WORKING FOR A HEALTHY FUTURE

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Health, socio-economic and environmental aspects of possible amendments to the EU Directive on the protection of workers from the risks related to exposure to carcinogens and mutagens at work

Diesel Engine Exhaust Emissions

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SUMMARY

Diesel engine exhaust (DEE) has been classified by the International Agency for Research on Cancer (IARC) as probably carcinogenic to humans based on animal toxicity and epidemiological data (IARC category 2a). The two cancers most clearly linked to DEE exposure are lung and bladder cancer. There is no occupational exposure limit (OEL) for DEE specified in the Directive. DEE is not classified under the EU classification and labelling legislation and it is therefore not currently within the scope of the EU Carcinogens Directive.

This report considers the likely health, socioeconomic and environmental impacts associated with possible changes to the Carcinogens Directive, in particular the possible introduction of an occupational exposure limit (OEL) of 100 $\mu g/m^3$ for DEE measured as elemental carbon (EC).

DEE arises from the combustion of diesel fuel in compression ignition engines. The sources of occupational exposure to DEE include motor vehicles, locomotives and diesel powered heavy equipment such as tractors and forklifts. Workers may either be exposed because they operate equipment that has a diesel engine or because their work takes them into environments where diesel engines are operating. DEE makes up an important part of the particulate air pollution found in European cities and towns.

Emissions from diesel engines are a complex mixture of gasses, liquids and solids. IARC identified that the carcinogenic components of DEE are probably associated with the particulate emissions and it is common to use EC, which makes up a significant fraction of these emissions, as a marker of exposure.

It is estimated that there are 3.6 million workers in the EU potentially exposed to DEE above background levels. The overall distribution of exposure levels across all industries in the EU gave an estimated geometric mean of 13 $\mu g/m^3$ with a geometric standard deviation of 2.7. The percentage of workers who may be exposed above the typical OEL (100 $\mu g/m^3$) was estimated to be between 0.1% and 3% in sectors other than mining, and between 10% and 54% in underground mining.

Over about the last 20 years EU legislation has required engine manufacturers to reduce emissions from vehicles and, for example, the permitted particulate emissions from trucks and lorries will decreased by a factor of more than 50 times between 1992 and 2013. Despite the increase in the proportion of diesel vehicles in the EU the exposure to DEE has probably been decreasing (we assume 7.4% decline per annum).

From a review of the epidemiological literature carried out in 2001 a relative risk (RR) of 1.24 was identified for bladder cancer incidence amongst high exposed work groups and 1.03 for low exposed workers. A pooled RR estimate for lung cancer was identified for high exposed workers from a review where the data were adjusted for smoking habits (RR=1.47) and for low exposed workers of 1.09. The RR for background-exposed workers was set to 1.

The number of people in the EU that are estimated to ever be occupationally exposed to DEE is projected to increase from about 12 million in 2010 to almost 20 million in 2060. This trend, in addition to the increased number of cancers that are expected to

occur in the general population because of increasing life expectancy tends to reduce the health impact of reductions in the level of exposure. In 2010 it is estimated that in the EU there will be 4,698 incident cases of lung cancer (4,242 deaths) and 1,031 cases of bladder cancer (314 deaths) from past exposure to DEE. Over the following fifty years the annual number of attributable cases of lung cancer is estimated to decrease to 2,643 (2,594 deaths) and bladder cancer to 415 cases (168 deaths). Annual DALYs for lung cancer decrease from 67,064 to 33,766 years and from 4,704 to 2,023 years for bladder cancer over the period to 2060. Total estimated health costs associated with inaction for the period up to 2069 range from €99,084m to €258,000m.

Current exposures in the EU are judged to be mostly below 100 μg/m^3 and so there are no predicted health benefits and no important costs associated with compliance with the suggested OEL (between €25m and €249m). There are also no social or macro-economic costs associated with introducing an OEL at this level.

To have an effect on the expected number of lung and bladder cancers the OEL would need to be much lower than is typically set in the EU (i.e. less than 100 μg/m^3) and the approach to controlling exposures more extensive. It would probably be necessary to make greater use of air-conditioned cabs in vehicles or ventilation in workplaces, and to consider the use of personal respiratory protection where other means of control were impracticable or uneconomic.

It is likely that there would be a positive health impact from introducing an OEL of 100 μg/m^3 in the mining sector, although it has not been possible of us to quantify the effect from the present analysis.

There are no significant environmental impacts foreseen from introducing an OEL at 100 μg/m^3.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

Diesel engine exhaust emissions (DEE) may cause lung and bladder cancer. Exposure to DEE has been classified as a group 2a carcinogen (Probably carcinogenic to humans) by the International Agency for Research on Cancer (IARC)[1], based on the available epidemiological and toxicological data. It is not classified in the EU under the classification and labelling legislation and is therefore already regulated as a carcinogen throughout the EU[2]. In this assessment we consider the impacts of introducing an exposure limit for DEE within the EU Carcinogens and Mutagens Directive.

