ORIMULSION[1] AND POWER STATIONS

- *Why are bitumen fuels of interest?*
- *pros and cons of environmental impact*

Fuels derived from bitumen (e.g. Orimulsion) are under consideration for expanded use in UK power stations - in particular in National Power's moth-balled station near Pembroke. Concerns have been raised in Parliament and elsewhere over the potential air pollution from such fuels, and the potential environmental effects of any Orimulsion spill in transit through Milford Haven.

This note looks at the environmental implications of fuels such as Orimulsion, and the issues raised.

BACKGROUND

Four of Britain's 27 fossil fuel power stations are capable of burning heavy fuel oil (HFO), but its current price makes it uneconomic to run these stations continuously (i.e. on 'base-load'), and they are used mainly at peak times. The resulting 'spare' capacity has led generators to look for cheaper fuels, and a leading candidate is Orimulsion (see **Box 1**). National Power (NP) proposes to burn this (possibly blended with bitumen residues from a nearby oil refinery) at its currently unused 2,000MW oil-fired Pembroke station.

Although this would not be the first experience in the UK[2] or the world, NP's proposals to burn 5-6 million tonnes of Orimulsion each year are the largest and have raised concerns, over:

- **Composition**. The high sulphur and metal content has led to questions over the environmental impacts of emissions, both locally and nationally.
- **Transport**. The fuel would be imported into Milford Haven by oil tanker; here, the *Sea Empress* accident in February 1996 has heightened concerns over the possible effects of a spill.

ENVIRONMENTAL IMPACTS

Because of its high sulphur content, many talk of Orimulsion as a 'dirty' fuel, since its 2.7% level is much higher than gas (near zero), coal (typically 1.6% in the UK) and is comparable to the HFO which was used in the Pembroke station up to April 1996. In practice the environmental impact is better judged on the basis of the pollutants emitted **after** the fuel has been burnt. Here, the efficiency in converting fuel to electricity, and the pollution control methods used are crucial. **Emissions of sulphur** (and other pollutants) for each unit of electricity generated are shown in **Table 1**.

1. Orimulsion is a registered trade name of Bitor Europe Ltd.

2. Powergen has used Orimulsion at two of its power stations since 1991: ~0.5M tonnes p.a. at the 228 MW station at Richborough, Kent (now shut down), and ~1M tonnes p.a. at the 450MW Ince-B station in Cheshire which will close on March 31 1997.

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BOX 1 WHAT IS ORIMULSION?

Orimulsion is a fuel derived from the bitumen that occurs naturally in large reserves in the 700 km long Orinoco oil belt in Venezuela. It is extracted, processed and distributed by Bitumenes Orinoco SA (Bitor), a subsidiary of the Venezuelan state-owned oil company, and is imported into the UK by Bitor Europe Ltd. It is transported by tanker as a mixture (an **emulsion**) of 70% bitumen and 30% water, with 0.2% of a surfactant (nonylphenol ethoxylate) to stop the mixture from separating. The fuel is currently used or being tested in a number of countries. As with coal or oil, there are a number of trace elements which influence its environmental impact: e.g. sulphur 2.7%, vanadium 300 mg/kg, nickel 65 mg/kg.

Orimulsion's cost of around £33/te means that the fuel costs are similar to coal (both 0.5p/kWh generated), but its price advantage over its chief competitor coal, comes from lower capital and running costs. It is cheaper than HFO because the latter is subject to customs and excise duties of around £19/te.

Source: National Power / ASA Consultants /DTI/Bitor

Table 1 TYPICAL FOSSIL FUEL EMISSIONS (g/kWh)

Fuel	SO_2	NOx	PM	CO_2
Coal without abatement*	6-15	2-5	0.2-2.2	800-1000
Coal with abatement	0.6-1.5	0.8-2	0.1-1	800-1000
HFO	10-14	3.0-4.3	~1	750-850
Gas (combined cycle)	trace	0.25-0.50	trace	400-425
Orimulsion without abatement	~20	~3	0.2-1.0	~800
Orimulsion with abatement	1.1	1.2	0.06	~800

