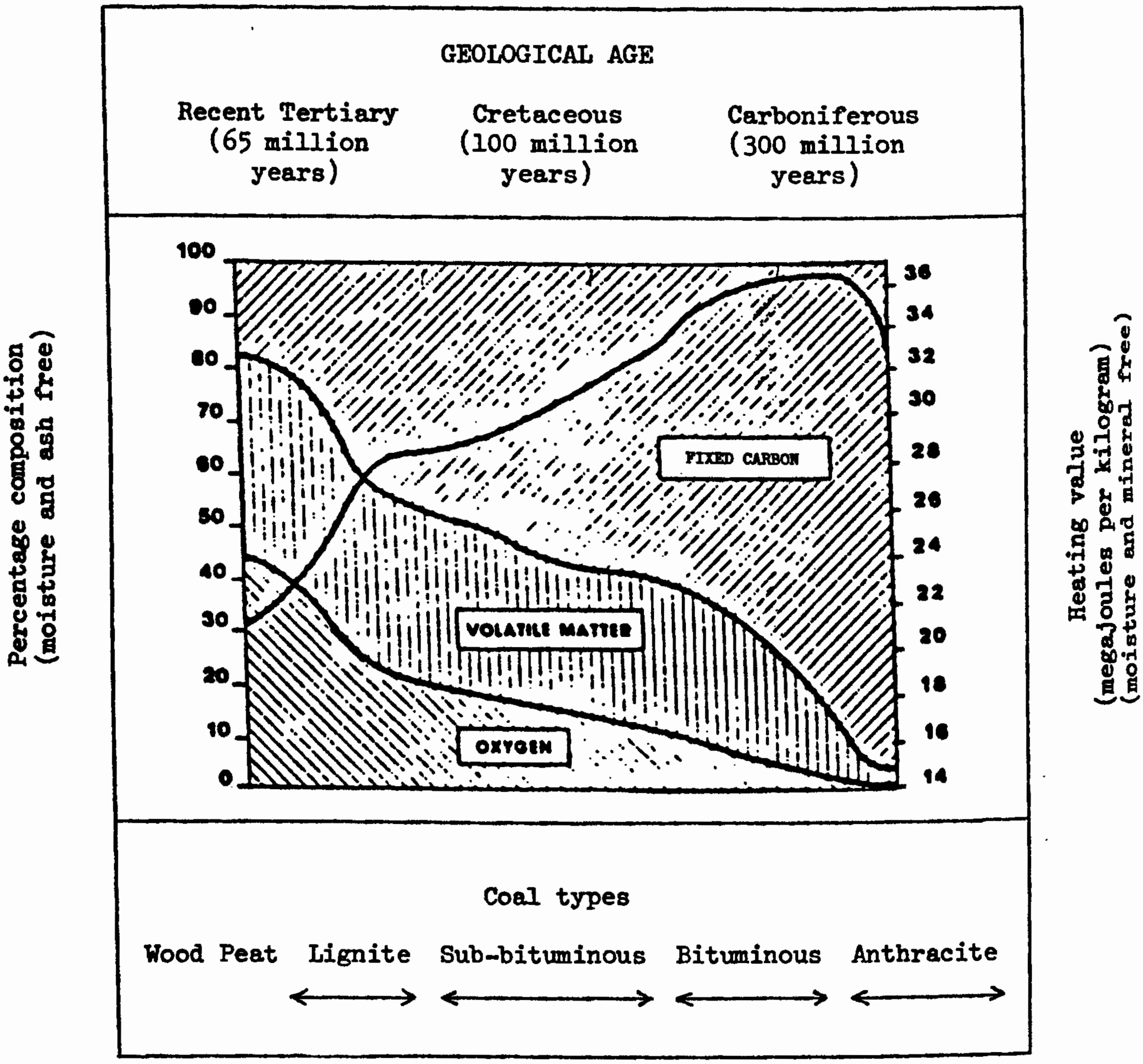
The formation of peat and peat-lands occurs, for example, in swamps, bogs and salt-water and fresh-water marshes that can be found world-wide.

The rate of peat formation is exceedingly slow and varies considerably between peat-lands. This variation is due primarily to climate and vegetation. Sphagnum moss probably forms peat quicker than any other plant material. Estimates of European peat formation are of the order of 20-80 centimetres per 1,000 years. Peat cannot be considered a renewable resource.

3. Fuel properties

In geological terms peat is regarded as young coal. Figure I shows the gradual development of various coal grades, starting from wood or plants.

Figure I. Comparison between peat and older coals



Source: United States Department of Energy, Peat Prospectus 1979 (Washington, D.C.).

The comparison shows that fuel wood and peat have basically very similar fuel characteristics.

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4. Special features of peat as a fuel

The biggest problem in using peat is its high moisture content, which in its natural state is over 90 per cent. There is still 70-80 per cent moisture content after drainage of the peat bog. For fuel purposes, the moisture content has to be reduced to 55 per cent or less.

In addition to its moisture content, other important characteristics of peat that affect the feasibility of its use in energy conversion are:

(a) Bulk density;

(b) Ash content;

(c) Chemical composition;

(d) Calorific value in dry substance.

Fuel peat is produced today in four basic forms, depending on the production method and type of utilization.

Milled peat is a heterogeneous mixture of loose small peat particles that have been cut mechanically from the surface of the bog. The cutting depth is about 2 centimetres at a time. The average particle size is 3-8 millimetres.

Sod peat is a mechanically cut and compressed fuel product. It can be cylindrical in form, with a diameter of 5-10 cm and a length of 10-30 cm. Compression is done during the production stage. The sods shrink and harden further during the air-drying stage. The sods can also be cubical.

Peat briquettes are normally made from milled peat, which is thermally dried to 10-20 per cent moisture content and then compressed into briquettes. In size and shape a briquette is similar to a normal brick.

Hand-cut peat is normally shaped in the form of a cube, measuring, for example, 10-20 x 20 x 30 centimetres.

Table 1 shows typical characteristics and potential usage areas of the various types of fuel peat.

Table 1. Characteristics and usage of fuel peat

Type of fuel peat	Heating value as received (megajoules per kilogram)	Average moisture content (percentage)	Bulk density (kilograms per cubic metre)	Usage
Hand-cut peat	11-15	25-40	200-400	Individual homes, cooking, heating
Sod peat	11-14	30-40	300-400	Moderate and small commercial usage, individual home usage
Milled peat	8-11	40-55	300-400	Large boilers, power plants and heating plants
Peat briquettes	17-18	15	700-800	Moderate commercial application, individual fire-places, heating and cooking

Table 2 shows comparative values for fuel-peat products, oil, coal, fuel wood and charcoal.

Table 2. Equivalent average amounts of fuel per equal amount of heat

Type of fuel	Fuel required for the same amount of heat as one unit of heavy fuel-oil: Weight	Volume
Oil	1.0 (40 megajoules per kilogram)	1.0 (38 gigajoules per cubic metre)
Coal	1.5	1.8
Fuel wood (air-dried)	3.1	6.5
Charcoal	1.3	4.0
Milled peat	4.4	11.0
Sod peat	3.1	7.5
Peat briquettes	2.2	2.9
Hand-cut peat	3.0	8.0

Fuel-peat products as a rule have quite a low density, which affects the design of the handling and burning equipment. The over-all economy then depends on the fuel and equipment costs. As a replacement for charcoal or fuel wood, it is a question of realizing the potential of peat and accommodating the proper production methods; of course, the availability of peat also has to be taken into account.

B. Peat resources

According to the data available, the total area of peat-land in the world as a whole is over 420 million hectares. It may be more - at least 500 million hectares - because in many countries the peat-lands have been only partially surveyed and for many other countries no data are available.

Table 3 gives estimates of the peat-land area in countries for which data were available in the literature or for which information was derived from an inquiry undertaken by the International Peat Society. The regions of peat accumulation in the world are shown in figure II.

