Railways and Atmospheric Emissions: Fuel Duty and Related Issues

A Discussion Paper from IEEP

February 2004

1 Introduction

This paper, commissioned from IEEP by the SRA, outlines some of the key atmospheric pollution issues facing the rail industry, sets out the policy background and presents some options for future progress. While the primary focus is on fuel duty and fiscal incentives, the paper begins with an overview of the atmospheric pollution issues for the rail industry. This is followed by a detailed account of the technical requirements in relation to fuel quality and diesel engine standards, as these are essential background for the discussion of taxes and incentives.

2 Atmospheric Pollution Issues and the Rail Industry

This paper will address the most important atmospheric emissions from the rail industry, and outline their relationship with current and future rail engines and fuels.

In this, the paper will focus on the diesel side of the industry. The distribution of diesel and electric engines in the UK, and their various size classes, varies significantly according to geography and application. For example, all freight trains are hauled by locomotives, and most of these are diesels. The passenger fleet is far more mixed, however. Rural routes are typically not electrified and are served by diesel multiple units (DMUs); cross country services are a mix of DMU and some older locomotives; while intercity services are hauled by a mix of locomotive types, governed in part by whether the line in question is electrified or not. As an indication, the mix of diesel and electric for passengers is around 50-50 in terms of train-kilometres.

Electric traction offers significant environmental advantages over diesel, in that it is virtually emission-free at the point of use. It does of course give rise to emissions from power plants, but it is also more efficient in energy consumption terms than diesel, and so total unit emissions are much lower. Almost certainly the best means to improve railôs emissions performance would therefore be further electrification, but this presents serious issues in terms of cost constraints. There are currently no plans for major new electrification, although some repairs and replacements are envisaged, and the reinforcement of the electricity supply in the Southern Region is going ahead.

In the medium term, fuel cells might offer an alternative route forward, as discussed below.

Regulated Pollutants

In terms of regulated pollutants (ie hydrocarbons, nitrogen oxides or NOx, carbon monoxide and particulates), the rail industry and its diesel engines have not to date been subject to the sort of regulatory attention applied to road vehicles. Rail engines contribute a very small percentage of total transport sector emissions, but these are local pollutants, so they may be more important sources of exposure in some localised areas ï most obviously railway stations. For local pollution, it appears that termini on diesel lines are the main hotspots, with emissions of NOx and SO_2, as well as particulates, possibly being important in such cases. However, it should be noted that the Air Quality Strategy published by the Mayor of London does not seem to have identified rail as a problem in the context of a London AQMA. On the other hand, it is reported that some boroughs have included stations in their AQMAs and propose to work with the SRA to promote best practice in train operation at stations.

Tighter standards are now in the pipeline (see Section 3), but it will be some decades before these have their full effect, since standards will apply only to new engines and it will be many years before the older engines are withdrawn from service.

Furthermore, the actual in-service emissions characteristics of railway engines, especially the oldest ones, are poorly understood and may be disproportionately high in some cases. However very little in-use emissions testing has been carried out in the UK post-privatisation. As a result, inventories for particulates and NOx in particular are very uncertain. It is thus difficult to be very certain either about baseline emissions for the sector, or of the relative benefits of the various technical options for improvement. In addition, it was noted that a clearer understanding of the relationship of test cycle to actual emissions is important in terms of identifying cost-effective policy responses. It might be useful to investigate those used in the National Atmospheric Emissions Inventory in more detail. For example, applying the industry-wide typical-loading emissions profile to trains in or leaving the principal emission hotspots (eg some railway termini), would underestimate the benefit of reduction policies.

In this regard, the impact of the use of old technology is exacerbated by the high sulphur content of the gas oil used in the rail sector. The emissions of sulphur dioxide that result are still fairly negligible as a share of total national sulphur dioxide emissions (for 2005, Customs and Excise recently estimated that gas oil was responsible for less than 19kt out of a national total of 628kt of SO_2, and of this fuel, rail consumed about 6 per cent[1]). However, the sulphur also seriously exacerbates the particulates problem. It seems to be generally recognised that there is a positive relationship between sulphur content and particulate emissions, but the exact nature of this relationship is poorly understood, which is an obstacle to effective policy formulation, as discussed below.

Especially with particulates, it is readily apparent that some rail engines are a major source, and emissions are often at their worst as the train pulls out of a station and its

[1] HM Customs and Excise (2003) *Hydrocarbon Oil Duty: Consultation on Duty Differentials for more Environmentally Friendly Rebated Oils.*

engines are under full load. Whether or not this poses a direct health threat to passengers, it clearly gives a bad impression of a ódirtyô industry. Furthermore, recent work for SRA by AEA Technology strongly suggests that on average rail is more polluting per passenger-km than car in respect of SO_x and PM_{10} - the latter being the pollutant of greatest concern in respect of air quality and health[2]. Passenger rail may as yet retain some advantage on average in terms of other important pollutants (NOx and CO_2), but probably not for diesel, and further improvements on road are likely to erode the position quite quickly unless rail load factors or average emissions are improved. Recent analysis from the Netherlands suggests that diesel rail traction is significantly more polluting than road in terms of NOx and PM_{10} on a tonne-kilometre basis[3]. UK data do not support this view in spite of the fact that freight is mainly diesel-hauled, and it might be useful to investigate the causes of this significant discrepancy. This therefore may well emerge as an issue for the rail industry at some point in the future, and merits some attention.

Fuel Use and Carbon Dioxide

Rail diesels also emit carbon dioxide (CO_2) through the combustion of the fuel. Again these are small in terms of total transport CO_2 emissions (rail emits 2 million tonnes of carbon (MtC), as against 42MtC for all transport and 152MtC for the whole UK in 2001; while in 2002 railway engines burned 0.33Mt of gas oil out of the transport sectorôs 48.7Mt of petroleum products). Railways also have the benefit of carrying large numbers of passengers, so emissions on a passenger-kilometre basis are not high on average. Nevertheless, the AEA calculations suggest that the industryôs average CO_2 performance per passenger-kilometre is not a great deal better than road, and cars are likely to improve significantly in the coming years owing to the EU voluntary agreement on new car emissions. Diesel-electric engines in particular are not very efficient, and if they do not already underperform the average car, then probably they soon will if improvements are not made.