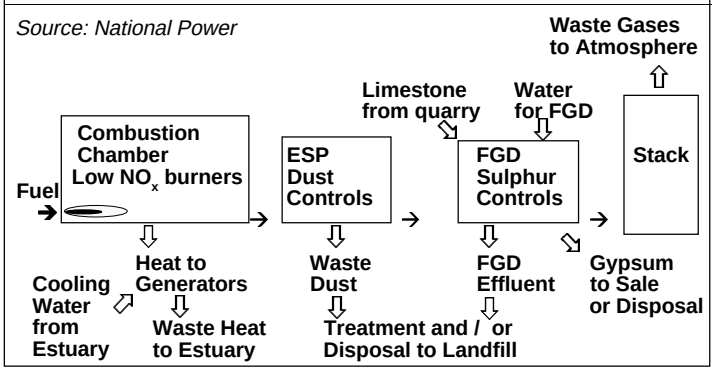
Key: SO_2 *sulphur dioxide* NO_x *nitrogen oxides* PM *particulate matter* CO_2 *carbon dioxide* * *Sulphur removal (FGD), low-NO_x burners, and electrostatic precipators*

Source: Powergen/ National Power

Whether Orimulsion leads to higher sulphur emissions than typical coal-fired stations depends on whether sulphur removal technology (flue gas desulphurisation - FGD) is used. With FGD, sulphur dioxide ($SO_{2)}$ emissions are below those from oil and coal without FGD, and comparable to coal with FGD. In terms of overall emissions, the proposal by NP is that the **Pembroke station would employ FGD**, and emissions of SO_2 would be 17,000 tonnes (tes) p.a. The FGD process uses limestone to neutralise the acid combustion gases, forming gypsum as a by-product which can then be sold for plaster-board, etc. **Figure 1** illustrates the key features of the pollution controls proposed. Until it was closed in April 1996, the station burned HFO for 5% of the time, and, without FGD, emitted ~10,000 tes of SO_2 p.a.

Another potential concern is over **particulates and toxic metals emissions.** As in coal or oil-fired stations,

Figure 1 PROPOSED CONTROLS AT THE PEMBROKE POWER STATION



some evade pollution control equipment, but because of their small size (mostly smaller than 1 micron) would disperse widely. Mathematical modelling by NP suggests that, at most, deposition of arsenic, nickel and vanadium over 30 years would add less than 1% to the existing background concentrations near the power station. The Environment Agency (EA) has looked at experience of burning Orimulsion at the Asnaes power station in Denmark, and found that particulate controls have reduced the concentration of metals in the stack gases to very low levels. Uncertainties remain over how well they can remove ultra fine particles which are implicated in respiratory disease (POST report 82).

The Pembroke station would also produce up to 11,000 tonnes of **ash** each year. As this is likely to contain various metals, it would be regarded as Special Waste, and would need to be disposed of to landfill, although metals recovery is being considered.

Orimulsion would be **imported into Milford Haven** in 120,000-tonne double-hulled oil tankers, with up to 40 deliveries a year. There are around 3500 oil tanker movements in Milford Haven each year, and so Orimulsion would increase traffic by just over 1%. Around 30 oil spills have occurred in the Haven every year over the last 15 years - one spill for every 100 ship-movements[3]. Most spills are small (annual totals are generally less than 5 tonnes), although larger spills have occurred. The *Sea Empress* lost more than 70,000 tonnes of crude oil in February 1996 (POSTnote 75) and was the largest spill in Milford Haven since records began in 1961[4].

The previous spill-rate of 1 in every 100 ship movements gives no guidance on the risks of an Orimulsion spill because of the different types of vessel and fuel-handling procedures involved. Bitor Europe has agreed that only double-hulled tankers would be used, and argues that the risks of a spill are very low. Were a spill to occur, the environmental impact would depend on:

- the quantity of Orimulsion spilt;
- how much floats, sinks or disperses into the water;
- the rate of dissolution and dispersion;
- the toxicity of Orimulsion to marine organisms;
- the success or otherwise of measures to minimise the effects of the spill.

