

The Peat Industry

Alternative energy ...out of the bog



Introducing
Peat Resources (PET.V)

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Executive Summary

In this report, we consider the potential role of peat as an energy source, in particular as a potential alternative to coal. As peat as an energy source is a new topic in Canada, we need to consider the environmental impact of peat extraction and burning, the general economics of peat combustion and how these map out in the province of Ontario.

Key Points

Fuel peat is a viable alternative to coal for power generation

While not a common fuel source in North America, peat is used extensively in Ireland, Scandinavia and Eastern Europe.

Current high energy prices and strong demand for coal underpin economics

In the short term, the economic case for peat burning is driven by high energy prices and the demand for coal. To some extent, the current high price of oil is being maintained by economic development in China and events in the Middle East

In the longer term, environmental concerns underpin increased use...

In the longer term, the relative merits of peat energy will be supported by higher energy prices, allied with increasing regulatory pressure on oil and coal energy in terms of its environmental impact.

but will also lead to higher environmental costs

While more stringent environmental standards will favour peat as an energy source, they will also bring about higher capital and monitoring costs.

Longer term, Kyoto Treaty and carbon emission pricing will affect economics

Canada signed up to the Kyoto Treaty in 2002 and needs to cut carbon emissions to 6% below 1990 levels by 2010. However, it has yet to pass any legislation committing itself to enforcing carbon reduction targets.

When correctly done, a low carbon-impact resource...

The impact of peat fuel on climate change depends greatly upon the restoration work carried out at the extraction site. Correctly done, peat extraction for energy can have a low carbon impact.

...with appreciably lower sulphur and mercury emissions

Mercury and sulphur dioxide emissions from peat appear to be appreciably lower than for North American coal supplies and can be further reduced through new boiler technologies.

Planned production levels are not a significant source of habitat loss

Peatland losses have been much lower in Canada than in Europe, with 81% of peatlands remaining in a pristine state in Canada against 20% in Ireland.

Relative proximity to markets makes it attractive for Ontario's power generators

The economic case for peat in Ontario is further boosted by the absence of coal mining in the province. This means that all coal has to be imported, usually from the USA. Not only does this increase the cost of coal as an energy resource, the energy costs of transporting the coal further enhances peat's desirability as a long-term sustainable alternative fuel resource.