Noise and Vibration

Another important environmental issue for the rail industry is noise and vibration. This is an issue which, in general, is advancing on the political agenda, and public tolerance for excessive noise appears if anything to be diminishing. It is possible that cleaner engines will in future also be quieter ones, particularly if we are to move to fuel cells and electric motors; however, engines are not in any case the most important source of rail noise or vibration, so there is rather little crossover between the emissions and noise agendas. The latter is not therefore considered further in this paper.

Assessment

To date, rail continues to enjoy a perception of good environmental performance on the grounds that it is a mass transit system, but on the basis of the information above this is not necessarily well-founded and perceptions might change. Particulates appear to be the most serious cause of concern, followed by the generally poor energy efficiency of diesels relative to electric trains and some other transport modes. It

[2] *Everyone's railway: the wider case for rail* (2003) SRA, London

[3] Vermeulen J P L, de Boer L C, Smith N and Dings J M W (2003) *Clean on track: Reducing emissions from diesel locomotives*. Report 03.4799.20, CE, Delft

would therefore be prudent to seek steps to improve on the current position, if ways could be found to offset costs or provide the necessary incentives to do so.

{*possible action:* investigate emissions measurement work and inventory emissions factors elsewhere in Europe; consider factors used in NAEI, and relationship of test cycle metric to real world emissions. Could check through UITP if it or any member has done work on this.}

3 The Policy Background

As noted above, rail engine technology is currently unregulated in terms of pollutant emissions, and railway gas oil is high in sulphur. There are, however, a number of areas of policy at EU and UK levels which have a direct or indirect bearing on this, and these are set out below.

3.1 Fuel Standards

Non-road fuels have not been as closely regulated as road fuels, not least because there has not been a demand for cleaner fuels to enable stricter emissions control technology. As a result non-road fuels are of lower quality, and in particular have a significantly higher sulphur content. However, more recent EU requirements are now beginning to impinge upon rail and other non-road fuels.

Directive 1999/32/EC on Sulphur Content of Certain Liquid Fuels

Directive 1999/32/EC, which amended an earlier Directive (93/12/EEC), is intended to reduce the emissions of sulphur dioxide (SO_2) in the European Community by limiting the sulphur content of certain types of liquid fuels (heavy fuel oils and gas oils[4]). However, it is important to note that fuel used in non-road mobile machinery and agricultural tractors is explicitly excluded from the scope of the Directive. The first limit value set by Directive 93/12/EEC for the sulphur content of gas oils was 0.2 per cent (2000ppm), and this level is retained under the later Directive until 1 January 2008, when it is to be reduced to 0.1 per cent by mass (1000ppm)[5]. Derogations are permitted for both gas oils and heavy fuels if a higher sulphur content (up to 0.2 and 3 per cent respectively) does not result in critical loads being exceeded in any Member State. It is not clear how or under what circumstances these derogations may be used, but it appears unlikely that they will be called upon in the UK. The Directive does not preclude Member States from retaining or setting stricter limits, provided that the Commission is informed of these.

In the UK the *Marketing of Gas Oil (Sulphur Content) Regulations 1994* prohibited the marketing of gas oil with a sulphur content exceeding 0.2 per cent by weight. In June 2000, new *Sulphur Content of Liquid Fuels Regulations 2000* to transpose Directive 1999/32 were required to revoke the 1994 Regulations, but the new legislation was virtually identical on all relevant points.

[4] Note that the terms ógas oilô and ódieselô are used in different contexts to refer to essentially the same type of fuel. Diesel is in most cases confined at present to use in road vehicles, and has a tighter specification, most notably in respect of sulphur content.

[5] Note that there are three widely-used ways of referring to the proportion of sulphur to be found in liquid fuels, ie by per cent, parts per million (ppm) and in mg/kg, the last two being interchangeable. For reference purposes, ó0.1 per cent sulphur by massô is equivalent to 1000ppm or 1000mg/kg.

It is believed in the UK that the impact of the 0.2 per cent sulphur limit under Directive 93/12 have been quite low, as the average sulphur content of gas oil, including that used on the railways, on the UK market over the period 1992-93 was already below 0.2 per cent or 2000ppm ï the limit imposed by the Directive. It was estimated at the time that only 10 per cent of the UKôs production of gas oil would require additional treatment to meet the standards set[6, 7]. However, the lower limit for 2008 is likely to have a greater impact, as the average sulphur content of UK gasoil is reported currently to be around 1500ppm. This conflicts with some other estimates that rail gas oil is typically in the range of 350 to 500ppm already, which is well below the new limit. This point should be clarified.

{*possible action:* SRA Technical Directorate to clarify position}

Directive 2003/17/EC relating to the quality of petrol and diesel fuels

The aim of this Directive was to reduce pollution from car emissions by introducing new environmental specifications applicable to petrol and diesel fuels. Directive 2003/17/EC amends Directive 98/70/EC which established a maximum permissible sulphur content of 50 parts per million for both petrol and diesel used by on-road transport to take effect from 1 January 2005. Directive 2003/17 sought to amend the content of sulphur allowed in both petrol and diesel for use in motor vehicles. Accordingly, Member States are to ensure that by 1 January 2005, unleaded petrol and diesel with a maximum sulphur content of 10 mg/kg (10ppm - referred to as ósulphur freeô) is marketed within their territory and made available on an appropriately balanced geographical basis. By 1 January 2009 Member States must ensure that only unleaded petrol and diesel with a maximum sulphur content of 10 mg/kg is marketed within their territory and again, made available on an appropriately balanced geographical basis.

The Directive also introduces for the first time, limits for diesel used in non-road mobile machinery (NRMM) and agricultural and forestry tractors. This effectively aligns the maximum sulphur levels allowed in diesel used by these machines with those allowed in the gas oil used in other NRMM, as set put in Directive 1999/32, ie 2000mg/kg at the moment and 1000mg/kg from 2008. However, it is not clear whether this applies to diesel used on the railways, as no explicit definition for NRMM is given (and railway locomotives are explicitly excluded from earlier legislation that sets emission limit values for engines used in NRMM; but see below). An unpublished survey by CONCAWE suggests that in 2001, the sulphur limit of non-road gas oil in the UK, in common with six other Member States, was 2000mg/kg. In most other Member States, the typical sulphur level for gas oil for off-road uses was identical to the on-road standard, which varied from 350ppm (in Austria, Germany, Greece, Italy, Luxembourg and Portugal) to 10 ppm in Sweden[8].