Although tests have been conducted in the North Sea, Liverpool Docks and in the Carribean, there have been no studies on the **behaviour and fate of an Orimulsion spill in the Haven**, and NP commissioned consultants to **predict** the consequences of a spill of 1000 tes into Milford Haven under a range of weather conditions. Because the bitumen in Orimulsion is already dispersed in water, it would not form a slick, but would disperse more widely into the Haven waters. Relative to an oil spill, this would reduce the danger of fouling birds at the surface. As far as effects on fish, shellfish and other marine life is concerned, Orimulsion's initial toxicity is less than that of crude oil because it lacks the volatile toxic fractions of the latter. However, the dispersion into the water column and possible sinking[5] could bring it into closer contact with marine life and also make it easier to foul shellfishing gear. The nonylphenol ethoxylate surfactant degrades into chemicals that can mimic the hormone oestrogen, and concern has also been expressed on the possible cumulative effects on marine life of even small spills, given the chemicals' potential to interfere with the reproductive system. The consultants discounted such effects, but Bitor Europe is investigating whether alternative surfactants can be used that have no potential for mimicking oestrogens.

Overall, NP's consultants calculate that a spill of 1000 tonnes of Orimulsion into Milford Haven would not kill any birds (as would a spill of fuel oil), and its primary impact would be via toxicity to fish, killing an estimated 0.3% of adult fish, and 5.5% of young (first year) fish. These model predictions must be treated with caution, however, since the consultants carried out no direct experiments to discover how Orimulsion disperses in real life under the influence of tides and waves in the Haven itself. The model also predicts that after a few days, and as the spill spreads into denser sea water, the detergent will degrade and cause some of the bitumen to float again as tar balls and be beached along the coastline.

In view of the different behaviour of Orimulsion, there are uncertainties over how well contingency plans in place would be capable of dealing with a major spillage, and a MHPA-led working party is looking into incorporating contingencies for an Orimulsion spill into existing plans.

THE OVERALL PICTURE

Although the primary concerns are over the risks of air pollution and the transport risks, other potential envi-

3 Source: National Power Environmental Statement, Nov 1994, Table 6.3.
4. The previous largest annual total was in 1973, when altogether 50 spills occurred with a total loss of 2316.5 tonnes of oil.

5. Orimulsion is heavier than fresh water, but lighter than sea water so whether it tends to float or sink depends on the salinity of the estuary water.

ronmental impacts include the need for cooling water and operation of the FGD plant.

Cooling Water will discharge up to 64 cubic metres per second of sea water, up to 10°C warmer than the estuary ambient temperature. NP computer models expect temperatures within Milford Haven to increase by 1-3°C on average as a result. The EA's main concern is to protect the migration of fish and a temperature water quality standard has been set - this will require temperatures to be monitored, and if they exceed the standard, NP would have to take remedial action or shut down the power station. There are, however, uncertainties over whether the temperature standard will avoid effects on the ecology of the Haven as a whole; and this has given rise to concern given its conservation importance[6].

Flue-Gas Desulphurisation. FGD would require 600,000 tonnes of limestone each year, which would be quarried and transported into Milford Haven by ship. NP has not yet placed a contract for the limestone, but DTI has stated that it could not be taken from any quarries within National Parks, Regional Parks in Scotland, or Sites of Special Scientific Interest (SSSIs). Similarly, NP has stated that it will only use quarries that have, or plan to implement, environmental management plans and codes of practice. The FGD plant would generate ~1M tpa of gypsum, which NP envisages being able to sell for wallboard manufacture, road construction, soil improvement, cement manufacture, etc. If customer specifications could not be met or if market demand were low, gypsum would have to be disposed of to landfill. At this stage, NP has not identified which facilities would be used for this.

The complex nature of NP's proposals for Pembroke power station mean that many regulatory permissions are necessary, as outlined in **Box 2**.

BOX 2 REGULATING THE PEMBROKE SCHEME

For the power station itself, NP would need to gain consent for:

- a substantial change in fuel and extension of the site (under Section 36 of the 1990 Electricity Act) from the Secretary of State for Trade and Industry.
- a variation to its Integrated Pollution Control (IPC) authorisation from the Environment Agency.