The key objectives of the present study are to identify the technical feasibility and the socioeconomic, health and environmental impacts of introducing a regulatory exposure limit of 100 $\mu g/m^3$ for DEE particulate as elemental carbon.

1.2 OELS/EXPOSURE CONTROL

The Institut für Arbeitsschutz der Deutschen Gestzlichen Unfallversicherung (IFA) maintains a database of occupational exposure limits (OELs) in EU member states.[3] Austria is the only member state for which an OEL is listed on the database for diesel engine exhaust emissions. In Austria the eight-hour exposure limits are 300 $\mu g/m^3$ (0.3$\mu g/m^3$) and 100 $\mu g/m^3$ (0.1 $\mu g/m^3$) respirable aerosol for underground mining and all other scenarios, respectively. It is not clear whether or not these limits refer to aerosol as elemental carbon, although we have understood this to be the case. For the purposes of this report an OEL of 100 $\mu g/m^3$ elemental carbon is considered typical for the EU.

1.3 DESCRIPTION OF DIFFERENT USES

Diesel engine exhaust emissions (DEE) arise from the combustion of diesel fuel in compression ignition engines. The sources of occupational exposure to DEE include motor vehicles, locomotives and diesel powered heavy equipment such as tractors and forklifts (Pronk *et al,* 2009). DEEs consist of a complex mixture of gasses and particulates, most of which are products of combustion. The gasses present in DEE can include water vapour, nitrogen, oxygen, carbon dioxide, carbon monoxide, sulphur oxides, nitrogen oxides, volatile hydrocarbons, aldehydes, and low molecular weight polyaromatic hydrocarbons (PAHs) (HSE, 1999; Report on Carcinogens, 2005). The particulate fraction of the emission is almost entirely (98%) in the respirable range and can consequentially reach the gas exchange regions of the lungs and about 92% is smaller than 1 µm (Report on Carcinogens, 2005). The particulate matter consists of elemental carbon cores on which are adsorbed a variety of organic materials (including PAHs) and traces of metallic compounds (HSE, 1999; IARC, 1989).

The quantity and composition of DEE can vary with operating conditions. Light duty diesel engines (such as those in automobiles) operate at faster speeds than heavy-

[1] Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf
[2] Available at: http://ecb.jrc.ec.europa.eu/esis/
[3] Available at: http://www.dguv.de/bgia/en/gestis/limit_values/index.jsp

duty engines such as those in lorries and buses and emit fewer particles, and engines with a low workload typically emit fewer particles with a higher proportion of organic compounds relative to engines with a high workload. Gas temperatures can also affect particle composition; low gas temperatures result in particulate matter with more adsorbed organics than that produced under high gas temperatures. Other factors that can influence the composition of DEE include the quality of the diesel fuel used, the type of engine, the frequency of engine maintenance, the state of engine tuning and the fuel pump setting (HSE, 1999; Report on Carcinogens, 2005).

The International Agency for Research on Cancer (IARC) concluded that DEE is probably carcinogenic to humans (group 2a) based on sufficient evidence of carcinogenicity of whole diesel engine exhaust and extracts of diesel engine exhaust in experimental animals. There was inadequate evidence of carcinogenicity in experimental animals of diesel engine exhaust with particles removed suggesting that the carcinogenicity arises from exposure to the particulate component of DEE (IARC, 1989).

Assessment of exposure to DEE is complicated by the wide range of combustion products present. Many of these substances are also constituents of other sources of pollution such as factory emissions and petrol exhaust; none are exclusive to DEE. Surrogates of DEE have been used to assess exposure and these include respirable particulate matter, carbon monoxide and nitrogen oxides. Since the 1990s elemental carbon and submicron particulate matter have been used increasingly to assess DEE concentrations as these are not produced in significant quantities by petrol engines. The use of elemental carbon (EC) as an indicator of DEE exposure is more difficult in coal mines as coal dust can interfere with its analysis, although this problem can be overcome through the use of size selective samplers to differentiate between DEE particulate which is almost all smaller than 1 μm and coal dust which is almost entirely larger than 1 μm (Dabill, 2005). For the purposes of this report we will only consider exposure measurements that use EC as a marker of exposure as this is the most widely used approach to assess occupational exposure to DEE and the most relevant to cancer risk.