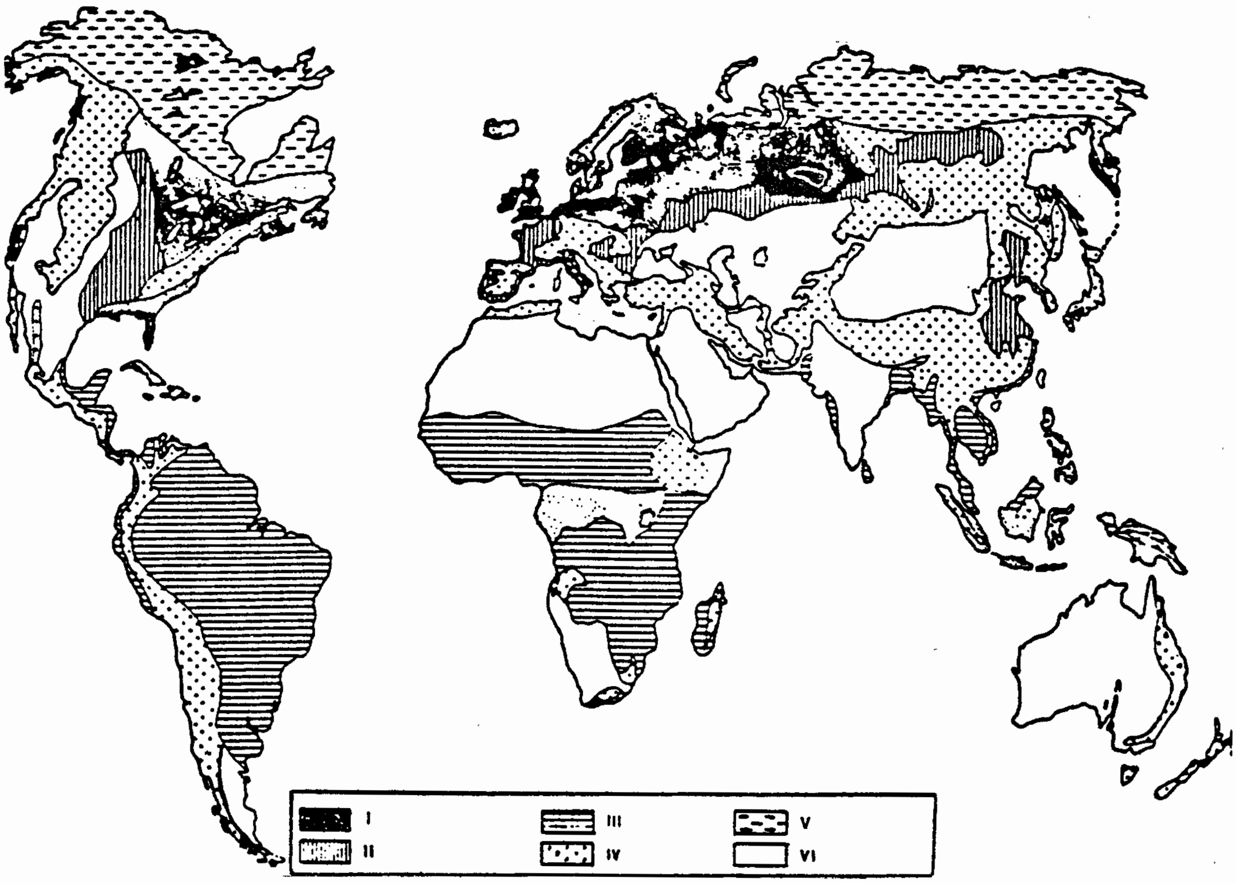
Table 3. Present estimates of the total (original) areas of peat-land in different countries, 1980

(Millions of hectares with more than 30 centimetres of peat)

Country	Area	Country	Area
Canada	170	Belgium	0.018
Union of Soviet Socialist Republics	150	Australia	0.015
United States of America	40	Romania	0.007
Indonesia	26	Spain	0.006
Finland	10.4	Greece	0.005
Sweden	7.0	Israel	0.005
China	3.48	Bulgaria	0.001
Norway	3.0	Angola	...
Malaysia	2.36	Bangladesh	...
United Kingdom of Great Britain and Northern Ireland	1.58	Bolivia	...
Poland	1.35	Botswana	...
Ireland	1.18	Brazil	...
Federal Republic of Germany	1.11	Burundi	...
Iceland	1.0	Chile	...
German Democratic Republic	0.550	Guinea	...
Cuba	0.450	India	...
Netherlands	0.250	Ivory Coast	...
Japan (Hokkaido)	0.200	Jamaica	...
New Zealand	0.150	Kenya	...
Denmark	0.120	Malawi	...
Italy	0.120	Mozambique	...
Hungary	0.100	Republic of Korea	...
Uruguay	0.100	Rwanda	...
France	0.090	Sri Lanka	...
Switzerland	0.055	Sudan	...
Argentina	0.045	United Republic of Tanzania	...
Czechoslovakia	0.031	Viet Nam	...
Austria	0.022	Zaire	...
		Zambia	...
		Zimbabwe	...

Note: Three dots (...) indicate that data are not available.

Figure II. Regions of peat accumulation



Source: Nikonow and Sluka, 1964.

Note: I: intensive peat-formation areas
II: weak peat accumulations in the temperate zones
III: weak peat accumulations in the tropics
IV: weak accumulations in mountain areas
V: weak accumulations in the arctic regions
VI: negligible or missing

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The estimates are in many cases very approximate, for example, it is estimated that Canada has 130-170 million hectares of peat-land with a peat deposit over 30 centimetres thick. The exploitable deposits are about 56 million hectares, or about 100×10^9 tons of peat calculated at a 40 per cent moisture content.

In the USSR, peat-land and swamp areas cover a total of 110-245 million hectares. Peat deposits over 1 metre thick cover about 71.5 million hectares and contain about 160×10^9 tons of peat (40 per cent moisture).

In the United States of America (excluding Alaska), 10 million hectares of peat-land are reported, whereas in Alaska there are estimated to be 30 million hectares.

The most accurate statistics on peat-land areas are from Europe. Only fragmentary data are available on tropical and subtropical peat-land. Recent surveys made in Indonesia show surprisingly large bog areas with thick peat deposits, indicating the possibility of vast peat deposits in some tropical areas of the world.

In table 4, peat resources are compared with the world's resources of coal, oil and natural gas.

Table 4. World fuel resources
(Billions of tons of oil equivalent)

Type of fuel	Technically and economically recoverable resources	Total resources
Coal a/	687	11,062
Oil a/	89	530
Natural gas a/	74	192
Peat	...	100

Note: Three dots (...) indicate that data are not available.

a/ World Energy Conference, Survey of Energy Resources, 1980.

C. Fuel peat production

The production of fuel peat corresponds to about 0.4 per cent of the world output of fossil fuels. Exploitation has nearly doubled during the last 30 years. The energy price crises of recent years have focused rapidly growing attention on the prospects for using peat energy reserves not only in the old peat-producing countries but even in countries which so far have no peat industry. In many

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countries it has recently been shown that fuel peat, after certain waste fuels, is the cheapest local fuel near the consumption sites.

Peat production today resembles agricultural production more than the mining industry. Production is highly dependent on weather conditions. There is a wide scale of production methods, ranging from manual peat-cutting to large-scale mechanized harvesting.

The biggest producer of fuel peat in the world is the USSR, with a share of about 89 per cent. Of this, 95 per cent is milled peat, usually harvested by mechanical track-laying harvesters. Milled peat is mainly used as fuel for large electric power stations. For domestic use, 6 million tons per annum of peat briquettes and some 4 million tons per annum of sod peat are produced. Sod peat is partly produced by excavators and baggers, but small sod-peat-cutter machines are commonly used on new sites. Peat accounts for only 2 per cent of Soviet energy supplies, but does have a significant local role in some areas.

Ireland ranks second as a peat producer. Milled peat is the main product and is mainly used as fuel in electric power stations. Also 0.3 million tons per annum of briquettes and about 1 million tons per annum of sod peat are produced by bagger-type machines. Some peat is still cut by hand. Traditionally, a year's supply of fuel for the house is cut quickly and easily from nearby bogs. Ireland has systematically developed its fuel peat industry since 1939 and fuel peat accounts for about 20 per cent of the national energy supplies.

Finland, the third biggest producer, has developed its fuel-peat industry since 1968, following a depression in the 1960s. Milled peat is the main product. Milled peat is used mainly for combined power and heat or back pressure power generation in municipal or industrial power stations. About 10 per cent of the fuel peat is sod peat, produced entirely with sod-peat-cutter machines. Sod peat is used partly as domestic and industrial fuel and partly as the raw material for special cokes. In 1980, 3-4 per cent of Finland's total energy was produced by fuel peat. The percentage is increasing rapidly and will probably double in 10 years.

Tables 5 and 6 show data from countries that supplied material to the International Peat Society in 1976 and 1980.

Table 5. Fuel-peat production and its growth

(Thousands of tons per annum, 40 per cent moisture content)

Country	1950	1960	1975	1980
China				800
Finland	300	200	500	3 100
Ireland	300	1 500	3 500	5 600
Sweden	100	100	-	-
Union of Soviet Socialist Republics	45 000	53 600	70 000	80 000
Others a/	1 000	500	300	400
Total	46 700	55 900	74 000	90 000

a/ Estimates.

Table 6. Present production of fuel and horticultural peat, 1980

(Thousands of tons per annum, 40 per cent moisture content)

Country	Fuel peat	Horticultural peat	Total
China	800	1 300	2 100
Czechoslovakia	0	270	270
Denmark	0	110	110
Finland	3 100	500	3 600
France	50	100	150
German Democratic Republic	0	170	170
Germany, Federal Republic of	250	2 000	2 250
Ireland	5 570	380	5 950
Norway	1	83	84
New Zealand	0	10	10
Poland	0	280	280
Sweden	0	270	270
Switzerland	0	1	1
Union of Soviet Socialist Republics	80 000	120 000	200 000
United Kingdom	...	170	170
United States of America (Minnesota)	0	330	330
Others	100	2 900	3 000
Total a/	90 000	130 000	220 000

a/ Rounded.

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D. Estimate of potential future use throughout the world

The over-all fuel peat-reserves have now been estimated at 400×10^9 tons at 40 per cent moisture. This equals 100×10^9 tons of oil equivalent. Globally, peat represents an energy resource constituting about 50 per cent of the known natural gas resources.