[6] Department of the Environment Transport and the Regions and the National Assembly for Wales (2000) *Implementation of European Council Directive 1999/32/EC on the Sulphur Content of Certain Liquid Fuels in England and Wales.* 28 February, DETR, London.
[7] Scottish Executive (2000) *Implementation in Scotland of EC Directive 1999/32/EC on the Sulphur Content of Certain Liquid Fuels*. 28 February, Scottish Executive, Edinburgh.
[8] CONCAWE (2001) *Summary of fuel specifications, volume and distribution systems* (unpublished) for GEME Non-Road Fuels Task Force

Even if the Directive does not affect the rail industry directly, the inclusion of NRMM and agricultural and forestry tractors would have important implications for red diesel, the most common form of diesel used in these vehicles, which could well have knock-on effects for the railways. Measures will need to be taken to lower the sulphur content of red diesel or gas oil used in NRMM and tractors. The National Farmers' Union warned that the move would pose serious problems for oil refineries, but it is anticipated that problems with the level of supply of diesel in the UK will be overcome in time. The NFU also concludes that the requirement would push up the cost of buying the cleaner red diesel by about 2.5p per litre ï which is consistent with the sort of price differential observed in the switch to ultra-low sulphur diesel on road. The red gasoil used by the rail industry is essentially the same grade as used elsewhere, so this move may well have direct cost implications for the industry, as it is unlikely that different specifications of red diesel would result in this case. However, details of changes to the supply system for off road fuels are complex and difficult to predict with certainty. rail fuel remains a sufficiently distinctive sector with its own refuelling infrastructure, such that separate treatment from the rest of the NRMM sector remains a possibility.

3.2 Proposed Rail Engine Emission Standards

Directive 97/68/EC on measures against the emission of gaseous and particulate pollutants from non-road mobile machinery

Directive 97/68/EC aims to harmonise the laws of the Member States on the emission standards and type-approval procedures for engines to be installed in NRMM. Its introduction resulted from the need to tackle the increasing level of emissions resulting from these types of engines, and also in part to mirror US practice in order to achieve global alignment of limit values. It covers most engines used in land-based equipment with an engine power of between 18 and 560kW (ie including engines of the size used in railcars or DMUs), but explicitly excluded railway locomotives. However, no reference was made to railcars and to whether these were included or excluded from the scope of the Directive, so hitherto there has been some confusion.

The Commission announced its intention to address emissions from railways in COM(2002)18, in which it stated that it would include ólight-duty diesel train enginesô in the revision of Directive 97/68/EC and develop technical interoperability specifications for heavy-duty diesel engines. However, discussions arose to the suitability of emission standards for railway applications being considered on a like for like basis with other NRMMs, in view of the fact that the driving pattern of a railway vehicle is considerably different to that of other NRMMs such as tractors and excavators. Attention was drawn to the fact that locomotives have different patterns of operation compared to other NRMM applications, and thus a separate test procedure ought to be used. The Commission identified the existence of a separate test procedure, the ISO 8178-4 steady-state test cycle type F which would appear to accurately reflect the operational behaviour of the old power train systems used on the railways. The Commission also undertook to consider the need for and feasibility of in-use compliance checks and specific test procedures for railway applications by 2006.

{*possible action:* SRA Technical Directorate to keep abreast of developments on test procedures and in-use compliance checks}

New Directive on Non-Road Mobile Machinery (COM(2002)765)

The Commissionôs amendment to Directive 97/68/EC was finally published late in 2002 (COM(2002)765) and proposed to tighten the existing Directive by introducing stricter emission limit values for NRMM. It also proposed to extend the scope of the Directive to cover small engines (those below 560kW) used in (among other things) railcar engines for DMUs, which would end the earlier uncertainty for these classes. The pollutants covered would be carbon monoxide, hydrocarbons, oxides of nitrogen and particulates.

The inclusion of measures for railway applications aims to improve their environmental performance and to align EU standards with those of the US, where new standards took effect in 2000. Since rail engine emissions had not been regulated previously, the US EPA created for this a comprehensive programme, including not only emission standards, but also test procedures and a full compliance programme.

The text of the proposal has already been discussed by both the Council of Ministers and the European Parliament and there appears to be broad agreement on its content. In relation to railway applications, this differs from the Commissionôs original proposal in that it also introduces emission limit values for railway locomotives, as well as railcars. It also includes clearer definitions of the distinction between the two types of vehicle. Enthusiastic support for the inclusion of rail in the Directive, particularly from Member States, is understood to have been in part responsible for its rapid passage through the legislative process and for the extension of its scope.

Emission limit values are set in two stages ï Stage IIIA and IIIB ï for engines used in railcars and locomotives, respectively, which have to be met at different dates. For railcars, with a power output above 130kW, Stage IIIA standards are applicable to the type approval process from 30 June 2005. For locomotives, the equivalent compliance date for is 31 December 2005 for engines of power output between 130kW and 560kW and 31 December 2007 for engines of power output above 560kW. For both railcars and locomotives, the compliance date for the type approval process for Stage IIIB is the end of 2010. However, derogations are allowed for engines where a contract has been entered into to purchase the engine before entry into force of the Directive, provided that the engine is placed on the market no later than two years after the applicable date for the relevant category of locomotives.

In essence, Stage IIIA will mainly have an effect on NOx and hydrocarbon levels, and should be fairly easy to attain as it is comparable to US standards already in force. Stage IIIB in contrast will require almost an order of magnitude reduction in particulates, and hence the use of particulate traps or deNOx catalysts. The Directive also specifies that Member States must allow for special markings to be attached to engines which meet the new standards ahead of the dates on which they become mandatory.

The proposal also commits the Commission to evaluate the application of test cycles for engines in railcars and locomotives no later than 31 December 2007. The

Commission must also consider the cost and benefits of a further reduction of emission limit values for NOx aftertreatment technology for locomotives by the same date (ie a Stage IV). It will also consider what standards of fuel might be needed for future emissions control technology, as tighter specifications may now be needed, and a possible in-use compliance regime. It is likely that meeting the Stage IIIB emission limit values is likely to need lower sulphur levels in gas oil than those of the 1000mg/kg upper limit to come into force in 2008; or alternatively a very good technical solution is required. The desk officer on the proposal reported that he could not be sure what fuel quality would be required but he estimated that it would probably be in the 10ppm to 50ppm range.