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

Bladder cancer

Bladder cancer is a relatively common cancer that is generally diagnosed on people over 60 years of age. There are about twice as many cases diagnosed on men compared to women. In the EU it comprises about 5% of all cancer incidence (Ferlay *et al*, 2007). Key environmental risk factors are cigarette smoking, some industrial chemicals, diet and genetic factors. Mortality amongst European men, especially younger men, has been dropping steadily since the mid-1970s, which is probably due to changes in smoking prevalence and reductions in occupational exposure to aromatic amines such as benzidine and α-and ß-naphthylamine (Levi *et al*, 2004).

Early symptoms of bladder cancer include intermittent haematuria (blood in the urine), changes in the frequency of urination and pain when urinating, although all of these symptoms are also associated with other non-malignant conditions. About three quarters of people diagnosed with bladder cancer can be treated by relatively minor surgery (transurethral resection of superficial bladder cancer), with chemotherapy and/or immunotherapy, giving a relatively good prognosis. For more serious cases of bladder cancer (muscle invasive tumours) the treatment options include surgery, chemotherapy and radiotherapy. Survival rates are lower for these types of tumours.

Lung cancer

Lung cancer is the most common malignant neoplasm among men in most countries and incidence has been steadily increasing among women. In the EU the incidence is about 30 per 100,000 persons, with about 290,000 new cases each year[4]. The main environmental cause is cigarette smoking, although other factors, such as genetic susceptibility, poor diet, and indoor air pollution, may act in conjunction with tobacco consumption as risks for lung cancer. Among both men and women, the incidence of lung cancer is low in individuals aged less than 40 years and increases up to age 70 or 75 (Quinn *et al*, 2001). In most European countries, the risk of lung cancer among men is regularly two to three times higher in lower than higher socio-economic classes (Quinn *et al*, 2005).

Lung cancer is highly fatal, so the trends in incidence and mortality are closely similar. In Europe about 10% of lung cancer patients survive for more than 5-years post diagnosis (Verdecchia *et al*, 2007). Lung cancer accounted for 15.5% of all cancers in men in Europe, and 6.9% of such cases in females (Ferlay *et al*, 2007).

There are a number of occupational agents that are known or suspected of causing lung cancer. Rushton *et al*, (2010) estimated that in Great Britain occupational exposures account for about 21% of male lung cancers and 5% of female lung cancers.

1.4.2 Summary of the available epidemiological literature on risk

Occupational exposure to diesel engine exhaust (DEE) has been associated in several different industries with an increased risk of bladder and lung cancers.

Bladder Cancer

An effect of diesel on bladder cancer is plausible because metabolites of PAH present in diesel exhaust are concentrated in the urine and may interact with the urothelium of the bladder (Silverman *et al*, 1986). Professional drivers, mechanics, and other professions are exposed to elevated levels of emissions from combustion engines including DEE. However, studies do not consistently show an excess of bladder cancer.

Occupational history of 8,110 cases of bladder cancer among Finnish workers born between 1906 and 1945 exposed to DEE, and diagnosed between 1971 and 1995 was assessed for exposure to DEE (Guo *et al* 2004). There was a slight elevation of RR for bladder cancer risk at the lowest exposure level of DEE. The only significant excess was seen among bus drivers (RR=1.29, 95%CI=1.02-1.62).

[4] http://globocan.iarc.fr/factsheets/populations/factsheet.asp?uno=990

An elevated risk for male drivers of tractors/trucks (OR = 2.4, 95% CI 1.4-4.1), with a significant positive trend in risk with increasing duration of employment (P_{trend} = 0.0003) was found in a population-based case-control study of 424 cases and 645 controls in New Hampshire, USA (Colt *et al,* 2004). This was higher than among drivers of other types of trucks and there was no increase for taxicab or bus drivers.

A population based, case-control study in Iowa, USA assessed the association between occupation and bladder cancer of 1,452 incident cases and 2,434 matched controls (Zheng *et al*, 2002). They reported an excess risk for mechanics in the automobile industry (OR=1.6, 95% CI 1.0-2.6) and in railroad transportation and mechanics.

Soll-Johanning *et al* (2003) investigated risk in Danish bus drivers and tramway employees in a nested case-control study of 84 cases and 606 controls from a cohort of 18,174 employees, employed between 1900 and 1994. However, no differences were seen in rates of bladder cancer even after 20 years of employment. However, after introducing a lag period of 10 years there was a tendency for an increase in risk with increasing time of employment, although there was no positive trend.

In contrast to the studies above, Boffetta *et al* (2001), in a study of occupational exposure to DEE and cancer risk in Sweden found no increased risk of bladder cancer in either gender from exposure to diesel emissions in a cohort from the Swedish Cancer Environment Register.