The major peat users today are in the developed countries. On the basis of their current consumption and future plans some predictions can be made for the major user countries (see table 7).

Table 7. Development of fuel-peat usage in major user countries

(Millions of tons of oil equivalent)

Country	Consumption 1980	Estimated consumption 2000
Canada	-	1-2
China	0.20	1-2
Finland	0.73	2-4
Germany, Federal Republic of	0.1	0.1
Ireland	1.27	1.5
Sweden	-	0.5-1
Union of Soviet Socialist Republics	22.7	23
United States of America	-	1-4
Others	-	...
Total	25.0	30-40

The estimates vary considerably. Peat will have great local importance, but it will not in most cases cover any major portion of the total energy consumption. Only in Ireland does it reach a percentage close to 20 per cent. The USSR and Finland account for 2-4 per cent. Although the peat resources are significant, no rapid or major changes can be expected.

It can be assumed that developing countries that do not have oil, gas or even solid fuel resources of their own and do have peat deposits will seriously consider using peat.

Potential peat usage has been estimated in developing countries that have proven peat reserves or are believed to have peat. The estimate was calculated by assuming that peat would account for 2 per cent, 5 per cent or 10 per cent of commercial or non-commercial fuel usage. Especially in countries that have an actual fuel-wood crisis, peat could have a rather high potential. Table 8 gives the estimates. If developing countries were, for example, to use peat for 5 per cent of their total energy consumption, the potential peat usage would be approximately the same as in the developed countries by 2000.

Table 8. Potential future use of peat in developing countries

(Millions of tons of oil equivalent)

	Energy consumption of developing countries with peat resources, 1976			Potential future use of peat at three levels (percentage of total energy consumption) in 2000		
	Commercial	Non-commercial	Total	2 per cent	5 per cent	10 per cent
Africa (21 countries out of 52)	20.6	82.1	102.7	2	5	10
Asia (9 countries out of 39)	164.0	174.1	338.1	7	17	35
Central America (7 countries out of 27)	9.8	6.6	16.4	0.3	1	2
South America (11 countries out of 13)	162.6	75.0	237.6	5	12	24
Oceania and Indonesia (2 countries out of 15)	22.1	48.6	70.7	1.4	3.5	7
Total	379.1	386.4	765.5	16	39	78

Taking into account the peat usage potential in developed and developing countries, the world total could be 45-115 million tons of oil equivalent during the next few decades. By the year 2000, the value could be 45-50 million tons of oil equivalent. The estimated fuel-peat resources would last, with this consumption, for several hundred years.

II. TECHNOLOGICAL STATUS

In general, peat technology is well established for conventional peat production and use. Methods for peat production and use may vary from one country to another and thus the existing technology may need to be adapted to local conditions in each case. Continuous research development and demonstration work is being carried out to make the technology more efficient, reliable and economic. Several non-conventional ways to produce, convert and use peat are coming up and the technology for them is at the research, development and demonstration stage.

A. Peat production

Peat has been cut for thousands of years for use as fuel, litter, soil substrate, medicine, building material etc. Mechanized fuel-peat production originated in 1845, since when many methods and thousands of various machines have been developed to make different fuel-peat products.

Peat production here is defined to include all the stages from preparation of the production site to the delivery of fuel peat to the user.

1. Preparation of peat production sites

Peat production has one significant advantage over oil and coal production; peat deposits are located on the surface and it is therefore easy to find them and analyse their quality. On the other hand, there are problems, too. The high moisture content, 87-95 per cent, of virgin peatland is a limiting factor; drying a peat bog for production normally takes from two to six years, depending, for example, on the quality of the peat. By drainage, about half of the water is extracted from the upper peat layer whilst the moisture decreases.

Besides drainage, tree-clearing, road-building, stump-extraction and levelling of the surface of the bog must all be carried out on a large scale before the area is ready for production. All these operations can be costly and demand high-capacity equipment for efficiency. Special machinery for bog preparation operations has been developed in many countries.

2. Milled peat production

The production cycle includes milling, harrowing, harvesting and stockpiling. In good weather conditions the length of a cycle is from two to three days with mechanical harvesting.

The harvesting season varies considerably. In Ireland, the season is rather long, about five months, but because of the rainy climate only about 12 harvests can be collected. In Finland, with a short three-month summer period about 16 harvests can be collected varying from 10 to over 20 yearly. In the USSR, from 20 to 30 harvests are usual. This means 300-500 tons yearly per hectare.

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(a) Milling

Milling can be started during dry weather, as soon as the peat is dry enough to support the machinery. The thin 0.5-1.5 cm upper layer of field is loosened and pulverized.

(b) Harrowing

Under favourable weather conditions, the thin upper part of the milled peat layer dries in a few hours to 40-50 per cent moisture. The dry upper layer of the milled peat is a good insulator and limits the drying speed below. The milled peat layer is therefore mixed once or twice a day with spoon harrows until the harvesting moisture, usually 40-50 per cent, is reached.

(c) Harvesting of milled peat

There are now three main peat harvesting methods in use:

(i) The Peco method, in which peat is first harvested into ridges in the middle of 10-20 m-wide fields and then moved sidewise step by step by a self-loading transporter to stockpiles at the side of the field. The stockpiles are 4-6 m high and as long as the fields, usually 500-3,000 m.

(ii) The Haku method, in which the ridges are loaded on to bog trailers or trucks and moved to stockpiles, which are usually on the roadsides. The stockpiles are usually rather big, 10,000-50,000 m^3.

(iii) The harvester method, in which self-loading trailers or harvesters collect the peat and carry it to stockpiles at the end of fields. The stockpiles are 6-8 m high and usually 40-60 m long and the volume is 1,000-3,000 m^3.

Ridging and harvesting can be done mechanically or pneumatically by vacuum harvesters or ridgers.

(d) Some problems

Unstable weather conditions make the mechanical harvesting of milled peat very uncertain. A partly dry peat layer will be repeatedly moistened by rains or even washed away into the ditches.

In hot climates it is often very difficult to prevent peat from drying below 40 per cent moisture, at which point milled peat begins to be very dusty.

In the USSR, when a bog cannot even be drained by pumping, peat is excavated and transported or pumped to drying fields, where it can be harvested using normal milled peat methods.

3. Sod-peat production

Sod peat is the traditional fuel-peat product, which is regaining significance as a domestic fuel. For thousands of years, people have been cutting peat for fuel with a spade. This method is practised even today, especially in Ireland, despite the well-established wholly mechanized large-scale industrial peat production described below. This is due to the old tradition of gathering the yearly fuel for house or farm use from the small nearby bog. Even today this is easily done by skilled people and it is very economical if the peat is of good quality. The work is usually lighter and more productive than wood-cutting. In eight hours one can cut 10 cubic metres of raw peat, corresponding to 1.5 tonnes of air-dried peat. This quantity is equal to 5 or 6 cubic metres of wood.

The traditional and still widely used method in mechanized sod-peat production is to excavate the peat to 2-7 m deep with a bagger, which macerates the peat and spreads it in sod form on to the bog surface. Owing to the high moisture, 88-92 per cent, by spreading the sods are usually badly shaped and the drying time is rather long. The sod-peat technology is now veering towards the milled-peat technology:

The field is very similar, drained by open drains 20-40 m apart;

Peat is taken from the upper layer, which gives relatively low (usually 80-83 per cent) moisture sods. This means well-shaped sods and a short drying time (often two to four weeks);

The dry sods are harvested using the same methods (Peco, Haku and harvester) and partly the same machinery as in milled-peat harvesting. The only difference is that every operation in sod-peat handling and harvesting must include the screening of the crushed peat from the sods.

(a) Sod-peat cutting

The two main types of sod-peat-cutting machines are the screw and disc cutters.

The screw cutter excavates the peat with a 40-130 mm diameter screw cutter, which makes a 400-1,000 mm deep angled cut into the surface. The screw macerator extrudes the 60-100 mm diameter sods onto the drying field behind the machine. The cut usually closes well because of the angle.

The disc cutters use a 900-1,400 mm diameter disc to excavate the peat from the 400-600 mm cut. It cuts rather well through wood and fibres, making it possible to use stumpy and fibric deposits in sod-peat production.

(b) Harrowing, ridging and harvesting

The sods are turned using a harrow or a plough to accelerate drying. Turning is often unnecessary because screened sod peat dries quite well, even in ridges. The ridges can be formed by angle-dozers, but because these often mix a lot of crushed peat with the sods it is better to use ridgers, which have a sieving effect similar to potato harvesters.

Peco method harvesting is done with a standard self-loading transporter, which must be equipped with a sieve to remove crush from the sod peat. The Haku method is mainly used if bigger roadside stockpiles are required. Self-loading harvesters can be successfully used on smaller bogs for milled peat. They make the stockpiles themselves but the piles are very small and moistening and in northern countries the snow hampers the quality. This can be prevented by plastic covering, for example.

(c) Starting small-scale peat production

In small-scale production the first stage in development could be the hand-cutting of sods, where the field drainage can also be done by hand if the bog is not too stumpy. Also, milled peat can be produced by hand or with the help of draught animals.