The agreed text of the Directive is currently being finalised and is expected to be approved without debate at a forthcoming Environment Council meeting. The length of time Member States have to transpose the Directive is not yet clear, as a date does not appear in the draft Directive in the version available to us at the time of writing. This will probably not be finally clarified until the Directive is published in the Official Journal of the EU.

3.3 Fuel Taxation

Community Framework for the Taxation of Energy Products

In common with some other industries, the railways use óred dieselô or óred gas oilô which has a heavily discounted duty rate relative to road fuels. The application of discount rates has historically been regulated at EU level by the so-called Mineral Oils Directives, which are superseded from 1 January 2004 by Directive 2003/96/EC *Restructuring the Community Framework for the Taxation of Energy Products and Electricity.* This Directive meets the Commissionôs obligation under the Mineral Oils Directive 92/82/EEC to review the minimum rates of excise duty on mineral oils. It can also be seen as a response to the deadlock surrounding the negotiations on the CO_2/energy tax, to present new proposals for the taxation of energy products.

The Directive came into force on 1 January 2004 and will expand the current framework for the taxation of energy products in the EU to include a broad range of products including electricity used for heating and other purposes, as well as setting minimum taxation rates for these products. Although the final agreement is much weaker than the original proposal for motor fuels, the minimum rates are increased from those set out in the Mineral Oils Directives, while for a range of other fuels used for commercial and heating purposes, minimum rates are set for the first time. No maximum rate is set, therefore allowing Member States to set duty rates higher for environmental or other purposes if they wish.

The minimum level of taxation applicable to gas oil is ú302 per 1 000 litres as from 1 January 2004, rising to ú330 on 1 January 2010 ï substantially below the current UK duty rate for diesel, but well above that applied on the railways. Under the original Mineral Oils Directive total or partial exemptions were permitted in the rate of reductions of duty for motor oils in both the ófield of passenger transport, and the carriage of goods, by railô and óexclusively in agriculture and in horticultural works, and in forestry and inland fisheriesô. Under the new framework on energy products however complete exemptions are no longer allowed for agricultural, horticultural and inshore fisheries uses of gas oil, only the reduced red diesel rate. However, of

relevance to the SRA is Article 15 1(e) which allows for Member States to apply total or partial exemptions or reductions in the level of taxation for "energy products and electricity used for the carriage of goods and passengers by rail, metro, tram and trolley bus". Such exemptions can be paid either directly, by means of a differentiated rate, or by refunding all or part of the amount of taxation.

This possibility is not new, but what is new is that the same possibilities have now been withdrawn for other major classes of red diesel users, which increases the possibility that special arrangements might be made for rail without creating a major precedent elsewhere.

UK Red Diesel Taxation

In the UK, nonetheless, the same duty rate is currently applied to all users of rebated red diesel. In the last budget, the fuel duty on red diesel was raised by nearly 35% (from 3.13 to 4.22 pence per litre). This was estimated to have cost the rail industry between £2 million and £10 million, for which there was no budget provision. Under these circumstances it is the SRA that effectively pays this additional cost, so the rail industry has lost this revenue, even if there has been no net cost to government. It appears that no prior warning was given to the SRA - or indeed any other rail industry body - that this measure was being considered, and it came as a surprise in many quarters.

In the past year or more, the Treasury has laid claim that it will develop a more coherent rationale and framework for the taxation of liquid fuels. In the recent pre-Budget Report, this was given particular form through a commitment to develop a framework for the taxation of alternative road fuels. However, we have not as yet received any explanation of how, if at all, the increase in red diesel duty fits into the overall framework, and some have suggested that it was a simple revenue-raising exercise with no deeper rationale. Another possibility, however, is that the increase was a prelude to an increasing differentiation of low-sulphur and high-sulphur fuels, as discussed below.

Currently there are no fiscal incentives for cleaner fuels for off-road vehicles as there are for road vehicles, including buses (see below). However, as noted above, there are legal requirements at EU level which will require cleaner fuels to be used in the future. As a possible move towards measures on the railways in Directive 2003/17 on the sulphur content of fuels, the Treasury has begun to consider how fiscal incentives could be used to encourage early entry into the market of these cleaner fuels, and hence to smooth the transition to their general use by the time they become mandatory. This is similar to the approach which has been used very successfully in the UK to encourage unleaded petrol and low sulphur petrol and diesel, and will soon be applied for "sulphur free" fuels containing less than 10ppm of sulphur on the roads.

It is apparent that in the absence of higher or differentiated duties on rebated gas oil, the quality of the latter has not improved to the same extent of gas oil used as diesel road fuel. Accordingly the Treasury has asked for consultation responses from producer and users of red diesel and environmental groups on the following:

- whether to adjust the existing duty differential between rebated gas oil and fuel oil to reflect environmental impact;

- whether to introduce new duty differentials for low sulphur rebated gas oil/and or fuel oil.

Although the results of this consultation have not yet been published the outcome of the findings have been indicated in the recent Pre-Budget Report which was released on 10 December 2003. The Government announced that a ómodest duty differentialô in favour of red diesel with a sulphur content of less than 0.005 per cent (50ppm) would be introduced. The level of this duty differential and any other conclusions from the consultation will be announced at the Budget in 2004.

Currently the pre-tax cost of rail gas oil is lower than that of ULSD reflecting the lesser refining requirements to reach gas oil sulphur levels rather than the 50ppm limit for ULSD. However, if the sulphur requirements were to converge, then so too would the pre-tax price of the fuel. As a guide, the analogous switch to ultra-low sulphur diesel (ULSD) for on-road vehicles occurred very rapidly once the duty differential between the two was increased from 2p to 3p per litre, suggesting that the additional cost falls somewhere between the two figures. An earlier differential of 1p per litre did not have any impact suggesting that this figure was insufficient. However, the market for rail gas oil, and other red diesel, is much smaller than that for road transport. Consequently, it is probably less important for refiners and therefore may not be as price-sensitive as that for on-road transport, so a larger differential might be needed. However, any rebate on this scale would represent a substantial proportion of the rebated duty level currently charged, and perhaps more than the ómodest differentialô that the Treasury seems to have in mind. Judging from past Treasury actions, it seems very unlikely indeed that the ómodestô differential which it has in mind will be greater than the 1p initial level used for on-road fuels, and may indeed be significantly less. Gradual increases over subsequent years might be foreseen, but it is important that the industry should make clear that a bigger incentive is likely to be needed before any action will result.