Boffetta and Silverman (2001) reviewed 35 epidemiological studies from Europe, USA and Canada published between 1977 and 1998, which provided information on bladder cancer occurrence associated with exposure to DEE. Various types of exposure to DEE have been investigated, ranging from groups of highly exposed workers, such as drivers to workers who were probably exposed. The study focussed on five occupational groups: railroad workers, garage maintenance workers, truck drivers, and drivers and operators of heavy machines in ground and road construction. They also considered studies providing a classification of exposure to DEE based on a job-exposure matrix or on experts' assessment of individual occupational histories. All but one of the 7 cohort studies included did not control for smoking, all but two of the 16 case-control studies controlled for smoking, and all the 6 studies based on routinely collected data were assumed to have adjusted for smoking. They did not carry out an overall meta-analysis because of the heterogeneity of the results, mainly due to the different definitions of exposure used in the studies. The summary RR for ten studies that considered DEE exposure based on a job exposure matrix or a similar approach was 1.13 (95%CI=1.00-1.27). A positive exposure-response relation was suggested by 10 of the 12 studies that provided relevant information. The summary RR for high DEE exposure was 1.44 (95%CI=1.18-1.76); the summary RR was 1.23 (95%CI=1.12–1.36) for any exposure in the subset of studies from which the high DEE exposure estimate was obtained.

Lung cancer

Two reviews have been undertaken evaluating the association between DEE exposure and lung cancer risk (Bhatia *et al*, 1998, Lipsett and Campleman, 1999). Bhatia *et al* (1998) evaluated 29 DEE epidemiological studies and selected 23 for inclusion in a meta-analysis. Studies of miners were excluded due to the potential for exposure to multiple airborne substances in the industry. Ten of the studies controlled for smoking. For all 29 studies the lung cancer RR was 1.33 (95%CI=1.27-1.40). There was no difference between cohort and case-control studies. In studies that adjusted for smoking the pooled RR was 1.35 (95%CI=1.22-1.49). However, there was significant heterogeneity between studies which was reduced when the analysis was stratified by occupational setting in which DEE exposure occurred.

Lipsett and Campleman (1999) included 30 studies (out of 47), that contained risk estimates, in their analysis that met their inclusion criteria. Occupations varied and included truck drivers, road maintenance, mechanics, railroad workers, heavy equipment operators, bus drivers and garage workers, dock workers, and other exposed worker groups. Individual study RRs ranged from 0.6 to 3.32. The overall pooled RR was 1.33 (95%CI=1.21-1.46) with little difference between cohort (1.29, 95%CI=1.14-1.47) and case-control (1.44, 95%CI=1.33-1.56) studies. In studies that adjusted for smoking the pooled RR was 1.43 (95%CI=1.31-1.57), or 1.47 (95%CI=1.29-1.67) after carrying out a sensitivity analysis excluding studies in which exposures to exhaust from diesel versus conventional internal combustion engines could not be easily distinguished. There was also little difference in the pooled RR between occupations.

In a large record-linkage study from Sweden, (Boffetta *et al,* 2001), men exposed to DEE identified at the 1960 census experienced an increased risk of lung cancer of 1.1 (95%CI=1.1-1.2) and 1.3 (95%CI=1.3-1.4) for medium and high intensity of exposure. The SIR for men (n=6,266) was 1.09 (95%CI=1.06-1.12), and for women (n=57) was 1.09 (95%CI=0.83-1.42).

In an update of a US railroad cohort of 54,973 workers between 1959 and 1996, there was a total of 43,593 deaths including 4351 lung cancer deaths (Garshick *et al*, 2004). Mortality did not increase with increasing years in work, but was elevated in jobs associated with work on trains powered by diesel locomotives.

Steenland *et al* (1998) compared DEE exposure between 954 cases who died between 1982 and 1983 and 1,085 controls; all were long-term union members enrolled in the pension system of the US trucking industry. DEE exposure was estimated based on a 1990 industrial hygiene survey. All analyses resulted in a significant positive trend in risk with increasing cumulative exposure. A male truck driver exposed to 5µg m^3 of elemental carbon would have a lifetime excess risk of lung cancer of 1-2%, above a background risk of 5%.

Bruske-Hohlfeld *et al* (1999) pooled two case-control studies on lung cancer in Germany, giving a total of 3,498 cases and 3,541 population-based controls. Information about occupational and smoking history was obtained by questionnaire. Drivers of lorries, buses, taxies, diesel locomotives and fork-lift trucks, bulldozers, excavators, and tractors, were considered as exposed to DEE. Among those ever exposed, the OR was 1.43 (95%CI=0-0) after adjustment for smoking and asbestos exposure. Higher ORs were seen in cases with more than 10-years work experience. ORs were greater among those hired after 1946 compared to pre-1946. Significant ORs were observed for a number of occupations: Professional drivers (OR=1.25, 95% CI 1.05-1.47); other traffic-related jobs (OR= 1.53, 95%CI 1.04-2.24); heavy equipment operators (OR=2.31, 95%CI 1.44-3.70); tractor drivers (OR = 1.29, 95%CI 0.78-2.14).