The second stage is when farm tractors are available. They can be used on drained fields under dry weather conditions for all operations using special light equipment developed for sod and milled-peat production. The tractor should be equipped with special wide or extra wheels. In sod-peat production it is possible to begin with small simple and cheap cutting machines, whereas the harrowing and harvesting can be done by hand.

Because the peat machinery designed for fitting farm tractors is simple and cheap, small-scale peat production can well be a sideline in normal farming. Also, big enterprises very often use hired farm tractors in their fields for mutual benefit.

Organized in a proper way, small-scale production of peat can be very economic, especially for producing cheap fuel for local domestic use.

(d) Transportation

In large-scale use, the peat transportation distance is often quite long.

Peat transportation is a task that must be carried out at all times of the year. The exacting nature of the task is increased by the fact that peat can be stored only in relatively small amounts by the user. In the USSR, fuel peat is transported solely by narrow-gauge railway. Peat for soil improvement is handled by truck. In Ireland, peat is transported by narrow-gauge railway, because the power stations and peat briquette factories are located near the production sites. In Finland, 70 per cent of the peat is transported by truck and the rest (30 per cent) by rail. Narrow-gauge railways are not used in Finland. Special equipment requiring considerable investment is needed for peat transportation. The contribution of transport to the fuel cost at the consumption site is approximately 30-40 per cent. Because of its low density, peat is regarded as a local fuel, with a maximum economical transport distance of 150-300 kilometres.

In local small-scale use, transportation is not usually a problem.

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B. Small-scale use

"Small-scale use" is understood to include all fuel needed in the stoves of individual homes or families for cooking or heating purposes and, in the larger sense, boilers producing hot water or steam for several houses and smaller communities. In many developing countries, the main domestic heating source is still the open fire. Traditionally, wood or charcoal have then been used.

The applicable peat fuel products that can be used on a small scale are hand cut peat, sod peat, peat briquettes or pellets and charcoal of peat.

As peat is a bulky fuel and expensive to transport in small amounts, small-scale use occurs mainly near the production site, in places where adequate storage space is available.

Higher fuel qualities are obtained by preprocessing the peat. Peat briquettes and pellets are uniform and their heating value per unit volume is quite high. This makes them suitable fuels in places where cleanliness is required and storage space is lacking.

Small-scale peat-firing facilities

In general, peat can be burned with the same equipment as wood. The conversion of existing oil-fired boilers for peat burning is, however, difficult, and in many cases almost as expensive as buying a new peat-fired boiler.

Most stoves designed for solid fuels can be used for peat-burning too. The use of peat briquettes is preferred because of their cleanliness, but sod peat can be used in outdoor stoves.

Heating and central heating boilers with an output range of 10-300 kilowatts are used to supply heat and hot water to houses or to a number of buildings located near each other. There are many boilers on the market designed to burn various solid fuels, which are also suitable for peat.

The drawback with open fire heating is that combustion is incomplete and a considerable part of the heat is lost through the chimney. A better heating result can be obtained by closing the furnace with scuttles and by limiting the amount of combustion air by the use of adjustable air registers.

Another common way of burning peat briquettes or sod peat is by using a small and simple chimney without refractory or heat transfer to water. Peat burns with a small flame and the radiant heat of the chimney warms the surrounding room. The efficiency of this burning method is rather low.

C. Large-scale use

Peat technology for producing heat and electricity is well established throughout the world. This is especially true in the USSR, Ireland and Finland.

Over the years, new and improved peat handling and burning systems have been developed, aiming at better over-all economy, the operational safety of the plants and increased unit size. The existing large units include condensing power plants, which only generate power, and co-generation plants, where both electricity and heat are generated for industrial or community use.

The largest single boiler plant units in operation have a thermal output of close to 200 megawatts. Present technology can be used to produce up to 600 megawatts of electric power in the condensing mode. There are several 200 megawatt electric power plant blocks equipped with two boilers in operation in the USSR.

1. Technology

(a) Peat handling

A typical peat handling system for a large peat-fired energy plant might consist of the following sequence. The peat is transported to the unloading station either by truck or train and first dumped into an unloading silo. The stumps and eventual frozen peat clods are crushed in a hammer crusher and burned together with the screened peat. Most plants are equipped with a storage silo to balance fluctuations in peat transportation. The peat is transported to the boiler house by belt conveyors.

Iron parts are normally removed from the peat flow by magnet.

The functioning of various parts of the equipment can be monitored with television cameras from the main control room of the plant. Various sensors can be located at critical points in the system to detect fires or pluggage.

Large stockpiles at the plant can be considered for large condensing power units.

(b) Conventional peat firing

In pulverized peat firing, the peat is crushed and dried in two to four pulverizers, each feeding a set of combination peat and oil (gas) burners. The drying is done by hot flue gases taken from the boiler furnace and introduced into the mill together with the peat; hot air can also be used.

The fuel and hot gas mixture may be tempered as necessary with air or cooler flue gases to achieve the required optimal temperature for drying. In some cases, a small amount of oil or gas may be burned in conjunction with peat for safety reasons.

To burn coarse particles that are not ground by the mill, a small after-burning grate is normally placed on the bottom of the furnace.

On a smaller scale, peat may also be burned in a grate. In this method, water-cooled inclined grates and after-burning grates may be utilized. Because

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control of the combustion and air flow, especially by partial load, may be difficult, it is often recommended that milled peat should be fired in conjunction with some other fuel, for example, bark.

(c) New firing techniques

(i) Flash drying of peat

Existing boilers can in some cases be converted to peat-burning without reducing the boiler capacity; flash drying of peat combined with pulverized-peat burning and after-burning on a grate can be applied. The peat is fed into a vertical drying duct, where it is dried by flue gases from a moisture content of about 50 per cent to a moisture content of about 20 per cent and fired normally in the boiler.

A high boiler efficiency (up to 90 per cent) can be maintained with the flash-drying method, because the flue gas temperatures from the dryer are only about 80°C. The boiler load can also be regulated fairly rapidly.

This can also be accomplished by separating the finer particles from the coarser ones in a wind screen instead of utilizing peat mills. The finer particles are then mixed with hot flue gases and blown to the burners and the coarser ones burned on a grate. The investment costs for this kind of system are lower than those for boilers equipped with ordinary peat pulverizers.

(ii) Cyclone firing

In this method, the peat is first dried by flue gases in an air classifier, which removes rock and coarse particles. The peat is then separated from the flue gases and blown through an ejector to the cyclone, in which the peat is burned in a rotating flame. The cyclone can be refractory lined and the temperature kept so high that slag continuously melts and runs out of the cyclone. The efficiency of this method can be as high as 85-90 per cent, owing to the flash drying of peat, under which the flue gases may be cooled almost to the dew point.

(iii) Fluidized bed combustion

In fluidized bed combustion, an air stream passes through a bed of solid particles and transforms it into a state in which it behaves like a boiling fluid. The bed consists of sand, ash and fuel. When peat is introduced onto the bed it is immediately mixed with the hot bed material and the water is evaporated and superheated. The dried peat ignites and burns in the air flowing through the bed.

2. Operating experience

In general, operating experiences have been quite promising and the plants have performed well, giving a satisfactory level of reliability as well as a good return on invested capital.

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It has, however, been necessary to overcome certain technical problems in order to improve plant performance even further. For example, the considerable variations in peat quality between various production areas, and even within the same area, have caused problems at power plants. In some cases, the moisture and humus acids which are always present in peat have caused corrosion in the fuel-handling equipment and the plants have had to replace ordinary steel with stainless steel in some parts of the system. The amount of sand in the peat received by some plants has also been abnormally high and caused considerable wear on the equipment.

Safety

Special safety regulations for peat boilers and furnaces have been prepared by major pea -using countries.

The availability and safety of the plants appears to have been satisfactory and it can be assumed that the safety level of coal-fired plants has been reached even with present techniques and applications.

D. Non-conventional uses of peat

1. Use in industrial processes

Dried milled peat, or gasified peat, can be used as an energy source in several industrial furnaces and ovens. Generally speaking, peat can be used in all furnaces where coal-burning is possible. Coke derived from peat may, in some applications, replace coal coke, especially when lower mechanical strength is acceptable. Gas produced from peat can be used in gas burners instead of natural or petroleum gas, for example.

Possible applications include the cement industry, the heavy clay industry (for example, burning bricks) and the glass industry.

The simplest technology is required in the clay industry, where intermittent kilns can be fired with peat. The cement industry requires sophisticated drying and milling plants, and the glass industry requires peat gasification.

The development of systems is under way. Research has been done but more work is needed before commercial systems can come on to the market. Peat was used in industrial processes in some countries during the Second World War. The rapid increase in energy prices has again made peat attractive.

2. Gasification and liquefaction of peat

Gasification and liquefaction can be applied to processes where direct use or combustion of solid fuels is not possible. Gasification and liquefaction were subjected to intensive research in the 1970s, and there are earlier experiences from partly industrial applications throughout the twentieth century. Research into the utilization of coal as the raw material for liquid and gaseous fuels is very intensive. Much attention is also paid to the liquefaction and gasification of peat in Finland and Sweden, as well as in the United States of America and Canada.