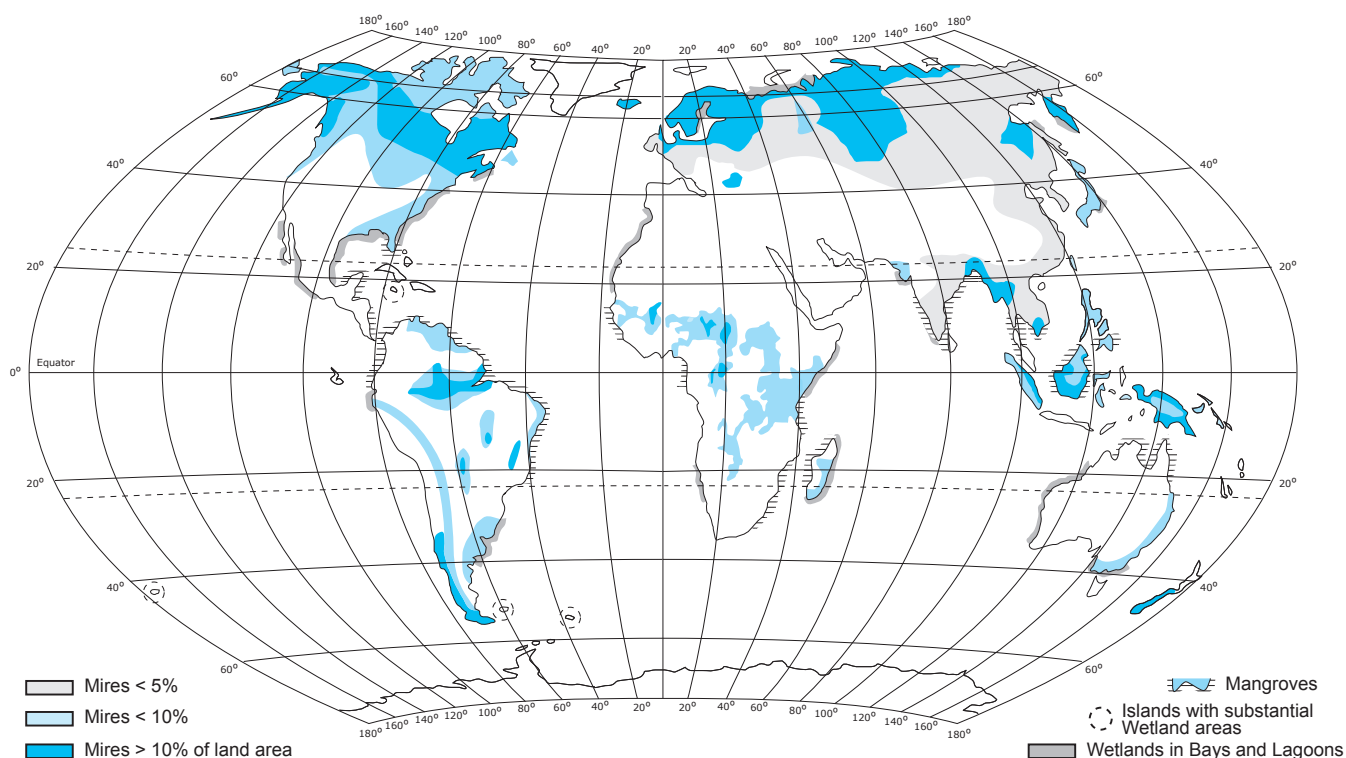
Analysts

Andy Hartwill
andy@objectivecapital.com

Dr David Lloyd Owen
david.owen@objectivecapital.com

Phone +44-870-080 2966

Global distribution of peat mires



Source: International Peat Society

1999 European Fuel peat production

Million tonnes	Prod.	Consump.
Finland	7.93	6.85
Ireland	2.93	2.32
Russian Federation	3.22	2.85
Belarus	3.09	2.16
Sweden	1.12	1.10
Ukraine	0.72	0.50
Estonia	0.58	0.35
Latvia	0.38	0.14
Rest of Europe	0.15	0.12
Rest of the World	1.16	1.15
Total	21.27	17.44

Sources: WEC Member Committees, 2000/2001; Energy Statistics Yearbook, 1998; United Nations; Survey of Energy Resources 1992 and 1998; direct communications from the International Energy Agency and International Peat Society

Introduction: The world of peat

Peat is extracted from wetlands for domestic heat, horticultural and agricultural use and as a source of energy. As the map above highlights, most peatlands occur in the higher latitudes, especially in Eurasia and North America. The total production area of energy peat in Europe in 1999 was 113,000 ha. Including the USA, Canada and South Africa, horticultural peat was produced on an area of 100,000 ha.

It is mainly used as an energy source in Ireland, Scandinavia and Eastern Europe. Peat fuel supplies 13% of electricity requirements in Ireland and 9% in Finland. There have been proposals to use peat as a fuel source in Maine and Colorado in recent years, but these as in Canada have, until today, not come to fruition.

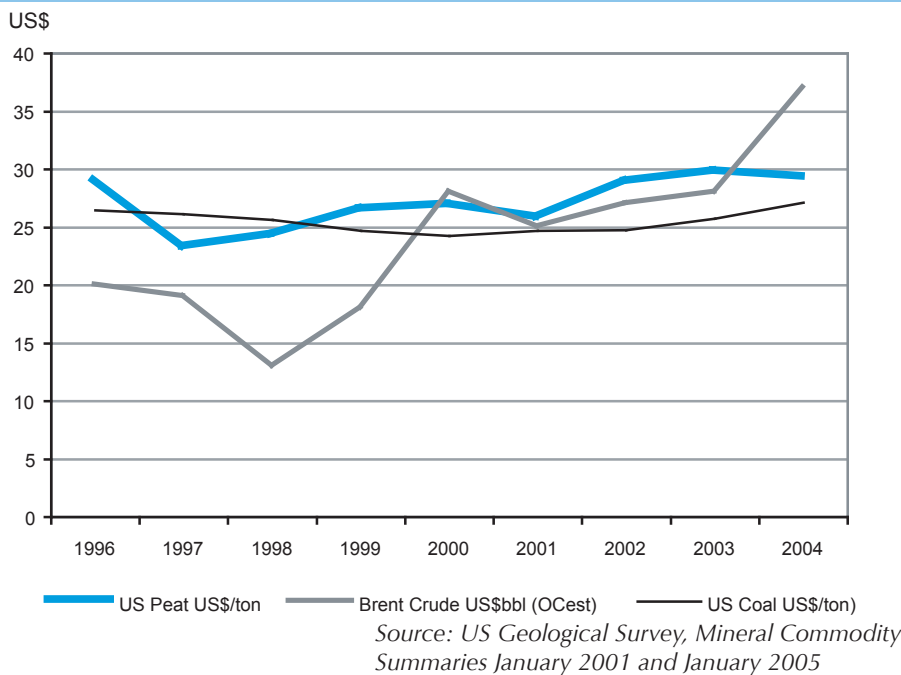
Co-firing peat and global sustainability