In a Finnish study economically active individuals (as identified by the 1970 census) were followed for lung cancer during 1971-1995 (n=33,664) (Guo *et al*, 2004). The occupation stated at the census was converted to DEE exposure with a JEM. Among men significant SIRs were observed for (Table 1.1):

Table 1.1 Occupations among which signification SIRs for lung cancer were observed among men (source: Guo *et al,* 2004)

Occupation	N	SIR	95%CI
Mines, quarry workers, metal ore	36	3.26	2.28-4.51
Mines, quarry workers, except metal ore	181	1.85	1.59-2.14
Mines, quarry workers, other	70	1.73	1.35-2.19
Truck drivers	620	1.13	1.04-1.22
Car mechanics	266	1.14	1.01-1.29
Asphalt workers	32	2.25	1.54-3.17
Dockers, stevedores	236	1.32	1.16-1.50

No exposure-response relationship was observed with cumulative exposure for lung cancer overall, but there was a small increase in small cell carcinomas with increasing exposure. Lagging exposures did not affect the exposure-response relationship.

A pooled analysis from 11 case-control studies of DEE in Europe and Canada found an increased lung cancer risk (adjusted for pack-years and time since quitting smoking) in the highest quartile of cumulative diesel exposure compared with the unexposed (OR=1.31, 95% CI 1.19-1.43). There was a significant exposure-response relationship, although ORs in the three lowest quartiles did not vary much (0.98, 1.04, 1.06 respectively).

1.4.3 Choice of risk estimates to assess health impact

Bladder cancer

An overall inverse variance weighted average of all RRs from the studies included in Boffetta and Silverman's review (2001) that were based on cancer incidence was calculated as 1.24 (95%CI=1.10-1.41) (random effects model); this has been used for the 'high exposed' group. Although Boffetta and Silverman did not offer an overall summary RR, due to the heterogeneity between studies with different definitions of DEE exposure, in the present study the value calculated for all studies (RR=1.18, 95%CI=1.08–1.28) is in line with their observation of an overall RR in the range 1.1–1.3. For the low exposure group, the 10 studies that classified exposure according to a job exposure matrix were used. Boffetta and Silverman note that although there were a few positive results (three above RR=1.1), most were close to unity. An attempt to reproduce their result from the data provided gave a summary RR (fixed effects model) of 1.04 (95%CI=0.9–1.2) rather than 1.13, and of 1.03 (95%CI=0.84-1.26) when only the 6 incidence studies were taken into account. This latter result has been used for the low exposure RR. Two of the 45 results in the Boffetta and Silverman review contributing to the overall RRs were for women, and a further 4 were for men and women combined. The overall RRs however will be applied to women as well as men.

Lung cancer

Lipsett and Campleman (1999) undertook a meta-analysis of 30 studies to investigate the relationship between occupational diesel exhaust exposure (DEE) and lung cancer. There was substantial heterogeneity in the pooled risk estimates for all studies combined and for most subsets. However, a meta-analysis of 12 studies (20 risk estimates) that had adjusted for smoking showed little evidence of heterogeneity. The authors also carried out sensitivity analyses by excluding studies in which exposures to exhaust from diesel versus conventional internal combustion exposures could not be easily distinguished. The pooled smoking-adjusted RR was 1.47 (95%CI=1.29-1.67), and has been chosen for the high exposure risk estimate. For the low estimate we have used the overall lung cancer estimate from the record linkage study by Boffetta *et al* (2001). The recent study by Olsson *et al* (2011) supports the categorisation of exposures as only high and low.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

For the purposes of this study, Eurostat data for 2007 for sectors that match the activities related to diesel exhaust emissions have been considered. These are set out in Table 2.1.

Table 2.1 Sectors from Eurostat considered for this study

Sector	NACE Code (v.1)	Description
Mining of coal and lignite; extraction of peat	10	This division includes the extraction of solid mineral fuels through underground or open-cast mining and includes operations (e.g. grading, cleaning, compressing and other steps necessary for transportation etc.) leading to a marketable product. This class also includes: - peat digging - preparation of peat to improve quality or facilitate transport or storage This class excludes: - service activities incidental to peat mining, - manufacturing of peat briquettes, - manufacture of potting soil mixtures of peat, natural soil, sands, clays, fertiliser minerals etc., - manufacture of articles of peat.
Mining of metal ores	13	This division includes mining for metallic minerals (ores), performed through underground or open-cast extraction, seabed mining etc. Also included are ore dressing and beneficiating operations, such as crushing, grinding, washing, drying, sintering, calcining or leaching ore, gravity separation or flotation operations. This division excludes:

Sector	NACE Code (v.1)	Description
		- roasting of iron pyrites, - production of aluminium oxide, - operation of blast furnaces.