Limestone and gypsum would be handled at a roll-on roll-off jetty near the power station, but this would need to be extended, requiring consent from MAFF, and the Department of Transport. Orimulsion itself would be handled at an existing jetty owned by Texaco, and this would be regulated under IPC.

ISSUES

Some environmental groups have objected to NP plans to use Orimulsion at Pembroke, questioning whether it is sensible to burn fuels with high contents of sulphur and metals, when 'cleaner' fuels (such as gas) are available. The power generators argue that what matters is protecting the environment by controlling the pollutants actually emitted, and point out that, **with FGD**, the emissions from burning Orimulsion will meet modern EC and UK emission standards for fossil-fuel power stations; indeed, SO_2 emissions per unit of electricity generated **will be considerably lower from Pembroke with FGD than from other power stations burning coal or oil without sulphur controls**. NP also points out that the existing authorisation to burn HFO at Pembroke allows emissions of up to 48,000 tes each year of SO_2,compared with 17,000 tpa proposed now. On this central measure, NP's proposals appear to raise few new issues.

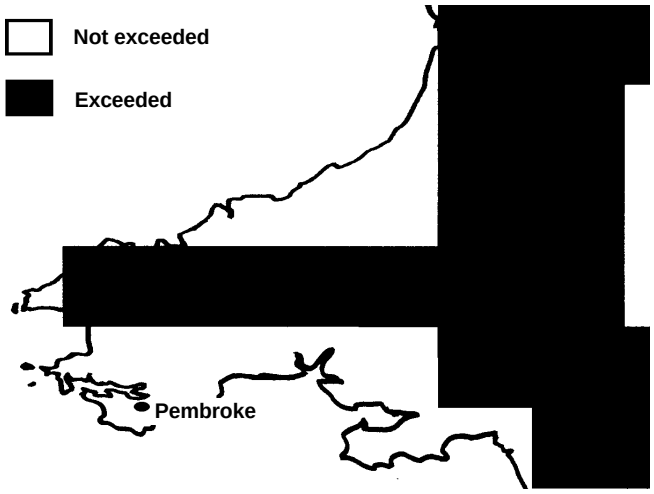
From a wider perspective however, Orimulsion does place pressures on the environment which are not posed by other fuels. There is the environmental impact of the FGD required by the fuel's high sulphur content - both in terms of quarrying and transporting the 600,000 tes of limestone required each year, and in disposing of the 1 million tpa of gypsum[7] generated (600,000 tes is equivalent to removing 40 hectares of land each year to a depth of 10m). The impact of a large spill would be very serious and doubts over the applicability of clean-up contingency plans to Orimulsion remain. This has led the Countryside Council for Wales to object to the original jetty proposals of the MHPA.

An additional consideration is whether there would be **local impacts** from particulates (which can contribute to respiratory disease) and sulphur and nitrogen oxides (which contribute to acid deposition). Uncertainties remain over how efficient particulate controls would be especially in removing ultra-fine particles. On acid gases, with FGD and low-NOx burners, full operation would emit annually 17,000 tes of SO_2, as well as 17,400 tes of NOx. Compared with local emissions in the rest of West Wales (67,000 and 26,000 tes respectively), this would be a significant local source. Acid deposition across Europe is controlled via the critical loads approach (see POSTnote 47) whereby the nature of the soils determine how much acid can be accommodated without environmental damage. As shown in **Figure 2**, Wales has many areas where the critical loads are exceeded at present, and environmental groups argue that the increased emissions compared to the existing situation will prolong current levels of damage to sensitive ecosystems and species. Moreover, FoE asserts that the flue gas from FGD plant will be cooler and wetter than from other stations and this, combined with the moist local conditions may cause more of the acidity to fall locally than NP's models predict, excacerbating

6. The Haven is a particularly sensitive area because of its importance to a National Park and Heritage Coast, nearby SSSIs (over 30), its likely designation as a European Special Area for Conservation (SAC) and 2 of the UK's 3 marine nature reserves (i.e. Skomer and Lundy).