(a) Gasification

The gasification of solid fuels entails their conversion to a gaseous fuel or a so-called synthetic gas suitable as the raw material for methane, methanol or oil products.

Gasification is partial combustion with either air, oxygen or steam or a mixture of these. The gasification process always includes pyrolysis - physical or chemical decomposition of a material by heat in an oxygen-free space. When a mixture of air and steam is used, "low-calorie fuel gas" is obtained.

A number of different processes have been developed for the gasification of solid fuels. The oldest and most well-known gasification method - gasification in a fixed bed - could be mentioned in this connexion. This method is most suitable for use in small units in both developing and industrial countries.

Research in the United States of America is concentrated primarily on the production of synthetic natural gas from peat. The test programme also includes the gasification of coking residue in a fluidized bed with oxygen and steam.

(b) Liquefaction

Liquefaction of peat is still at the laboratory stage. In principle, peat should be suitable as a raw material for liquefaction. Several processes are being studied and developed, for example, hydrogenation, pyrolysis, gasification by Fisher-Tropsch synthesis or methanol synthesis and production of ethanol by hydrolysis.

The most industrially attractive liquid products from peat would be ammonia, methanol and ethanol.

At present synthetic fuels are manufactured industrially only from coal, in South Africa, and the commercial development of peat liquefaction will take several years.

III. ECONOMIC VIABILITY

Today, peat is a competitive fuel in many countries. The difference between unit energy costs of peat, and particularly fuel oil, is increasing all the time, to the advantage of peat.

The cost of producing energy from peat and the competitiveness of peat over alternative fuels depends very much on local conditions, such as tax laws, interest rates, labour and material costs, government support, land cost, transport distances and the relative costs of alternative fuels. Plant or facility size and the length of the annual operating period also affect energy production costs.

The factors affecting peat energy production costs vary widely from country to country. Figures given in this chapter are based on Finnish conditions only, and show only the order of magnitude.

In general, the cost structure of peat use is rather similar to that of coal or wood use. The cost of equipment is usually higher than for oil or gas use but the fuel cost may be considerably lower.

Since peat technology is already well established, costs can be rather reliably estimated, although they may vary from country to country.

Strictly speaking, peat is always a domestic fuel. Peat utilization, especially on a large scale, offers a good opportunity to replace imported fuels and will have a positive effect on the balance of trade. For example, Finland is mostly replacing heavy fuel oil by peat and, with current fuel prices, the annual peat usage of 10 million cubic metres means a saving of about $US 300 million. Every domestic energy alternative should be seriously considered in developing countries, which use a disproportionately large share of their income for the purchase of imported fuels.

A. Large-scale use

1. Condensing power plants

The economic advantages of peat for generating condensing power are good in comparison with heavy fuel oil. Under certain conditions, peat is even able to compete with imported coal and nuclear power.

A peat-fired power plant should provide base load power and should be located close to major peat deposits. Figure III compares the costs of power generated by alternative fuels, based on conditions prevailing in Finland in 1980.

Peat is especially competitive in 60-200 megawatt power plants. The feasibility of larger plants depends very much on the availability of peat deposits large enough to support the power plant. Plants with capacities of less than 60 megawatts are no longer economically viable under the conditions prevailing in Finland.

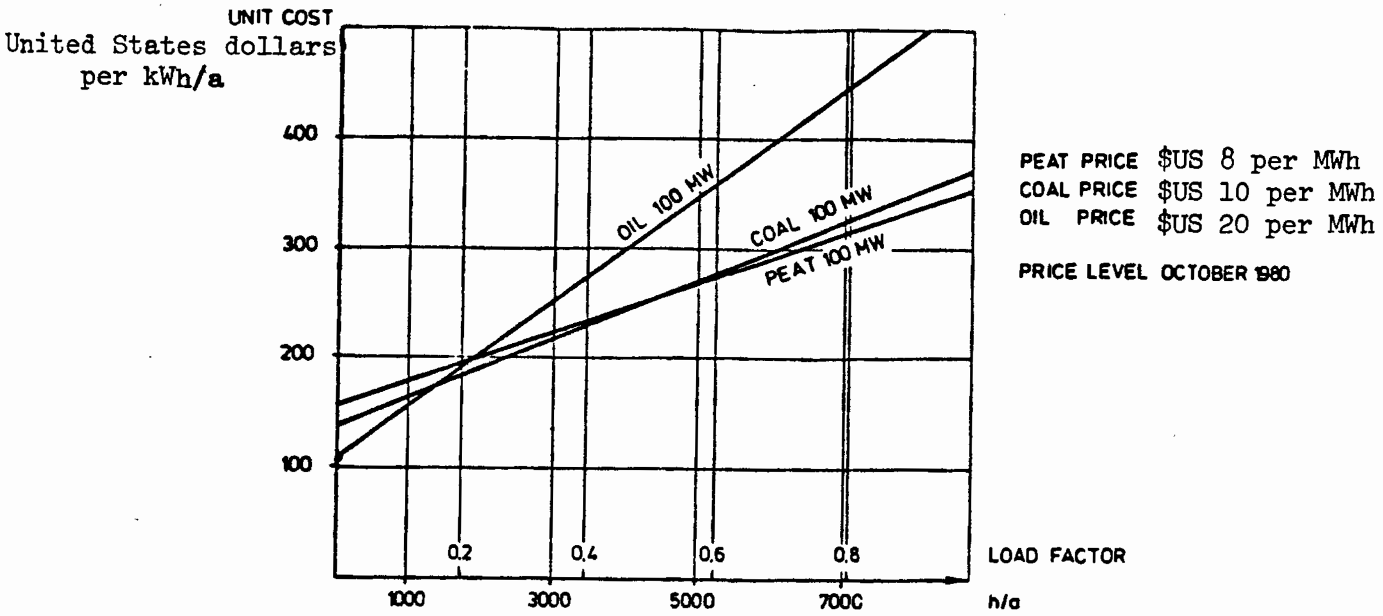
2. Cogeneration plants

The most economical peat-fired plants in Finland are combined district heating and power plants or industrial back-pressure power plants that provide base load power. Optimum electrical output varies from 20 to 60 megawatts and thermal output from 50 to 200 megawatts.

3. Steam plants and district heating plants

Peat-fired steam plants are competitive in those process industries where the demand for steam continues all year round. In steam plants, as in other peat-fired units, peat becomes more economical as the plant size increases.

Figure III. Comparison of power production costs of peat, coal and oil in a 100-megawatt condensing power plant



Peat-fired district heating plants are more economical than oil-fired plants only when providing base load power. An oil-fired peak-load plant is therefore necessary to supplement the base load from peat. Coal and peat are quite equal as to economy.

A peat-fired steam or heating plant costs roughly from three to five times as much as its oil-fired counterpart when the capacity is 1-30 megawatts. The capital investment for a coal-fired plant is equal to that for a peat-fired plant.

B. Small-scale use

The use of peat in small heating boilers, from 20 kilowatts to 1,000 kilowatts, is increasing. Such boilers normally use sod peat or briquettes.

Peat-burning in small boilers is especially competitive with light fuel oil. Competitiveness can, however, depend on the personnel costs, because peat-firing normally requires daily charging and ash-removal operators, whereas oil-fired plants can operate for several weeks without service.

Sod peat and peat briquettes can also be used in stoves and ovens for cooking purposes. The burning facilities are the same as those for firewood, brown coal briquettes or charcoal. The use of peat depends on its availability and price. In Finland, sod peat, or peat briquettes, costs a little less than firewood. Many firewood users, such as farmers, do not have to purchase their fuel and no price comparison can be made.

In developing countries with peat resources, peat could be an alternative to firewood and charcoal for small-scale use in rural areas, but it may not be the cheapest alternative when purchased in towns and villages far from peat deposits. Again, this could also be a question of the avilability of alternative fuels.

C. Gasification and liquefaction of peat

At the moment there are no commercial peat gasification or liquefaction plants anywhere in the world. Gasification and liquefaction of peat is, however, under research and development and the basic technical methods are well known. Finland, for example, is currently investigating the gasification of peat for use in diesel engines. Preliminary results show that this system could be very competitive compared with fuel oil. Diesel engines are especially suitable for providing both electricity and heat in remote areas.

The United States of America is developing a very large peat gasification scheme, which will produce synthetic natural gas equal to over 3,000 megawatts from peat. The price of the gas has been estimated at $US 2.9 per gigajoule. This is possible only if adequate peat resources are available.

Commercial peat liquefaction plants seem to be something for the distant future. At present, liquid fuels produced from peat are not competitive with oil products, but economic security will support the development of peat liquefaction.

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D. Peat production

The cheapest alternative in small-scale production is just a shovel and the necessary labour. Some Finnish figures are shown below to illustrate capital inputs in peat production.

1. Large-scale and medium-scale production

Sod-peat and milled-peat production require roughly the same investments for bog preparation, peat production and peat transport equipment.