Other mining and quarrying	14	This division includes extraction from a mine or quarry, but also dredging of alluvial deposits, rock crushing and the use of salt marshes. The products are used most notably in construction (e.g. sands, stones etc.), manufacture of materials (e.g. clay, gypsum, calcium etc.), manufacture of chemicals etc. This division does not include processing (except crushing, grinding, cutting, cleaning, drying, sorting and mixing) of the minerals extracted
		
		This class includes:
		- support services on a fee or contract basis, required for mining activities, including:
		  - exploration services, e.g. traditional prospecting methods, such as taking core samples and making geological
		  - observations at prospective sites
		  - draining and pumping services, on a fee or contract basis
		  - test drilling and test hole boring

Construction	45	Includes: • Site preparation • Demolition and wrecking of buildings; earth moving • Test drilling and boring • Building of complete constructions or parts thereof; civil engineering • General construction of buildings and civil engineering works • Erection of roof covering and frames • Construction of highways, roads, airfields and sport facilities • Construction of water projects • Other construction work involving special trades • Building installation • Installation of electrical wiring and fittings • Insulation work activities • Plumbing • Other building installation • Building completion

Sector	NACE Code (v.1)	Description
		• Plastering • Joinery installation • Floor and wall covering • Painting and glazing • Other building completion • Renting of construction or demolition equipment with operator • Renting of construction or demolition equipment with operator
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	This class includes: • Sale of motor vehicles • Maintenance and repair of motor vehicles • Maintenance and repair of motor vehicles • Sale of motor vehicle parts and accessories • Sale of motor vehicle parts and accessories • Sale, maintenance and repair of motorcycles and related parts and accessories • Sale, maintenance and repair of motorcycles and related parts and accessories • Retail sale of automotive fuel • Retail sale of automotive fuel
Land transport; transport via pipelines	60	Land transport; transport via pipelines • Transport via railways • Transport via railways • Other land transport • Other scheduled passenger land transport • Taxi operation • Other land passenger transport • Freight transport by road • Transport via pipelines • Transport via pipelines
Supporting and auxiliary transport activities; activities of travel agencies	63	• Cargo handling • Storage and warehousing • Other supporting transport activities • Other supporting land transport activities • Other supporting water transport activities • Other supporting air transport activities • Activities of travel agencies and tour operators; tourist assistance activities n.e.c.

Sector	NACE Code (v.1)	Description
		• Activities of travel agencies and tour operators; tourist assistance activities n.e.c.
		• Activities of other transport agencies
		• Activities of other transport agencies

In the absence of any more precise or comprehensive publicly available data, the Eurostat data was considered suitable for this study. The majority of cost information from Eurostat is average enterprise data rather than sector totals. Table 2.2 shows the total number of people employed and number of enterprises.

Table 2.2 Statistics of the sectors used in this study

Sector	NACE code	Total number of employees in sector[1]	Number of enterprises
Mining of coal and lignite; extraction of peat	10	99,847	1,480
Mining of metal ores	13	20,059	276
Other mining and quarrying	14	163,138	18,463
Construction	45	11,651,073	2,588,787
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	4,336,644	820,380
Land transport; transport via pipelines	60	5,769,860	941,000
Supporting and auxiliary transport activities; activities of travel agencies	63	2,721,434	192,894
Total	**-**	**24,901,131**	**4,563,280**

[1] This gives the total number of employees employed in each sector and does not represent the number of personnel exposed to DEE (as shown in Table 2.3)
Source: Eurostat data

2.2 PREVALENCE OF DIESEL ENGINE EXHAUST EMISSIONS EXPOSURE IN THE EU

The prevalence of exposure to DEE was estimated from the Finnish CAREX estimate of 2000, the Spanish CAREX estimate of 2004 and the Italian CAREX estimate of 2000 – 2001 (Mirabelli and Kauppinen, 2005). A 2007 Finnish CAREX update was not available for DEE. The proportion of exposed workers in each industry was taken from each of these three CAREX estimates and the average proportion exposed across all three countries was found for each industry. The average proportion of exposed workers was applied to information on the number of employees in each industry obtained from the structural business statistics and the Labour Force Survey available on the Eurostat database.[5] The average proportion of exposed workers was multiplied by the number of workers employed in each industry in each country in 2006 to estimate the number of exposed workers in each industry and country. For Finland, Spain and Italy the proportion of exposed workers from their respective CAREX updates were used rather than the average proportion.

The number of employees in some industry groups and countries was not available on the Eurostat database. Where possible, missing data have been substituted with data from 2002 - 2005 data for the applicable industry and country. Where these data were also unavailable we have indicated that the data were unavailable for the industry and country.