The Example of Bus Fuel Duty Rebate (Bus Service Operators Grant)

Aside from the above, there are a number of policy models and precedents which might be considered in order to facilitate the introduction of environmentally friendly technologies and/or fuels to the rail industry. For example, when low-sulphur diesel was introduced for road vehicles, there was initially no incentive for bus operators to switch owing to their Bus Service Operators Grant (BSOG) system. However, the BSOG was adjusted accordingly such that there was some financial incentive to make the change.

The BSOG is a general cost subsidy for local buses, making fares lower and service levels higher than they otherwise would be. It was not designed to influence operatorsô fuel choice, but has the effect of making it more difficult for the Government to incentivise the use of fuels other than standard diesel because bus operators do not pay the full duty. The industry see the BSOG as a favourable mechanism because it is factored into the industryôs business model. Although the BSOG provides higher levels of rebate for alternative fuels such as biodiesel, LPG and CNG, arguably the BSOG only facilitates the use of cleaner fuels to a limited extent. This is because although the fuel may be cheaper, alternatively fuelled buses are seen as more costly to run, in terms of increased downtime, lower range and

additional training etc. Therefore whilst the grant differential makes alternative fuels cost neutral, fuel is not the only cost of running a bus.

There is also some doubt as to whether under the BSOG bus operators will switch fuel in response to the Governmentôs introduction of a duty differential for sulphur free fuels of 0.5 pence per litre relative to the rates for ULSD from September 2004.

However, it is not clear how close an analogy BSOG provides to rail operators, in that duty is handled very differently between the two sectors.

4 Technical Options and Uncertainties

The developments outlined above will clearly have some benefit in terms of cleaning up rail fuels and, in the future, engines. However, there are a range of technical options which can be deployed, some of which go beyond what is currently under active consideration, and these are outlined below as a prelude to consideration of additional policy action. In addition, this section outlines technical uncertainties which need to be resolved in moving forward on the various options which might become available.

4.1 Cleaning Up on Particulates

The Distribution of Diesel Emissions

In considering the best approach to cleanup, it would be useful to develop a better understanding how the emissions burden is distributed. In particular, are particulate emissions across the fleet broadly proportional to fuel burn, or is there an identifiable set of ógross polluttersô which might be targeted? If the former, then it may be that cleaner fuels or other across-the-board measures are the best that can realistically be achieved; if the latter, then tailored actions to improve the worst emitters, retrofit them, or scrap them as appropriate, might deliver a disproportionate benefit for a relatively limited cost.

Introduction of Stage IIIB engines

As noted above, the new Directive on NRMM will require cleaner engines, and these will improve the picture with respect to NOx and particulates. Stage IIIB engines are likely to require particulate traps, and will become mandatory towards the end of this decade. Most or all of the major manufacturers will have engines available by the due dates, but some with more advanced engine designs may well seek to gain a market advantage by offering engines which meet the new standards ahead of their required date.

Better Repairs and Maintenance?

It would be useful to have a better understanding of the underlying reasons for the poor emissions performance of some rail engines, and in particular whether better repair and maintenance could have an influence on this. If so, this might prove to be a relatively inexpensive way of targeting gross polluters.

{*possible action:* check for any UK or overseas experience of the relationship between levels of maintenance and emissions, or consider how such information might be generated.}

Retrofitting

PM_{10} has been reduced by exhaust treatment devices for road vehicles, and there is increasing potential to transfer this technology to rail. In essence, DMUs use engines which are the equivalent to large truck engines, so similar particle trap retrofit options are available.

Also locomotive engines are similar to those used in some static power generators, and selective catalytic reduction (SCR) technology has been applied successfully to the latter. Particulate traps can be fitted to engines of all sizes, if necessary with several traps in parallel. The latter approach is being discussed in Switzerland.

Cleaner Gas Oil

Reducing sulphur content is recognised to offer three benefits: it offers proportionate reductions in SO_2 emissions; some reduction in particulates; and it enables exhaust retrofits to tackle NOx, particulates, or both.

Of these, the first is not significant as a proportion of the total national inventory. Nonetheless there appears to be consensus that there is a positive relationship between the sulphur content of the fuel and the mass of particulates emitted, although there is little information on the precise nature of this relationship, or on the way in which the ultrafine fraction of the emissions is affected. Sulphur level will certainly impact on the sulphate fraction of the particulates, but possibly not the carbon-based part. Discussion seems to confirm that the relationship of sulphur to particulates is not well understood, and is complicated by the fact that other changes to fuel specification are likely to follow from the removal of the sulphur.

It is also clear that reducing sulphur content to, say, 50ppm, would be a valuable step in enabling the introduction of aftertreatment equipment, on either new or retrofitted engines. As against this, there remain concerns in some quarters that reduced lubricity or shrinkage of oil seals would result, causing serious problems in older engines in particular. As against this, it is argued that similar concerns have always been raised when sulphur reductions have been proposed, but real problems have not materialised. In particular, it is argued that the oil industry now has a great deal of experience of formulating fuels with reduced sulphur content, and any lubricity problem in particular could be tackled through other additives, as they have been successfully with road fuels. If there really were a problem, then a slightly different formulation for rail could be countenanced, in that it represents a large and fairly homogeneous market. This would need to be agreed in advance between rail and petroleum supplier interests, to ensure that an appropriate standard were adopted.

Experience elsewhere in the on-road sector supports this, as for example, when very low sulphur fuels were introduced in Sweden in 1993, there were initially problems with lubricity, as there were later in other countries when sulphur was removed from diesel. However, alternative lubricity additives are now used to counter the impact of removing the sulphur[9]. Oil seals might well need to be replaced in some of the oldest engines on account of the much lower aromatic content of low-sulphur gas oil, but this would be a one-off exercise if so.

[9] CONCAWE (1999) *Fuel quality, vehicle technology and their interactions* report no 99/55 (available at www.concawe.org)

It has been reported that there is some experience with using ULSD in the Roscos, and this should be consolidated. Concerns were also raised over the possibility of voiding engine warranties with low sulphur fuel, but as there is currently no relevant off-road sulphur specification, it was not clear whether this is a relevant issue.

Sweden has already switched to rail fuel with a maximum 10ppm of sulphur, and this is required to be used in all rail engines up to 40 years old. This has apparently been achieved without major problems, but it might be instructive to consider what lessons might be learned from experience there.