Investment costs for the production of 1 million cubic metres of milled peat per annum (100,000 tons of oil equivalent)

	Millions of United States dollars
Bog preparation	7
Production machinery	4
Transport equipment	1.5
Total	12.5

The total investment cost for 100,000 cubic metres of sod peat (12,000 tons of oil equivalent) is about $US 1.5 million. Under Finnish conditions, the production season is only about three months long, so under better conditions, investment costs will be reduced.

2. Small-scale production

The main alternatives are sod peat and hand-cut peat and in some cases milled peat as well. The investment cost for small-scale production is very dependent on the preparation of the bog. The investment for hand-cutting is very small; only shovels are required. Sod-peat production on a small scale can be carried out with farm tractors and relatively cheap equipment. The investment required for the smallest sod-peat-cutting machine with a capacity of 1-2 tons per hour and suitable for a 40 horsepower farm tractor is $US 3,000.

3. Prices of peat products

Peat prices will vary from country to country, but the relative prices compared with other fuels are almost the same.

The price of milled peat in Finland at the bog site is about $US 6 per megawatt hour. When transported about 100 milometres, the final price is about $US 9 per megawatt hour. Light fuel oil costs $US 30 per megawatt hour, heavy fuel oil $US 22 per megawatt hour and imported coal $10-$12 per megawatt hour. Sod peat costs about $3 more per megawatt hour than milled peat. The price of peat briquettes to the consumer is about $16 per megawatt hour.

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IV. ENVIRONMENTAL IMPACTS

In general, peat production has not caused any such environmental impacts as could impose a serious constraint on the energy use of peat. The impacts can be divided into environmental impacts on the production site and on the user's site.

A. Environmental impacts of peat production

The use of peat-land has an impact on the environment and on socio-economic life. In each case, the impacts need careful consideration before peat-land is exploited. The various interest groups must agree on the ultimate usage of the area. In many cases the area for fuel-peat harvesting is a very small portion of the total wetland area and there should not be any major conflict of interest.

Exploitation of peat-land, especially on a large scale, can affect ecology, climate, hydrology and people. When using conventional methods of peat production, the bog has to be cleared of vegetation, access roads have to be built and the bog has to be drained. This activity will change the appearance of the area at least temporarily, although it does not create any vast open pits. Normally the areas are very large and the deposits are shallow.

Drainage water contains a certain amount of suspended and dissolved solids. So far, experience has shown that proper drainage does not alter the pH values of the receiving streams or create a harmful imbalance in the environment.

The major negative impact is dust formation during large-scale production, especially with milled peat. Health studies have indicated that peat dust can cause itching and smarting eyes and symptoms of rhinitis. Proper protective measures, such as air-conditioned and sealed cabins for the machinery are recommended.

After exploitation of usable peat, the area can be used for agriculture or forestry. In many cases peat-land utilization has a positive effect; after providing energy and jobs for people during peat production, it also creates permanent employment when continuous use of the exploited land area has been established.

Various environmental impacts of peat-land utilization are subject to continuous research. Experience shows that, properly conducted, peat-land exploitation does not endanger the quality of the surrounding environment. Its socio-economic effect is primarily positive, for it creates infrastructure, job opportunities and land for agriculture or forestry as well. Of course the wetland can also be reconstructed and repaludification allowed.

B. Reclamation of cutaway peatlands

As a consequence of the sharp increase in peat production, more and more bottom layers of peatlands are being bared in many countries and will be bared in the next few years. These can effectively be used for cultivation or pasturing, afforestation or cultivation of fuel-wood forests.

1. Cultivation of cutaway peatlands

In vast peat-land areas in the north-western region of the Federal Republic of Germany, the surface peat has been used for soil improvement and the more decomposed peat of the lower layers for fuel. Regulations in the Federal Republic of Germany require that a peat layer at least half a metre thick must be left at the bottom of the peat field for cultivation. A deep-ploughing method has been developed for cultivation of cutaway peatlands; peat is mixed with mineral soil. In this way an excellent substrate is obtained for agricultural crop production. The same method can be used for recultivating weak peat-land cultures. In the north-western region, some 120,000 hectares have been recultivated by the deep-ploughing method since 1936.

The deep-ploughing method has also been used in the Netherlands, Sweden and Norway. Peat deposits are also exhausted by the modern peat industry in Ireland and these cutaway areas are successfully used for farming and especially for grass production. Hand-cutting of peat for fuel has been, and still is, widespread throughout Ireland. Some hand-cut peat areas have been reclaimed for agriculture. These can produce grass, sustain beef cattle and support vegetable crops in a manner comparable to upland mineral soils.

2. Utilization for forestry

In many cases, afforestation is the most rational use for cutaway peatlands. The areas are usually well suited to forestry because of their efficient drainage and largely shallow peat layer, through which tree roots are able to reach the underlying mineral soil.

Soil preparation with deep ploughing is preferable if the peat layer is thin and the bottom soil is not stony. Fertilization is needed where the peat layer is thicker than 40 centimetres. In some cases, grey alder interplanting can replace fertilization. Because of the extreme microclimate of these areas, only frost-resistant pioneer tree species can be used in afforestation. In Finland, Scots pine is the most suitable species; some short rotation species may also be used in future.

There are also other possibilities for using these areas. Near settled areas, they can be reclaimed for recreation. If drainage is problematic, they can be used as water reservoirs. If there is no practical use, we can leave them alone and let paludification begin once more.

C. Emissions

Peat-fired boiler plants have been operated in several countries for many years and have generally been considered safe with regard to emissions into the environment. Peat as a fuel is very similar to wood; this similarity also applies to environmental considerations.

The main environmental disadvantage sometimes mentioned has been dustfall in the vicinity of the plants. This is to be considered a minor problem, as centralized particle collection can be easily improved with better electrostatic precipitators or equivalent methods.

Peat contains little sulphur in comparison with fossil fuels. This is a big advantage over other fuels, as sulphur emissions are considered one of the worst problems in energy conversion. Sulphur dioxide emissions from peat-fired plants are less than one fifth of those from oil-fired plants.

1. Emissions and different peat-burning methods

Obviously different burning methods have a very great influence on the formation of pollutants.

(a) Pulverized peat-firing, which is practised in large boilers, yields ash with low unburned material content. The ash is very fine and requires an electrostatic precipitator. Owing to flue-gas recirculation and complete furnace cooling, the furnace temperature is comparatively low, producing very moderate concentrations of NO_x. The formation of PAH has not been detected but, owing to the long residence time of the fuel at elevated temperatures, it is expected to be low.

(b) Grate-burning produces quite variable amounts of ash, depending on peat grade and load conditions. The furnace temperature fluctuates very much, producing peaks of unburned gases and moderate levels of NO_x emission.

(c) Cyclone-burning as a rule uses very high combustion temperatures, causing the formation of high levels of NO_x. The combustion is relatively complete.

(d) Fluid beds are expected to be environmentally sound owing to their complete combustion and moderate reactor temperatures. The PAH formation is unknown and requires further study.

(e) Some peat-drying systems work in an open mode, which means that the drying gases are not returned to the boiler furnace but released into the atmosphere. This drying method, if carried out at elevated temperatures, could possibly be unsafe because of the thermal dissociation of peat and the emission of hydrocarbons. Another disadvantage is the emission of ash with a low pH from the dryer to the atmosphere.

2. Flue-gas treatment

The only flue-gas treatment today is particle removal. The results of dust collection by various methods are quite reliable. Owing to the relatively heavy dust loading of the gases before collection, mechanical separators are often insufficient if concentrations below 500 mg/m^3n are desired. For very small plants they are still economically viable. Electrostatic precipitators are needed for larger plants.

Wet scrubbers are an interesting alternative to mechanical collectors and electrostatic precipitators. The advantages of a scrubber are reasonable cost and fire safety.

In conjunction with the open dryer system, the fire safety of dust collectors is of great importance.

Very small units, for example, for home heating, usually do not have flue-gas treatment. This can be justified by the very local impact of the emission and the substantial cost of filter equipment.

3. Comparison with other fuels

Emissions from peat-fired plants are very similar to those from wood-fired plants. In particular, the very low sulphur content of peat makes it environmentally more acceptable than many coals. No sulphur-removal devices are necessary with peat. Solid dust emissions can be controlled with similar technology in coal-fired units.

V. SOCIAL AND INSTITUTIONAL ASPECTS OF PEAT USE

Peat use can have a great impact not only on energy supply but also on socio-economic and environmental matters and on external payment problems. These aspects must be considered when peat utilization is begun.

A. Manpower requirements

The manpower and expertise required for peat use depends primarily on the technological level chosen. Manual methods and small-scale technology - probably the most appropriate alternatives for developing countries - are rather labour-intensive. Large-scale and more mechanized production and usage requires less manpower but more skilled personnel and capital.

The personnel needed is also dependent on the local conditions, the educational background of the human resources available and the organization and realization of the peat development programme.

Thus, no general recommendations can be given. A careful study of the local conditions must be performed in all cases.