The estimated exposure prevalence for the EU member states based on 2006 employment data is shown in Table 2.3. We have estimated that approximately 3,670,800 workers in the EU were potentially exposed to DEE.

The estimated number of male and female employees in each industry group in each EU member state is shown in Appendix 8.1. These data were obtained by applying the average male-to-female employee ratio for the industry group for each country to the total number of employees. Male-to-female employee ratios were calculated with data from the Labour Force Survey available from the Eurostat database (single digit NACE Code data available only). Managers, salespeople and office clerks were excluded from these calculations as they were assumed to be unexposed.

[5] Available at: http://epp.ec.europa.eu/

Table 2.3 Number of workers exposed to Diesel Engine Exhaust Emissions by country and NACE code

	NACE CODE 5	10	11	13	14	15	16	17	18	19	20	21
Austria	NA	20	NA	NA	1803	987	NA	15	24	5	887	176
Belgium	7269	NA	NA	NA	NA	1251	2	31	22	2	318	142
Bulgaria	NA	2488	20	3518	2797	1425	6	34	420	22	460	110
Cyprus	1870	0	0	0	221	165	0	1	4	0	72	8
Czech Republic	NA	5310	NA	16	2461	NA	NA	46	101	11	1689	200
Denmark	190	NA	NA	0	487	NA	NA	6	7	NA	346	75
Estonia	NA	NA	NA	0	324	223	0	9	32	2	446	19
Finland	NA	0	0	209	578	480	0	0	0	0	284	318
France	2873	571	94	188	10648	8439	4	77	202	31	2004	785
Germany	NA	7445	255	0	13297	10682	12	102	164	20	3294	1436
Greece	157	NA	NA	393	2313	1115	3	19	112	6	334	75
Hungary	NA	46	44	NA	1676	1584	2	20	116	14	620	172
Ireland	NA	NA	NA	NA	1369	643	1	3	4	0	161	34
Italy	3026	0	1663	NA	NA	10029	18	1030	1927	722	8030	663
Latvia	34	328	0	0	300	457	0	8	39	1	739	16
Lithuania	NA	218	20	0	620	668	NA	18	97	2	761	23
Luxembourg	NA	0	0	0	125	NA	NA	NA	NA	0	14	NA
Malta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Netherlands	NA	7	229	0	814	1650	4	14	12	2	458	217
Poland	NA	23033	101	NA	NA	5824	7	83	460	37	3169	442
Portugal	566	0	0	573	5231	1392	1	76	334	62	1072	120
Romania	874	3491	2835	4740	4179	2676	2	71	772	97	1856	163
Slovakia	NA	914	46	NA	914	610	NA	14	73	17	339	76
Slovenia	NA	NA	NA	NA	NA	253	NA	10	32	6	278	53
Spain	0	4390	0	257	9189	1404	0	0	0	0	1229	563
Sweden	NA	113	0	2865	1001	NA	NA	7	5	1	977	411
UK	NA	1019	1274	0	11377	5727	5	78	113	11	1964	735
TOTAL	**16858**	**49393**	**6583**	**12759**	**71724**	**57684**	**67**	**1771**	**5072**	**1070**	**31800**	**7031**

NA = Not Available

	NACE CODE											
	22	**24**	**26**	**27**	**28**	**29**	**30**	**33**	**35**	**36**	**40**	**41**
Austria	51	133	1557	497	717	326	29	16	102	44	288	99
Belgium	69	345	1419	507	679	175	22	8	85	24	166	228
Bulgaria	34	128	1291	337	417	281	54	7	102	34	384	678
Cyprus	5	9	148	5	38	4	0	0	1	2	NA	NA
Czech Republic	89	205	3382	863	1671	653	269	36	196	67	371	738
Denmark	73	147	796	81	474	251	28	18	71	26	138	122
Estonia	13	15	253	6	129	22	7	2	26	12	67	59
Finland	167	18	51	91	92	175	22	0	15	0	0	0
France	378	1358	6089	1500	4294	1223	204	137	1336	141	1599	1301
Germany	727	2260	10637	3865	7889	4226	1019	327	1255	230	2347	1536
Greece	57	90	1126	206	403	91	22	2	126	NA	NA	NA
Hungary	68	158	1261	288	746	275	232	20	73	31	329	786
Ireland	31	122	481	37	131	46	334	26	34	NA	NA	0
Italy	281	2347	29705	4604	17125	3461	43	238	878	1122	2588	2879
Latvia	19	22	279	54	97	29	4	2	49	14	131	74
Lithuania	24	30	525	14	184	44	11	4	65	28	194	223
Luxembourg	NA	5	129	91	43	10	0	2	NA	0	9	4
Malta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Netherlands	161	315	1288	314	985	358	136	26	226	37	192	179
Poland	194	533	6210	1080	2778	829	168	51	640	204	1569	1754
Portugal	73	106	2655	145	882	191	22	7	96	57	105	493
Romania	74	241	2657	911	1028	413	112	16	543	106	960	1309
Slovakia	22	63	924	398	345	181	38	7	66	17	259	477
Slovenia	19	69	424	137	341	109	19	7	24	15	77	148
Spain	0	365	1559	560	864	697	9	0	290	0	0	0
Sweden	100	215	894	703	851	469	111	27	200	47	292	40
UK	659	1058	4957	1097	3326	1112	657	111	1325	167	1106	964
TOTAL	**3389**	**10358**	**80699**	**18392**	**46532**	**15652**	**3573**	**1098**	**7823**	**2424**	**13171**	**14092**