{*possible action:* check UK and overseas experience (eg Sweden) regarding use of low-S fuel. A new UIC Working Group (which began work in January 2004) will be considering options for diesel to comply with the new EU standards, and this too may include information on the cleaner fuels.}

4.2 Improving Fuel Economy

More Efficient Conventional Technology

As noted above, diesel electric engines in particular are not very efficient in energy terms. Hence the most effective available option for improving the energy efficiency and emissions performance of the railways at present is to electrify them; but this is an expensive solution.

A second option is to consider the possibility of purchasing more efficient diesel trains. Given the average age of the vehicle stock (nearly 20 years), there is a strong likelihood that more modern engines run more efficiently as well as more cleanly than the average. However, this trend appears to be counteracted by other adverse trends in train weight and on-board energy demand, such that the average demand for power per passenger kilometre appears in fact to be rising.

Fuel Management

By analogy to the haulage industry, there may be scope for more active management of fuel use. Although the total fuel bill of train operators is large, it is presumably a relatively small share of total operating costs, and may not therefore receive close attention. Experience from road haulage suggests that merely monitoring fuel consumption more closely can lead to savings, as it helps to pinpoint drivers or vehicles that appear to have excessive fuel consumption, and corrective action can then be taken.

Driver Training

Again by analogy to road haulage, it is now well-established that driving style can have a substantial impact of fuel consumption, and that training and reinforcement of correct driving style can therefore bring large savings. There is some evidence to suggest that the same may be true of rail as well, and this might merit further consideration.

There was a general recognition that fuel management and driver training are both ósoftô and relatively inexpensive means to achieve some improvements in environmental performance. Both might offer ancillary benefits, eg fuel savings or improved safety, and there are parallels and precedents. For example, building fuel-

saving coasting into operations (an option which reportedly was used during the oil price shocks of the 1970s and 1980s) would result in marginal increases to journey times, but such slack could be helpful for making up lost time. This is an area which might offer significant savings in cost and emissions quite cheaply, and is therefore worth further consideration.

Hybrid Engines

Although hybrid rail engines are already in operation, it was noted that hybridisation is only really useful in some specialist applications such as shunters. Elsewhere the operating regime of rail engines largely negates the benefits of hybrids, especially on inter-city rail.

Nonetheless, the Canadian firm RailPower claims that its new hybrid shunter should be cheaper to both buy and run, as well as offering very substantial reductions in NOx, particulate and CO_2 emissions. This may therefore prove to be an attractive solution in whatever areas hybrids can operate.

Fuel Cells

It was widely recognised that fuel cells offer decisive environmental advantages for displacing diesel rail. The relatively large size of rail engines, especially in locomotives, makes them very suitable applications. They might well be applicable to multiple units, and might also offer a 'halfway house' configuration with a centralised fuel cell stack located in a set which is otherwise composed of units similar to modern-day EMUs. This would provide a far cleaner and more efficient solution when compared to current diesel electric engines.

An unresolved issue, however, was how they would be fuelled (and possibly even what will emerge as the preferred fuel cell technology for rail). Hydrogen is currently the preferred option for road-based mobile fuel cells, but a range of options could be possible for rail. These include hydrogen reformed from natural gas and stored at refuelling points; or methanol or even a more conventional hydrocarbon fuel which would be reformed on the train.

These uncertainties plus high costs lead some to conclude that fuel cells may not be available for some decades, although others suggested a much shorter timetable. However, only a few prototype mobile fuel cells are yet in operation, and fewer still for rail. Therefore they are as yet far from tried and tested for mainstream rail industry use, and costs would be very high. Issues about fuel choice and fuelling options will also need to be resolved before they can be widely developed or deployed. This is certainly a very promising option for which developments should be actively followed, but in the near term, cleaning up conventional engines, especially those with a long working life still ahead of them, is likely to be the more effective approach.

The timing of the introduction of fuel cell trains is an important issue when we are considering possible policy options, as, for example, a new locomotive in 2003 could last until around 2030, by which time fuel cell trains could well be in service. This

affects investment decisions. Work being undertaken for National Express should shed some light on the question of the cost-effectiveness of fuel cells.

While fuel cells are clearly the highest-cost and longest-term option, it was pointed out that the costs might look much more favourable if seen as an alternative to electrification, in that much of the additional infrastructure cost could be avoided by this means. Even if no major new electrification is planned, fuel cells might be an attractive alternative to replacement or reinforcement of existing electrified networks, as exemplified by the ECML and Southern Region third rail systems respectively. In the latter for example, even selective use of fuel cells might in theory avoid the need to upgrade, which itself is expensive. It is therefore possible that the initial use of fuel cell trains will be where they provide savings in other parts of a rail investment package, and should therefore be actively considered in such contexts once appropriate technology becomes available..

Biodiesel and Other Alternatives

At the time of writing we are not aware of any serious consideration of using biodiesel on the rail network. This is now under active consideration for road vehicles, probably in a blend of up to 5 per cent in conventional diesel. This offers some CO_2 benefits, and it appears likely that a similar approach would be technically possible for rail engines. However this is likely to prove an expensive option, which will not make economic sense as a rebated fuel particularly without substantial additional government support. Currently the government remains sceptical of the cost-benefit ratio of liquid biofuels for the road sector; it seems very unlikely that it would go even further to encourage their use for rail.

5 Additional Approaches to Accelerate Emissions Improvements

Options and Uncertainties

It is apparent from the above that there are options available or under development which will have some benefit in terms of cleaning up rail fuels and, in the future, engines. However, the pace and scale of required improvements is currently limited, and this section considers the various policy options which might be available to help accelerate improvements. As noted above, the precise approach which is most effective and cost-effective to cleaning up on particulates is likely to be affected by their distribution. However, this section sets out the range of options available.

At present, we do not have sufficient data on costs or benefits either to judge the attractiveness of each of the technical options, to prioritise between them, or to compare them to measures in other sectors. Also, none of the options is cost-free and some would be expensive, so it was recognised that a good business case would be needed to attract new funds to incentivise changes. It can however be argued that sufficiently robust data could probably be assembled and used with a relatively modest amount of effort, and some indications of possible ways forward are indicated at various points in this paper.

{*possible action:* explore means to improve cost and benefit data}

Strategic Approaches

Before considering action to promote specific options for environmental improvement, two very different strategies can be delineated.