In the USSR it is estimated that the average annual large-scale production capacity of a worker is approximately 3,000 tons. In Finland, owing to the shorter production season, it is only about 2,000 tons. Thus in an annual production of 1 million tons, (roughly 0.3 million tons of oil equivalent), about 300-500 workers, 30 supervisors, 10-20 administrative staff and crews for 30-50 peat transport trucks are needed. The manpower requirement for bog preparation, when not carried out in connexion with peat production, is about 5-10 workers per 100 hectares of annual prepared area.

Special attention must be paid to the educational background of the professional personnel involved in peat utilization. High-technology peat production and use is very specific, with a need for specialists with various professional backgrounds, such as geology, mining, horticulture, agriculture, silviculture, energy, chemical technology etc. Environmental aspects, nature preservation and the use of cutaway areas also need their own experts.

Peat utilization can be roughly divided into three groups, which to some extent illustrate the need for expertise:

Evaluation of the quality and the quantity of the peat resources and their usability for various purposes;

Planning of peat production, bog preparation and peat transportation;

Use of peat as fuel, for industrial purposes (mechanical, thermal and chemical processing) and for agriculture and silviculture.

Naturally, developing countries, when starting to use their peat resources, cannot have endogenous expertise in all these fields. Collaboration with the peat-producing countries may be necessary in the initial phases.

B. Social acceptability

Manual production and small-scale use of peat have far-reaching traditions in most European countries, and are thus well accepted both socially and culturally.

An important feature of peat production has been its positive effect on employment; peat resources are often situated in developing areas. This effect will be accentuated even further in developing countries.

Because of the severe fuel-wood shortage in many parts of the developing world, fuel peat can affect the lives of low-income groups as a cooking fuel and by providing energy for agriculture and rural industries. An added feature is the suitability of cutaway peat-lands for agriculture or forestry.

The main obstacle to the social acceptability of large-scale use in industrialized countries has been the environmental impact. There is a new awareness of the value of bogs and wetlands for leisure activity, for wildlife or for conservation. Thus, successful reclamation of peatlands is of immediate importance.

C. National organizations

1. National Governments

In all the main peat-producing countries, the national Government plays a major role in promoting the use of peat for energy. The Governments in those countries where peat production is just starting or is planned have also taken the initiative. This is due to the following reasons, especially in large-scale use:

(a) Promoting the use of indigenous fuels is one of the main objectives in almost every national energy programme;

(b) The investment schedule and financial requirements may make it difficult to start peat production on a purely private basis;

(c) Peat production is often located in developing regions, and is used as a means of promoting local employment as well;

(d) Peat technology development has required research, development and demonstration, which few individual private organizations can afford.

Of course one reason why the Governments have had to carry the action in the past has been the low price of conventional fossil fuels (oil, coal). In future, the private sector may be more active.

Certain legislative measures might be necessary. In Ireland and Finland, legislation exists for the compulsory acquisition of bog-lands, although it has very seldom been used. In both countries, bog-lands have been leased or bought under voluntary contract. A process similar to that for claiming mining rights is also possible in bog-land acquisition but requires similar legislation.

Active participation by the public sector thus seems necessary for promoting the energy use of peat. This is also true even of the industrialized countries, where the economic infrastructure and the resources of the private sector are fairly well developed. Moreover it seems that the role of the Government is more important in less developed countries.

2. Regional and local authorities

Regional and local authorities can also play an important role in promoting peat use. In some cases they may be responsible not only for the use of peat but also for its production and transport.

3. Peat organizations

Small-scale activities such as manual peat-cutting and sod-peat production are not usually formally organized. The work is done by farmers individually or in co-operation with other villagers.

Large-scale production and refining need special organizations, which are often strongly supported by the Governments. The same organization is usually responsible for both activities.

The large-scale use of peat as a fuel does not need any special organization; it is part of normal energy production or industrial activity.

Research, development and demonstration activities in peat areas must be concentrated in an organization, either a separate one or one operating in related fields.

D. International organizations

Peat experts from different countries have always co-operated closely. Some work is also done both in developed and in developing countries on a bilateral project basis. However, international organizations so far have no explicit peat development programmes or research activities, whereas they do have them for renewable energy resources. Peat is included only in some projects; for example, the High-Level Group for Energy Technology Commercialization of the Organisation for Economic Co-operation and Development is including some peat projects in its comprehensive list of technologies, which can be commercialized in the near future.

Peat as an energy source will be seriously discussed on a multilateral governmental level for the first time at the United Nations Conference on New and Renewable Sources of Energy to be held at Nairobi in August 1981. In addition to that, a United Nations peat workshop and study tour is going to be arranged in Finland in June 1981.

The promotion of peat use, especially in the developing countries, faces many constraints, such as financing, lack of trained personnel and suitable technological infrastructure etc. It seems that a system of international collaboration is necessary. Part of the task can be handled by bilateral development assistance schemes. It is, however, important that international organizations, strengthen their role in peat promotion, and that the United Nations system, with its relevant bodies and the international development banks could include peat in their programmes to assist developing countries.

International Peat Society

The International Peat Society is a non-governmental organization founded at Quebec in 1968 in connexion with the third International Peat Congress. The aim was to activate and co-ordinate the co-operation of specialists in different countries and in different fields of peat and bog use.

Up to now, six international peat congresses have been organized: at Dublin in 1951, at Leningrad in 1963, at Quebec in 1968, at Helsinki in 1972, at Poznan in 1976 and at Duluth in 1980. At Duluth there were 442 participants from 22 different countries, both developed and developing. The congresses offer a scientific, technical and even commercial forum, where experts can discuss matters related to the use and development of peat technology.

Between congresses, the six branch commissions have organized international symposiums on special topics, such as the peat industry, the processing or combustion of peat, afforestation, cultivation and conservation of bogs, hydrology, chemistry, physics and classification of bogs and peat, balneology and the uses of peat for example, in horticulture, environmental protection etc.

At present the Society has national committees in 14 countries and individual and supporting members in 25 countries. It has contacts with the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organization of the United Nations (FAO) and the International Union of Forestry Research Organizations. It is still small and has only limited resources; the permanent staff consists of only one person - the General Secretary. The Society publishes an annual bulletin and the proceedings of different congresses and symposia. By increasing the number of its members, and with governmental or preferably United Nations support, it could be possible to expand the Society's work on the promotion of co-operation in matters concerning peat and the collection and dissemination of information.

In addition to its function as a forum for scientific co-operation, the Society has also played an active role in carrying out practical measures to implement peat technology, for example, by arranging contacts between peat specialists and commercial organizations and by assisting developing countries.

The official languages of the Society are English, German and Russian. At the moment the Society is working on a peat vocabulary (Russian-English-German-Finnish) containing about 7,000 terms.

VI. MEASURES TO OVERCOME THE CONSTRAINTS ON THE USE OF PEAT AS AN ENERGY SOURCE

A. Potential constraints

Although peat seems to be a viable and indigenous alternative energy source in many developing countries, there are many constraints on the use of peat for energy.

The following are the most important:

(a) Peat is at present used as a fuel in only a few countries, and in other countries there is a lack of information on peat as a possible alternative fuel;

(b) In most developing countries adequate data on indigenous peat resources and their feasibility are not available;

(c) There is no comprehensive international information system for peat;

(d) As peat is neither a traditional fossil fuel nor a renewable energy source, it has not been explicitly included in the energy development programmes of international organizations;

(e) National energy planning and programming is still at an early stage in many developing countries;

(f) Developing countries have not generally had the time and resources to adapt foreign energy technology to their local conditions.

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The measures that must be taken to overcome the constraints lie in the following areas:

Planning and programming;

Research, development and demonstration;

Transfer of technology;

Dissemination of information;

Education and training;

Financing.

B. Planning and programming

One important task is to develop national energy plans that can provide a framework for including peat in the energy economy. The best alternative would be an over-all plan for peat utilization.

The main items to be included are:

Estimation of resources;

Prospects for peat demand;

The feasibility of peat as a fuel on a national and regional basis;

Alternative utilization of peat (for example, in agriculture);

Selection of suitable peat production areas, taking into consideration the location of potential consumers and the available infrastructure;

Assessment and selection criteria for appropriate technology for peat production, combustion and processing;

Financial arrangements;

Institutional arrangements.

Peat utilization can naturally begin without any systematic planning, but planning is necessary at later stages, when important budgetary or policy commitments are required.

Recommendations for promoting the planning of peat utilization

(a) Countries with unexploited peat resources

Include peat as a possible future energy source in the national energy programmes;

Initiate co-operation with international organizations and peat experts for the preparation of a peat utilization plan.

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(b) Peat-producing countries

Provide peat experts to assist other countries in planning the utilization of their peat resources, either through bilateral agreements or through international organizations.

C. Research, development and demonstration

Modern peat technology is based on existing knowledge and traditional methods of peat handling. It is developing through the close collaboration of experts from the various peat-producing countries and is supported either by government funds or by private industry. Because of the interdisciplinary nature of peat science and technology, research, development and demonstration is scattered among many different institutions and is partly unco-ordinated.

All countries that are starting to use their peat resources will, of course, make full use of the relevant knowledge already available in the world. But peat technology developed for a particular country is not directly applicable to other countries with different local conditions (resources, climate, infrastructure, social habits etc.).