7. With the amounts of gypsum being produced by other FGD facilities at Drax and Ratcliffe, some see the UK market becoming saturated. Overseas markets may thus be important to Pembroke gypsum. Were markets not found, gypsum would have to be treated as waste.

Figure 2 AREAS IN WEST WALES WHERE CRITICAL LOAD IS CURRENTLY EXCEEDED*



*Exceedance of critical loads of acidity for soils by non-marine sulphur deposition 1991-2.
Source: DoE Critical Loads Advisory Group, Critical Loads Mapping Centre, Institute of Terrestrial Ecology, Monks Wood.

local impacts. Taking a national perspective, however, NP and EA point out that if Pembroke were consented, then an equivalent capacity of unabated generation elsewhere in the country (i.e. older coal-fired stations) may close down, leading to a net reduction in acid emissions for the UK.

The situation is thus not so cut-and-dried when looked at holistically, and **one policy question is whether the regulatory system outlined in Box 2 is capable of taking the broad overview.** The Environment Agency controls the direct emissions from the plant, but has no statutory control over the movement of oil tankers in the Haven (this is MHPA's responsibility), or over any spill. MAFF has to give regulator's approval for extending the jetty, but can only consider the potential impact on fisheries of the jetty's construction, not of subsequent shipments to it. Equally, the impact of the limestone quarrying would be for local consideration at the site of extraction, as would any proposal to landfill gypsum. Environment groups argue that the overall proposal is not being assessed holistically, challenging whether the proposal is the Best Practicable Environmental Option (BPEO). Specific criticisms of NP's case are that it has not taken into account the environmental impacts of quarrying and transporting the limestone to Pembroke, nor considered the external costs of pollution, mining, transport etc., in the economic analysis.

In the latter respect, the ability of the EA to take a broad view is limited by its statutory powers, and its consideration of the application for the IPC authorisation cannot take into account such off-site issues (or, for that matter, the possibility that older 'dirtier' power stations may be shut down if Pembroke is commissioned). The EA would,however, have some control over day-to-day unloading operations because this would be included in the variation to NP's IPC authorisation. A more holistic research investigation is underway at DTI's Energy Technology Support Unit (ETSU) through an EU-funded programme to evaluate the full life-cycle environmental impacts of using Orimulsion.

This case also brings into focus debate at national level of the principle of **how far industrial pollution control should rely on end-of-pipe technology to meet emission standards rather than seeking to use the 'cleanest' process possible**. At present the IPC regime seeks to prevent releases to the environment as a first priority, but where this is not practicable, the EA applies the principle that emissions should be minimised and rendered harmless by techniques constituting the Best Practicable Environmental Option (BPEO), implemented using the Best Available Techniques Not Entailing Excessive Cost (BATNEEC).

In this respect, some groups see the Orimulsion proposal revealing a tension between the Government's environmental and energy policies and argue there should be a more explicit commitment to the principles of sustainable development, whereby such proposals should be judged on their overall impact on the environment and resources. Part of this could be an 'energy hierarchy' (along the lines of the Government's waste recycling and disposal hierarchy):

- Firstly, the potential for energy conservation and efficiency should be maximised to reduce the need for additional generating capacity.
- Secondly, the potential for renewable sources (such as solar or wind energy) should be explored.
- Thirdly, fuels such as gas (which are inherently 'cleaner') should be used.
- Only when the above options have been exhausted should additional capacity be permitted using 'black' fuels and here, these should be as 'clean' as possible - e.g. with a low sulphur and metal content.

NP, the Environment Agency and the DTI point out, however, that the power industry's primary operational objective is to provide energy, and the statutory process requires each application to be considered on a case-by-case basis. In a free market for energy, they argue, generators should be at liberty to choose whichever fuel they like, subject to their being able to meet emission standards. The Pembroke project is thus considered in isolation to any wider arguments about general energy policies. Opponents counter that relying on the market makes it important that market signals are as objective as possible, and question whether this is the case. First, there is the fact that the main alternative to Orimulsion (HFO) is subject to customs and excise duties, whereas Orimulsion (and coal and gas) are exempt; secondly there is the inability described above to take into account external costs. The economic attractiveness of Orimulsion and the rules of the market are thus interlinked.