The first of these would be to rely on the new EU legal requirements to begin to filter in to the fleet over the next decade, and to focus on fuel cells to give a major improvement thereafter. This relies on the expectation that fuel cells will be able to provide an environmental óstep changeô which will far outweigh incremental improvements in conventional technology. However a drawback of this approach is that it might appear a passive policy, offering only ójam tomorrowô, and the uncertainties over the likelihood and timing of the introduction of fuel cells weaken the argument.

An alternative would be to argue that, owing to the long lifespans of engines, there are worthwhile options which might be introduced at relatively modest cost and relatively soon, which would give worthwhile and long-lasting benefits irrespective of the merits of fuel cells.

Thus a strategic decision is needed, as well as detailed consideration of the various options.

Accelerated Introduction of Stage IIIB engines

Prior to the NRMM Directive coming into effect, there may be some attraction for rolling stock companies and operators to offer trains which meet these standards early, particularly if some financial incentives were also offered along the lines discussed below.

As noted above, the Directive also provides for engines which meet advanced standards before they become mandatory to be labelled as such. This might prove attractive to customers and improve the environmental credentials of any operating company which took advantage of this option. However, some research has suggested that rail users, generally, do not travel by rail for environmental reasons and do not, therefore, consider such matters when making their travel decision. Hence, it can be argued that the labelling of locomotives as provided for under the Directive will not have much impact and will not therefore act as a strong incentive for early introduction of cleaner technology.

Cleaner Gas Oil

Cleaner gas oil would bring environmental benefits, but against this there is the issue of cost. As discussed above, this may well not be an attractive option for operators without a duty reduction (ie increase in rebate) in the region of 2.5p/litre. This appears likely to be more than will be offered by the Treasury, but there is scope to argue either that a higher differential is needed from the first, or that it must be increased progressively over time until the market is stimulated to offer the cleaner fuel as a mainstream alternative.

The incremental approach has been used quite successfully in bringing ultra low sulphur fuels into the road fuels market. That is, modest duty discounts have been

offered initially and have had little direct impact on the market but have perhaps acted as a signal for further changes to come. Experience is that, once one supplier has decided that they can economically supply the cleaner fuel and gain a market advantage by doing so, others fairly quickly follow suit in order to avoid losing out. Also, even an initially-small differential could have a significant effect in future, especially if associated with an increase in the duty of high-sulphur (ie normal) grades, which is quite plausible given recent moves to raise red diesel duty.

Broadly similar considerations would apply to other variants on conventional fuel such as emulsions.

Already the duty differential between on-road biofuels and conventional fuels is set at 20p/litre, and this is claimed to be insufficient to stimulate a major domestic biofuel market. Given the low level of total duty on rail fuel, it therefore seems unlikely that it would be possible or cost-effective to establish sufficient incentive to use biodiesel on the railways.

Incentives for Retrofitting

Obviously there is a cost attached to retrofitting or re-engining existing stock, not only in capital but also in additional maintenance. Incentives in the form of grants have been used to support retrofits on heavy trucks through the CleanUp programme administered by the Energy Savings Trust (EST). As well as traps, EST funds have been used for some repowering of trucks (eg conversions to compressed natural gas).

By analogy, both retrofitting and re-engining might be incentivised for the rail sector as well. The latter does not fall within the current remit of EST and there are no funds currently available to extend its activities in this way, but there is no obvious reason why the remit of EST could not be extended if a strong case were made and new funds were available. We should consider how rail might seek similar grant aid to assist in achieving better environmental standards. The costs of such measures on railway engines is likely to be higher per unit than for road vehicles, but so too are the potential savings on account of the larger engines and high use factors.

Furthermore, for road vehicles EST maintains registers of approved equipment and equipment which meets standards in advance of their becoming mandatory. In advance of (or in the absence of) grants becoming available for rail equipment, this might be a way forward which would at least give purchasers of new equipment or retrofits a reliable guide to the best available technology.

The Carbon Trust, set up by the Government to take the lead on low carbon technology and innovation in the UK, could in principle become involved in encouraging more energy-efficient rail equipment through grants. However, thus far it has left virtually all transport-related developments to EST, and our information is that in practice it is unlikely to seek to expand its remit in the near future.

{*possible action:* Further investigate experience of use of subsidies in the road sector, and consider how these might be applied within the financial structures of the rail industry}

Adapting Existing Measures

One existing measure which might be adapted to encourage environmentally friendly trains is the Freight Facilities Grants, which already have an environmental dimension. To enhance the latter, there is a possibility that new grants (or a higher level of grants) be made conditional on operators meeting certain environmental requirements, such as use of low sulphur fuel or environmentally enhanced engines for the subsidised services. This would be a reform of an existing measure which would add little to the cost or complexity, and is therefore a lever that would bring incentives for environmental improvement without necessarily adding to costs for government.

Another possibility is that differentiated track access charges might be developed as an incentive for the environmentally best-performing engines. The advantage would be that these could provide a modulated level of benefit across the lifetime of an engine, and could also introduce a geographical component to direct the cleanest engines towards the most sensitive areas. In administrative terms, differentiated charges would be quite possible as long they fitted within the existing recording regime. That is, charges could not currently distinguish between trains of the same sub-class if they had different environmental characteristics, although it would probably be feasible to increase the number of categories to some extent to deal with this. It would also require accurate reporting of engine type used by operators.

{*possible action:* Further investigate the potential for modification to the FFG or track access charges, and consider how these might be applied }

Selective Scrappage

In principle, a targeted scrappage incentive programme could be used either to target gross polluters directly, or, if appropriate, to retire some old engines which were incompatible with low sulphur fuels. It would also assist with fleet modernisation more generally. This could enable either an early switch to low sulphur gas oil on parts of the network, or the full introduction when it becomes mandatory. It seems unlikely that the current requirement to move to a maximum of 1000ppm would necessitate this, but a much more stringent 50ppm might.

There are some examples of early scrappage programmes in the road sector, but as yet these have only been considered in some contexts in the UK. We are not aware of any as yet for the rail sector. Such a scheme could have a role to play, but would need to be carefully considered. For any scrappage programme, it is difficult to set the incentive at the right level to provide an incentive for genuinely advanced scrappage, without merely subsidising the owners of engines that were about to be scrapped anyway.