The primary responsibility for the utilization of peat resources rests with the country itself. Indigenous scientific and technological activities are thus of essential importance for the continuing successful adoption of foreign technology. The major research, development and demonstration efforts should be directed towards resource estimation, the study of climatic conditions for peat production and small-scale appropriate technology.

Recommendations for promoting research, development and demonstration efforts

(a) Countries with unexploited peat resources

Assign to a specific organization the responsibility for obtaining the required peat expertise;

Motivate scientists from related disciplines to become specialists in peat production and processing;

Co-operate continuously with other peat-using countries.

(b) Peat-producing countries

Strengthen and co-ordinate peat research, development and demonstration efforts on the national and international levels;

Include items of potential value for developing countries in their peat research, development and demonstration programmes;

Co-operate with and assist developing countries in their peat research, development and demonstration efforts;

Encourage international organizations to include peat in their development programmes.

D. Transfer of technology

Small-scale and large-scale peat technology is well in hand and has been tested for decades. It originates in the main peat-producing countries, and is ready to be transferred to all countries that are beginning to use their peat resources.

The main alternatives are:

(a) Technological assistance;

(b) Consulting services;

(c) Export/import of machinery and equipment;

(d) Turnkey deliveries;

(e) Licensing;

(f) Direct investment.

The suitability of the alternative depends on the technology that is being transferred and the partners involved.

Technical assistance and consulting services are particularly necessary in the planning phase for the evaluation of the peat resources and production planning. The services can be provided through international organizations, for example, the United Nations system, and the international development banks or bilateral development assistance schemes.

Machinery imports, turnkey deliveries, licensing and direct investment are in general based on direct agreements between industrial firms or governmental bodies.

When the imported technology is capital-intensive, with a wide assessment of the whole country, for example, large-scale peat technology, the role of the Government is important. But the details of the transfer, for example, machinery and equipment, must be a matter of choice at the enterprise level.

Successful planning of the transfer process is, however, essential. Effective transfer calls for special efforts by both donor and recipient.

Recommendations for promoting the transfer of peat technology

(a) Countries with unexploited peat resources

Formulate a policy and improve conditions for the transfer and acquisition of technology. This should be supported by a legal framework (industrial property, foreign investment etc.);

Strengthen their capacity for evaluation, selection and assessment of peat technology through indigenous research, development and demonstration activities, technological production and international co-operation;

Co-operate and share their knowledge of peat with other developing countries.

(b) Peat-producing countries

Strengthen their bilateral peat development assistance;

Encourage and facilitate the transfer of technology for their peat-machinery industry (small and medium-sized) - this can be done, for example, through government-supported export drives;

Comply with the requests of developing countries for assistance, including experienced personnel.

E. Information flow

The flow of peat information is hindered by several specific obstacles:

(a) Science and technology pertaining to the utilization of peat as interdisciplinary: information must therefore be sought from many different fields (agriculture, forestry, geology, energy, transportation etc.), and the coverage of peat information in these sources is rather poor;

(b) There is no abstract journal or data base with international coverage of the whole peat field; there are, however, two recent important international projects; UNESCO has undertaken a study on an international information system related to new and renewable energy sources and the Organisation for Economic Co-operation and Development/International Energy Agency is starting an information system for biomass energy, which includes peat;

(c) There is no international, specialized peat journal that could act as an effective channel for scientific, technical and commercial information;

(d) Only a minor part of the information about peat is published in English; the essential technological knowledge originates in the leading peat-producing countries and is thus often published in Russian, Finnish, German or Swedish. The use of this information in other countries is thus hampered by language barriers;

(e) The obstacles to the systematic transfer of peat information are thus high, even in peat-producing countries. Personal contact is, at the moment, the most successful method. For developing countries with undeveloped information systems, this transfer is nearly impossible.

Recommendations for promoting the flow of peat information

(a) Countries with unexploited peat resources

Give the responsibility for following, collecting, disseminating and translating international peat information material to an organization (co-operation with other developing countries); the organization should maintain contacts with international information centres and systems in the field of peat utilization;

Promote and support membership in international organizations and participation in international conferences (for example, the International Peat Society) in order to improve and intensify the exchange of information through personal contacts;

Favour bilateral or multilateral agreements and co-operation with leading peat-producing countries;

Invite peat specialists from abroad to act as technical assistants or teachers;

Heighten the awareness of the general public, industry and other appropriate circles regarding the role of peat as an indigenous energy resource.

(b) Peat-producing countries

Strengthen and co-ordinate the handling of peat information (for example, the activities of IPS);

Start an international peat journal covering all aspects of peat utilization;

Make information that is readily accessible to domestic users equally accessible to users from developing countries;

Publish general material on peat as an energy resource, such as booklets, films etc., for distribution in developing countries.

F. Education and training

The utilization of peat requires much specialized knowledge, which is not directly included in other educational programmes. This is particularly true with respect to knowledge about the quality of peat and peat-lands, climatic effects and demands on peat production and the environmental aspects of peat utilization. Because of this, and the fact that special expertise is needed in large-scale utilization of peat and peat-lands, personnel training must be arranged simultaneously with other practical measures for the realization of peat development programmes.

Training programmes are necessary at all levels; for experts and management personnel as well as for peat workers, drivers, maintenance personnel etc. The programmes must be based on local conditions. In developing countries, manual production methods and household usage of peat must also be included. However,

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external aid is necessary in many cases, especially at the starting stage of a peat development programme. The most critical is the training of people to evaluate the peat resources and planning of peat production. A small mistake at this stage can cause a great deal of harm and additional costs later.

The training must include both theoretical courses and practical work, for example, in experimental production. Essential aspects of the education and training of peat experts are international co-operation and participation in conferences and seminars.

1. Training programmes for the peat industry in Finland

Systematic training of peat workers was started in 1972, at a course centre where the drivers of heavy machines were trained. At present, there are three course centres in Finland for drivers and repair and maintenance personnel of peat enterprises. The maximum duration of the courses is 48 weeks. About 700 workers have so far received specialist training in peat production at these three course centres. Courses have also been arranged for peat briquette and peat-processing factory workers.

Field supervisors are the second largest group to require additional training. They are usually machine, agricultural or forest technicians whose basic education includes only a little knowledge to prepare them for work in peat-mining operations. For this group, 14-week courses have been arranged since 1975.

Various organizations have participated in the training of management personnel. The courses have been of shorter duration (2-3 days) and there have been 2-3 courses annually.

2. Recommendations for promoting education and training

(a) Countries with unexploited peat resources

Investigate local education suitable for peat production and usage;

Investigate the total training requirements at an appropriate technological level;

Prepare a training programme based on local conditions.

(b) Peat-producing countries

Assist developing countries with programmes, teachers and educational material for their training programmes;

Establish special training and exchange programmes for peat workers from other countries.

G. Financing

Like any energy project, peat utilization can, in the starting phase, be economically burdensome. Without sufficient financial support, even for small-scale use, it is not possible to start production. As opposed to most of other "new" energy resources, peat technology is tried and tested and ready to use. The financing patterns are thus different.

In developing countries, where domestic financing capacities are probably insufficient, an essential part of the financing should come from international financing organizations (for example, the World Bank), noting the following:

Interest should not be high (less than 6 per cent);

Repayment time should be relatively long (15-20 years);

Because of the long bog-preparation time, loans should be free from repayments for the first three to five years.

In all countries the use of peat for energy should be promoted by special government measures (for example, loans, tax incentives).

Recommendations for promoting the financing of peat development

(a) International organizations and funds

Include peat energy projects in their short-term and medium-term lending programmes.

(b) Peat producing countries

Include peat projects in their bilateral development assistance schemes.

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Appendix

List of authors and contributors

Members of the Committee set up to produce the report

Seppo Hannus, Chairman	Ministry of Trade and Industry, Energy Department
Dan Asplund	Technical Research Centre, Fuel and Lubricant Research Laboratory
Pertti Härme	Ministry of Trade and Industry, Energy Department
Raimo Sopo	State Fuel Centre
Antti Sucninen	Association of Finnish Peat Industries
Pentti Leino, Secretary	EKONO Consulting Engineers
Pirjo-Liisa Vainio, Secretary	Ministry of Trade and Industry, Energy Department

The report was produced in co-operation with the Finnish National Committee of the International Peat Society and was edited by EKONO Consulting Engineers.

Other contributors

Tryggve Boström	EKONO Consulting Engineers
Erkki Ekman	Technical Research Centre of Finland, Fuel and Lubricant Research Laboratory
Lena Hakulin	EKONO Consulting Engineers
Anssi Kalmari	EKONO Consulting Engineers
Erkki Kivinen	
Eino Lappalainen	Geological Survey of Finland
Hannu Mannerkoski	University of Helsinki, Department of Peatland Forestry
Timo Nyrönen	State Fuel Centre
Yrjö Orispää	EKONO Consulting Engineers
Pekka Pakarinen	University of Helsinki, Department of Botany

Viljo Puustjärvi	Peat Research Centre, Hyrylä
Aarno Rantala	State Fuel Centre
Kari Saviharju	EKONO Consulting Engineers
Jaakko Tukia	EKONO Consulting Engineers
Leif Åström	EKONO Consulting Engineers