While this note takes a look at peat as a fuel resource on its own, it should be noted that peat is a flexible fuel resource. Peat can be used as an energy resource on its own or with other fuel sources, when co-fired with other fuels, such as coal or wood residues. The latter option can be particularly attractive when peatlands are close to forestry operations. The chemical properties of wood fuel alone may cause certain problems in boilers. Burning peat together with wood helps to control the combustion process and reduce corrosion in the superheater tubes. This is mainly due to the mineral components of peat, which are proportionally higher than those of wood. As noted by researchers in Ireland and Scandinavia, co-firing peat with wood wastes can reduce sulphur dioxide (SO₂) emissions.

The economics of peat as a fuel source are almost as murky as the bogs from which it is taken. For an industry that needs to attract capital to fund the extraction, processing and, increasingly, environmental remediation associated with peat there is surprisingly little material available on which to assess the economic argument.

In this article we attempt that task by making the comparison inevitably with oil – not so much because oil is the natural alternative fuel source. Rather because it is a freely traded global commodity whose price therefore tends to set the reference against which other fuel sources can be judged. In a period of rising and, in nominal terms, high oil prices the natural argument should favour sources normally considered speculative or whose costs otherwise would be prohibitive. Such argument would appear to work well for peat.

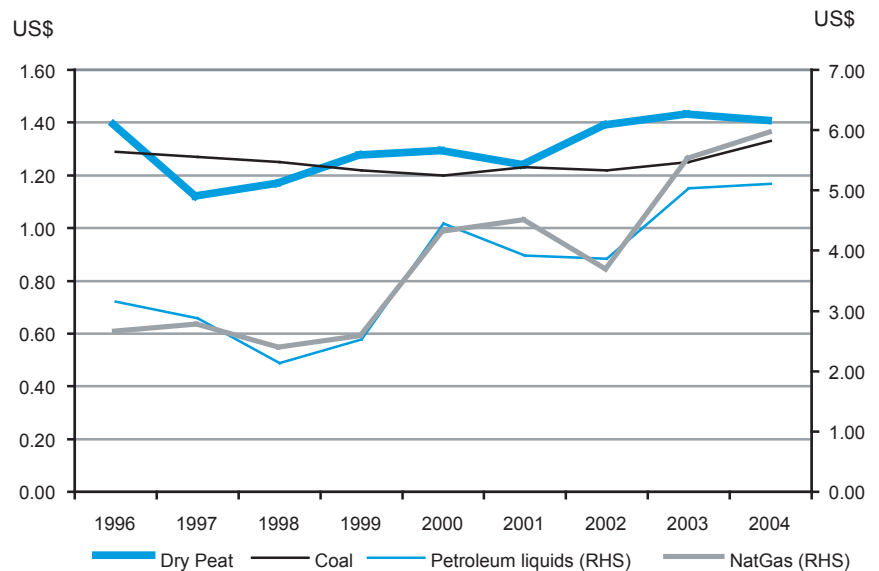
US peat prices (annual average) against oil and coal prices



The above chart compares the costs of peat to oil and coal. The chart shows a striking similarity in the price trends for peat and coal. Both have been stuck in a narrow band, US\$25 to US\$30, for the period of the chart and, at best show only a weak correlation with the rising oil price. During the same period the price of oil (annual average; OC estimated) has almost doubled. Coal prices are also up sharply. On this data there is a case to be made for peat as a substitute for coal. Indeed the experience from Ireland suggests just such a phenomenon. Bord Na Mona estimates that, as the proportion of electricity generated by peat fell between 1975 and 2000 so the proportion produced from coal rose from 1% to 28% over the same period – peaking at 41%.