Capital Allowances on Advanced Technology

The 2002 Budget introduced enhanced capital allowances (ECAs) for the purchase by companies of low carbon and energy saving technologies. This includes cars (emitting up to 100g/km CO_2 or electrically propelled) used in their business or by their employees. Also qualifying for ECAs is equipment for refuelling vehicles with natural gas or hydrogen fuel. Qualifying expenditure attracts ECAs whereby 100% of the cost can be claimed against tax in year one rather than 25% and then 25% of the remaining

balance over several years. Currently this does not extend to heavier vehicles or rail, however, but it would be useful to consider whether this approach offers any possibilities for ógreenerô trains.

Enhanced Capital Allowances (ECAs) might be an option that could be developed for the environmentally best-performing engines for the Roscos, given that there is a precedent in the road sector for this. ECAs might be particularly attractive in the rail sector, where rolling stock allowances would otherwise be spread over a longer period. This would depend critically on how capital expenditure is currently treated in the rail industry, and whether this offers the possibility of incentives.

{*possible action:* Further investigate experience of use of ECAs in the road sector, and consider how these might be applied within the financial structures of the rail industry}

Fuel Duty Futures

Increasing fuel duty is a prime means to encourage greater fuel efficiency and a switch to less polluting fuels. However, with slow stock turnover the responses available are limited, and the costs to the SRA of raising fuel duty are appreciable. The SRA now needs to understand the background to recent developments, any long-term strategy that Treasury / DfT may have, and the wider public policy pressures - from lobbyists of all persuasions including, for example the oil industry and environmental pressure groups. Currently we are not aware of any strong pressure for an increase in rail fuel duty outside the Treasury. Environmental and transport NGOs are generally favourable towards rail and do not tend to press for duty increases, although there is opposition to the equally high levels of duty discount given to some other groups such as farmers and fishers.

Clearly increasing fuel duty will only lead to increasing costs unless there are credible options to cut fuel consumption. In the short term the options are fairly limited, however, as set out elsewhere in this section.

Encouraging 'Soft' Measures

In the previous section a number of ósoftô policy measures were identified, such as improved fuel management, better driver training, etc, which might improve fuel economy and environmental performance more generally. Often such measures are relatively cheap, and may even be cost-effective in terms of the amount of fuel (and possibly wear and tear) which is saved. Again the activities of EST in relation to the road sector may provide useful analogies and models for the adoption of such policies for rail.

{*possible action:* Further consideration of the use of ósoftô measures to improve environmental performance}

In-use Testing

It has been reported that DG Environment is looking at this option, which is prefigured in the new NRMM Directive. Some sort of óMoTô covering emissions and

fuel economy might be a logical step with such long-lasting and heavily-utilised equipment. SRA needs to keep abreast of possible developments in this area.

{*Possible action*: Check progress and thoughts in DG Environment on this possibility}

Carbon Trading

This could be seen as a possible future opportunity to bring new money into rail, and one which might provide an incentive to reduce CO_2 emissions. As yet however there remain major uncertainties as to when or on what terms rail might become involved.

Transport projects are not yet included in the UK or EU emissions trading schemes, but the possibility of the rail industry becoming involved in carbon trading under either UK or EU trading regimes should be borne in mind. Note, however, that even on the most optimistic date for the introduction of fuel cell trains that was mentioned, ie 2015, this is after the date of the establishment of the emissions trading scheme for the purposes of the Kyoto commitments. However, the issue is probably highly relevant for meeting the UKôs 2050 target of a 60 per cent reduction in CO_2 emissions. This merits further consideration.

6 Conclusions

In short, there is a range of options available to improve the emissions performance of the rail sector, and particularly of diesel engines. Some of these are operational measures which might be undertaken relatively cheaply and possibly on a voluntary basis in order to tackle the most polluting and least efficient engines.

Beyond this, however, more substantive measures would probably entail steps to secure early introduction of tougher environmental standards for fuels or trains, and/or retrofitting of some existing vehicles. The costs associated with such actions are more substantial, and some type of financial incentive scheme is likely to be needed to encourage this type of response.

Malcolm Fergusson
Dawn Haines
Ian Skinner

Annex: List of Contacts Identified during this Study

Name	Organisation	Email/Telephone	Expertise
Nick Coad	National Express	ncoad@natex.co.uk	Rail operators and environment policy
Stephen Potter	Open University	**S.Potter@open.ac.uk**	Transport taxation and incentives
Paul Watkiss	AEA Technology	paul.watkiss@aeat.co.uk	Emissions factors, UK inventory
Sujith Kollamthodi	AEA Technology	Sujith_Kollamthodi@uk.aeat.com	As above
Tony Grayling	IPPR	t.grayling@ippr.org.uk	Transport and sustainability policy; rail industry structure and finance
Alex Veitch	Energy Saving Trust	AlexV@est.co.uk	Environmental incentives in road transport
Robert Evans	Environmental Industries Commission	EvansRJ@matthey.com	Chair of Transport WG of EIC; overview of emissions abatement technology and policy
Joe Stevenson	Environmental Industries Commission	stevej@matthey.com	Emissions abatement technology
Malcolm Watson	UKPIA	7632 9882	Technical Director; fuel supply and standards
Tim Smith	HM Treasury	020 7865 5600 (direct line) 'timothy.smith@hmce.gsi.gov.uk'	Desk officer, HMT consultation on rebated oils
Paul OôSullivan	HM Treasury	paul.osullivan@hmce.gsi.gov.uk	Head of environment and taxation
Malcolm Fendick	DfT TET	Malcolm.fendick@dft.gsi.gov.uk	Head of transport and environment policy
Mike Dunne	DfT TET	7944 2087	Head of vehicle emission standards
Steve McFarlane	DfT TET	7944 2087	NRMM Directive
Paul Jefferiss (Board Member)	Carbon Trust	7222 0101	Contact point only
Arthur Marin or Melinda Treadwell	NESCAUM	amarin@nescaum.org mtreadwell@nescaum.org	US off-road vehicle policy
Mats Ericsson	DG Environment		desk officer Non-road mobile machinery proposal

Bernd Lange	EP Environment Cttee		MEP and rapporteur, Non-road mobile machinery proposal
Brian Brangan	DG Environment		(not actually the desk officer, as they have moved on), Sulphur in fuels Directives
Marcus Liechti	T&E	markus.liechti@t-e.nu	Road charging in Europe
Steven Salmon	Confederation of Passenger Transport	020 7240 3131 (not direct line) 'stevens@cpt-uk.org'	