To the extent however that there is some correlation between oil and peat prices the currently high oil prices suggest at least stabilising prices for peat. Indeed the outlook we believe is likely to be more of the same at least. Any casual observer of the (nominal) oil price over the last fifteen years will have noticed a drift upwards – with occasional sharp spikes. Even the real price of oil has risen

Per MBTU fuel costs for US Electric Utilities



since about the end of the last century. The spikes of course have typically, in this period, been associated with the two Gulf wars. For us the most significant feature today is that the price has not fallen back to pre-existing levels after the end of hostilities. That suggests a combination of two things; a rise in the demand profile globally for oil and / or a rise in the risk premium.

The newly industrialising countries such as those of the former Soviet-bloc and the further development of the populous economies of India and China suggest demographic pressures at least to maintain high oil prices - if not to push them higher still. The possible offset to that would be a reduction in the risk premium. But, as we observe in the relationship between equity and bond yields, global investors appear to be in no hurry lower their guard.

For the foreseeable future we believe that the demographic pressures are likely to dominate, thus to sustain relatively high oil and coal prices and thereby the economic viability of peat. There will come undoubtedly a happy day when the risk premium can relax from current levels. But the peat industry can afford to cross that bridge when it gets to it.

For most observers however the real interest lies in the comparative costs per unit of energy generated. The chart above compares those for peat, coal, oil and gas. The chart shows the strikingly different costs per unit of energy between two groups of fuel. The most expensive are oil and natural gas. The cheapest are peat and coal – and by a considerable margin: some 5 times on the most recent data (note that the costs for oil and gas are plotted on the right hand axis).

But perhaps the most significant feature of the chart is the close correlation in the price trends of peat and coal. The two appear to be economically substitutable fuel sources, all else being equal. But the chart also shows the recent rise in the cost of

coal-generated electricity. The table below shows estimates that that trend may continue modestly over the next two decades. We have seen no comparable suggestion for trends in peat prices.

In other words the economic case for peat appears to be intimately connected to that of coal. At current prices they are effectively substitutable energy sources. In regions where there is local peat but no coal, transport costs would quickly make coal uncompetitive against peat. If the estimates in the table below are correct, the rising cost of coal is likely only to make an increasingly persuasive argument in favour of peat in the future.

Forecast Energy Costs (in 2003 US\$/ million BTU)						
Period	2002	2003	2010	2015	2020	2025
Steam Coal	1.27	1.28	1.25	1.23	1.25	1.31

Source: Energy Information Administration / Annual Energy Outlook 2005

However, in the long run the high carbon content of peat means above average CO₂ emissions compared say to wind generation. In today's climate (no pun intended), the possibility of fiscal initiatives to control emissions weighs against peat when put up against other alternative energy sources. Arguably the developing market in trading CO₂ emission "credits" may go some way to ameliorate that. Even so the case for peat is challenging.

While prepared in 2001, and specific to local conditions, the effect of different carbon tax regimes on the unit cost of electricity can be seen in the tables on the following page. Since then gas and coal prices have risen sharply and the oil price (Brent Crude) has risen from around US\$27 (monthly average) to some US\$40 recently. This will naturally have promoted oil and coal-related sources further up the comparative tables. Such moves may have altered the relative rankings today but we suspect that "Peat" would still be at or near the top of the league tables.

The widely held view is that coal, and presumably substitutes, will be largely unaffected until carbon credits trade above Euros20/t, a situation unlikely before 2010.

Overall the economic case for peat is, in our opinion, challenging. The data appears to support the argument for its use as an alternative to coal in power generation. As such the case for specific projects must rest on relative proximity to the market. In the long run, as for coal, carbon taxes represent a significant challenge to the industry. Perhaps the greatest opportunity for peat as a fuel source is in territories where coal reserves are limited.

Estimated cost (€ cents) / kWh for base-loaded plant 2001 for varying tax rates**Ranked by cost with tax rate 20%**

Technology	Tax Rate	
	0%	20%
Peat - existing	8.4	11.6
Gas - new open cycle gas turbine	6.3	7.5
Peat - new	4.9	7.2
Oil - existing plant	5.3	6.7
Gas - existing plant	5.4	6.4
Wind & Gas - new open cycle gas turbine	5.2	5.8
Gas - new combined cycle gas turbine	4.2	4.9
Coal - plus Flue Gas Desulphurisation	3.0	4.7
Coal - existing plant	2.6	4.3
Wind - new	4.2	4.2
Hydro	2.8	2.8

Ranked by cost with tax rate 0%

Technology	Tax Rate	
	0%	20%
Peat - existing	8.4	11.6
Gas - new open cycle gas turbine	6.3	7.5
Gas - existing plant	5.4	6.4
Oil - existing plant	5.3	6.7
Wind & Gas - new open cycle gas turbine	5.2	5.8
Peat - new	4.9	7.2
Gas - new combined cycle gas turbine	4.2	4.9
Wind - new	4.2	4.2
Coal - plus Flue Gas Desulphurisation	3.0	4.7
Hydro	2.8	2.8
Coal - existing plant	2.6	4.3

Source: 2002. *The Macro-economic Effects of Using Fiscal Instruments to Reduce Greenhouse Gas Emissions* (The Economic and Social Research Institute of Ireland - Adele Bergin, John Fitzgerald, Ide Kearney).

Thinking globally, acting locally – Peat economics in Ontario

The economic case for peat in Ontario is further boosted by the absence of coal mining in the province. This means that all coal has to be imported, usually from the USA. Not only does this increase the cost of coal as an energy resource, the energy costs of transporting the coal further enhances peat's desirability as a long-term sustainable alternative fuel resource.

As peat as an energy source is a new topic in Canada, we need to consider the environmental impact of peat extraction and burning. While habitat destruction is a clear environmental concern, compared to coal using peat produces lower levels of mercury and sulphur emissions, and less impact on climate change issues.

Habitat issues

Peat extraction is seen as environmentally contentious in Europe, because of the relative scarcity of peatlands remaining in a more or less pristine state. In Ireland, the intensity of peat extraction has made peat to energy an environmentally contentious issue. Ireland's 220,902 ha of natural peatlands in 1998 represent 19% of the original area, so the fact that peat energy projects in Ireland are extracting 3.5 million tonnes pa of peat from 85,000 ha of peatland has a clear impact on the fate of the habitat.

Since the start of large scale settlement from c1800, 19% of Canada's peatlands have been lost, typically to agricultural development. Peat extraction has contributed 0.02% of this loss.

The total extraction of peat in Canada in 1997 was 7.25 million m³ against 8.40 million m³ for energy and 1.62 million m³ for horticulture in Ireland. Given that Canada has 113.4 million ha of peatland (approximately 25% of the world's resources) compared with Ireland's 0.2 million ha, this is not such a pressing concern.

PET aims to extract 1 million tonnes pa of dry peat fuel for at least 20 years or a minimum of 45 million tonnes of peat. PET holds Land Use Permits from the Ontario Ministry of Natural Resources covering 500,000 ha of land. The company has identified nine principal bogs for extracting fuel grade peat, with a total area of 17,652 ha.

29.3% of Ontario's surface area is covered by peat bogs (31,300,000 ha) accounting for some 28% of Canada's peat resources. The project therefore would involve the extraction of peat from 0.056% of the State's peatlands.

The Canadian Sphagnum Peat Moss Association (CSPMA), the New Brunswick Department of Natural Resources and Energy, and the Secretariat to the North American Wetlands Conservation Council (Canada) have been researching sustainable peat harvesting techniques. Their research indicates that new and many existing sites will revert to functioning peatlands with proper site management during and after use. Where peat bogs have been left to regenerate the process can take up to 20 years, but active restorative management indicates that time can be shortened to five to eight years.

Peat and the environment

Peatlands in Canada

Current extraction	1.2 million t pa
Bioaccumulation	70.0 million t pa
Total peatland area	113,400,000 ha
Current extraction area	17,000 ha
Fully extracted area	2,300 ha
Restoration schemes	500 ha
Peat deposits	3,000,000,000,000 M ³

Source: Canadian peat harvesting and the environment (second edition, 2001, NAWCCC)

In the case of PET, the project involves peat extraction on a similar scale to that of all of Canada's horticultural peat extraction. Given the size of Canada's peat resources, this is not a great concern. However, aftercare and restoration costs need to be carefully considered, especially when one considers that C\$51 million has been spent on restoration research and projects to date by the horticultural peat industry in Canada.

70% of atmospheric mercury emissions are from coal-fired power stations. Peat has significantly lower emissions

Mercury emissions

Mercury has been linked with brain damage during child development, ranging from learning difficulties to impaired nervous systems. In 2002, the United States Research Council estimated that about 60,000 babies born each year in the US could be at risk of mercury poisoning, while more recent exposure data published by the US Centre for Disease Control and Prevention, indicates that the number at risk could be as high as 300,000, indicating that globally the number could run into the millions. The word 'could' indicates that this information is uncertain, to say the least.

The United Nations Environmental Programme (UNEP) published a global assessment of mercury in the environment in 2003. The report says that coal-fired power stations and waste incinerators now account for around 1,500 tons or 70% of new, quantified man-made mercury emissions to the atmosphere. The US EPA estimates that 50-75% of mercury released annually comes from human activities. Coal-fired utility boilers accounted for 33% of the estimated 158 tons of mercury emitted annually into the atmosphere by human activities in the United States, with 77% of this coming from plants built prior to 1977. *(Source: U.S. Environmental Protection Agency, 1997. Mercury Study Report to Congress)*

Estimates of how far mercury travels from incinerators and power plants are varied to say the least, but point to 2-14% being deposited within a 30-mile radius *(US EPA, 1997. Mercury Study Report to Congress)*, while the US Electric Power Research Institute and the Minnesota Pollution Control Agency calculate that 5-10% is deposited within 62 miles, 50% within 621 miles, and the rest is transported regionally and globally.

The UNEP report does not mention peat burning as a current or potential source for mercury emissions. It is evident that man-made mercury emissions have been building up in peat bogs in Canada and Alaska over the past 200 years, but no research has been identified that regards this as an area of material concern.

Finnish mercury emission data

Combustion process	µg / MJ
Pulverised peat combustion	0.11
Grate peat combustion	0.10
Circulating FBC peat	0.03
Pulverised coal combustion	0.12

The tome *Control of pollutants in flue gases and fuel gases* (Ron Zevenhoven and Pia Kilpinen 2nd edition, 2001) is a pretty solid overview of gaseous emissions from various fuel sources. While mercury concentrations in peat is pretty stable at 0.06-0.07 parts per million, dry weight, for coal it varies between 0.02 and 3.00 parts per million. Looking at what comes out of the chimney demonstrates the importance of the process used (see table to left).

Interestingly, with one exception, emissions from coals from North America are noted as having an appreciably higher mercury concentration, whether subject to emission controls or not. As far as mercury is concerned, peat appears to offer significantly lower emissions than most forms of coal fired power generation. There may still be cost issues relating to the degree of stack emission control required for the facility.

CO_x, NO_x & SO_x – Acid rain and climate change

The combustion of peat involves the production of air emissions relating to climate change and acid rain, both of which are issues of active concern in Canada. Carbon Dioxide (CO₂) and Methane (CH₄) emissions are the principle causes of climate change, while Nitrous Oxides (NO_x) and Sulphur Dioxide (SO₂) cause acid rain depositions.

Canada signed up to the Kyoto Treaty in 2002 and is seeking to reduce carbon emissions to 6% below 1990 levels by 2010. However, Canada has yet to pass any binding legislation for enforcing such carbon reduction targets. This voluntary approach has partly been driven by the aggressive stance taken against curbing carbon emissions by the USA. Now that Canada has formally ratified the Kyoto Treaty, a more positive fiscal stance may emerge, which ought to favour peat against for example coal and oil.

In Ontario, Premier McGuinty has committed to phase-out Ontario's coal-fired power plants by 2007. According to the Ontario Clean Air Alliance (OCAA) coal fired plants represent 17% of Ontario's total greenhouse gas emissions. Closure will provide Ontario with approximately 50 to 80% of the province's Kyoto target reductions. Given the availability of viable alternatives it is unclear how realistic this target is. Peat fuel may be an alternative approach which offers the added advantage of enhancing Ontario's energy self-sufficiency.

Peat extraction and climate change

Since the late 1980s, greenhouse gasses (GHG) have become a major issue in looking at the environmental impacts of energy production. Extensive work has been carried out on the impact of peat extraction on climate change gasses in Sweden and Finland. The studies '*Climate Impact from Peat Utilisation in Sweden* (Uppenberg, Zetterberg and Åhman, 2001) and *The Role of Peat in Finnish Greenhouse Gas Balances* (Crill, Hargreaves and Korhola, 2000) resulted in peat being recognised as a 'slowly renewable' source of energy by the European Union.

Each square metre of virgin peat accumulates 37-96 grams of CO₂ per year or an average of 58 g/m² pa in Sweden. However, peat emits methane (CH₄) with a range of 2-40 g/m² pa in Sweden, averaging at 17 g/m² pa. NO_x emissions are negligible. As CH₄ has 21 times the greenhouse gas effect of CO₂, this means that

Mercury concentration in coal

US coals (µg / MJ)	Uncontrolled	Controlled
Bituminous	1.70 – 13.3	0.17 – 7.70
Sub-bituminous	35.0	1.80 – 2.50
Lignite	-	0.10 – 9.50

Using peat has 20-25% less impact on climate change gases than coal. Lower sulphur content is also significant for air quality

virgin peat mires are a significant source of greenhouse gases, pumping out 6.2 times as much in GHG equivalents as they take in.

What happens when peat is extracted?

Emissions (g/m ² pa)	CO ₂	CH ₄	NO _x
Virgin Mire	-58	17	0
Drained Mire	600	2	0
Extraction	1,000	2	0

Drainage and extraction has its costs. Drainage typically takes five years, with a further 20 for the extraction phase. In terms of CO₂ equivalents a net emission of 299 g/m² pa rises to 642 g/m² pa during the drainage phase and 1,042 g/m² pa during extraction. During restoration, CH₄ emissions remain low while CO₂ uptake returns, meaning that as time passes, the effects of extraction are compensated for. The rate of CO₂ uptake depends greatly upon how the habitat develops.

Depending on the restoration option used, this research suggests that in Scandinavia over the life cycle of peat use and post extraction restoration can range from having a climate change impact similar to that of natural gas (good) to being worse than coal (very poor). The variance relates to the poor quality of data available due to the small number of studies and need for long term data. Research suggests that the climate change impact of peat extraction and combustion can be optimised through using rapid afforestation or peat restoration techniques that minimise CH₄ emissions and allow for a high CO₂ uptake.

Combustion emissions

Emissions (g/MJ)	Peat	Coal	Gas
CO ₂	93.500	94.200	61.000
CH ₄	0.005	1.101	0.040
NO _x	0.006	0.012	0.001

Peat combustion and climate change

When peat is burned for energy, it produces a similar amount of CO₂ to coal, but its significantly lower CH₄ emissions mean that it has 20-25% less impact than coal.

Irish power plant peat burning

Year	1990	2001
GHG emissions (Gg)	3,065	2,667
% of CO ₂	9.6%	6.3%
% of CO ₂ & CH ₄	7.0%	3.8%

Cleaning peat combustion up

In Ireland, 4 million tonnes pa of milled peat is produced per annum, generating 6% of the total primary energy requirement and 7.6% of electricity used in Ireland. (*Byrne and Sappi, Case Study on the Greenhouse Gas Budgets of Peat Use for Energy in Ireland, 2003, IEA*). While the effect of peat on CO₂ emissions is broadly neutral, in recent years, it has had a beneficial effect on the combined effect of CO₂ and CH₄ emissions. This is shown by emission data for peat in 1990 and 2001.

Combustion techniques have had a significant impact on emissions and are continuing to improve. The new generation of boilers will allow a further 38% reduction in CO₂ emissions, along with improved combustion efficiency. This also needs to be combined with more systematic drying of peat prior to its combustion.

The Edenderry power plant is the first of three new peat burning plants in Ireland, using a bubbling fluidised bed boiler with 38% efficiency. It has an electricity production capacity 118 MW, using 1 million tonnes of peat annually, via a fuel supply agreement with Bord na Móna, with annual CO₂ emissions of around 900,000 tonnes.

Acid rain and sulphur emissions

Burning coal and lignite generates significant quantities of SO₂, which causes both acid rain and particulate pollution, as those old enough to remember (and survive) the London smogs will attest. Peat has a lower sulphur content, which is reflected in its combustion emissions.

It is interesting to note that generally, coal sources in Canada and the USA have higher sulphur concentrations, especially in lignite than seen in many European sources.

Environmental costs - Risks and opportunities in context

Taking a broader look at environmental risks points to three areas where additional costs can be incurred by a project such as PET's:

Extraction

The method of extraction (dry harvesting versus dredging) needs to be decided, balancing the impact of the operations, with the time it is possible to work the site, winter being something of a distraction in Ontario, along with getting the extraction plant atop the peat. Then there are issues such as the impact of the operations on hunting and trapping rights.

Power production

The power plant needs to be well located to optimise the efficiency of transport of peat fuel to the plant. This is a significant cost factor for many operations. The combustion process (pre combustion drying, the boiler and the emission control system) may need to be upgraded to meet new emission standards, as is proving the case in Europe, as a new generation of EU environmental directives take force.

Aftercare

The cost of habitat restoration and the broader costs of habitat aftercare and monitoring are likely to be significant, given the intensity of research effort in this area both in Scandinavia and Canada.

Irish power plant peat burning

Dry matter	Sulphur
Peat Fuel	0.24%
Lignite	0.90%
Lignite (Atikokan)	0.47%
Powder River Basin Coal	0.50%
US Coal (eastern US bituminous)	1.70%

Source: Ontario Hydro Ltd. (1990) Combustion Characteristics of a Processed Peat Sample

Appendix

Peat resources and reserves at end of 1999 (million tonnes)

	Proved amount in place	Proved recoverable reserves	Estimated additional amount in place	Estimated additional amount recoverable
Africa				
Senegal	17	-	-	-
North America				
Canada	1,092	-	336,908	-
United States of America	6,400	15	103,600	-
South America				
Argentina	90	80	50	15
Asia				
Turkey	53	-	-	-
Europe				
Estonia	2,370	1,520	-	-
Finland	850	420	2,200	1,000
Germany	157	36	-	-
Hungary	28	24	159	121
Ireland	138	98	140	120
Latvia	473	190	324	194
Netherlands	-	120	-	-
Poland	40	-	5,400	-
Romania	25	13	10	10
Sweden	700	70	-	-

Tonnages are generally expressed in terms of air-dried peat (35%-55% moisture content), except those for Ireland, which are reported on a 0% moisture content basis.

Source, World Energy Council, Member Committees in 2000/2001

Summary of Canada's Coal Resources (million tonnes)

Province	Resources of Immediate Interest		Resources of Future Interest	
	Reserves	Measured, Indicated and Inferred	Measured Indicated and Inferred	Speculative
British Columbia	2,562	19,805	3,100	4,600
Alberta	1,911	46,935	71,745	85,000
Saskatchewan	1,670	7,595	27,615	
Ontario		180		
New Brunswick	20	75		
Nova Scotia	415	1,405	1,715	
Northern Canada		2,880	15,550	35,500
Total	6,578	78,875	119,725	125,100
- Metallurgical	1,918	31,730		
- Thermal	4,660	47,145		

Source: Canada's Coal Resources, Geological Survey of Canada, EMR/GSC Paper 89-4. For better comparison, the original resource figures have been rearranged and are shown by predominant coal rank.

Objective Corporate Research

Objective Capital Limited

2nd floor, 145 St. John St.

London EC1V 4PY

Tel: +44-(0)870-080-2965

Fax: +44-(0)870-116-0839

editor@objectivecapital.com

Corporate: www.ObjectiveCapital.com

Research: www.ObjectiveCapital.co.uk