	NACE CODE												
	45	**50**	**51**	**52**	**55**	**60**	**61**	**62**	**63**	**64**	**75**	**85**	**Grand Total**
Austria	10860	9889	602	985	728	34407	101	233	6360	339	759	319	73356
Belgium	11302	9065	688	896	498	27126	397	139	5710	534	1267	457	70847
Bulgaria	7967	5767	442	750	345	26725	1257	62	4437	315	674	151	63939
Cyprus	1481	1016	60	103	116	1356	1115	57	781	29	90	13	8772
Czech Republic	16907	10291	724	1080	475	60072	171	NA	4691	500	977	299	114559
Denmark	8724	7018	520	661	314	22248	3418	141	3716	392	500	468	51454
Estonia	2151	1405	123	135	56	6578	247	18	1248	56	117	36	13834
Finland	2315	3669	0	0	0	22456	2000	0	2077	250	229	0	35494
France	71016	50871	3255	5329	2746	208328	3919	1810	30570	2962	7221	2776	436278
Germany	64447	81230	3852	8305	3947	191645	7655	1389	56807	4540	8630	3809	509279
Greece	13317	12090	1016	1556	911	36235	4159	95	4593	282	1142	191	82234
Hungary	10318	9108	509	995	381	46541	282	67	3519	431	858	259	81827
Ireland	3117	4659	263	565	422	8644	NA	NA	2247	196	314	193	24078
Italy	172682	39110	3233	5354	3346	128316	4499	1731	28796	4086	9238	2270	495040
Latvia	3146	2429	166	312	92	13621	170	28	1861	104	264	48	24936
Lithuania	5368	5203	236	430	116	18597	402	21	1745	115	227	102	36333
Luxembourg	1536	932	44	61	46	3700	35	94	300	31	67	18	7297
Malta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	42	11	53
Netherlands	20691	16980	1438	2253	1035	55877	NA	NA	10064	863	1692	1192	119709
Poland	30112	29979	2182	3727	694	139832	929	139	8648	1196	2752	808	270166
Portugal	21230	14634	879	1315	828	29927	547	243	4347	232	1063	312	89816
Romania	18379	12326	1063	1504	364	59392	906	88	7677	610	1456	368	134258
Slovakia	3101	1853	266	258	65	17629	175	20	1223	193	486	144	31215
Slovenia	3085	1803	131	159	96	9144	60	17	992	87	171	54	17819
Spain	50915	66708	5847	8887	6297	181519	1886	0	41792	0	2199	0	387426
Sweden	11676	9695	694	846	373	38790	3537	187	6639	578	757	694	83797
UK	59919	68059	3567	8858	5780	161123	3667	2253	42164	3327	6116	3300	406976
TOTAL	**625761**	**475789**	**31802**	**55323**	**30069**	**1549828**	**41533**	**8831**	**283001**	**22248**	**49306**	**18290**	**3670795**

Classification of Industries by Exposure Level

Industries in which DEE exposure occurs have been classified as high or low exposure based on an evaluation of the peer-reviewed literature, information from industry and expert judgement. The industries, grouped by NACE code, were identified from the CAREX data. The exposure classification by industry is presented in Table 2.4.

Table 2.4 Classification of industries by exposure level

Industry	**Nace Rev 1.1**	**Classification[1]**	**Number of People Exposed in the EU 2006[2]**
Fishing, fish farming and related service activities	5	Low	16,858
Mining of coal and lignite; extraction of peat	10	**High**	49,393
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	11	Low	6,583
Mining of metal ores	13	**High**	12,759
Other mining and quarrying	14	**High**	71,724
Manufacture of food products and beverages	15	Low	57,684
Manufacture of tobacco products	16	Low	67
Manufacture of textiles	17	Low	1,771
Manufacture of wearing apparel; dressing and dyeing of fur	18	Low	5,072
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	19	Low	1,070
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting mater	20	Low	31,800
Manufacture of pulp, paper and paper products	21	Low	7,031
Publishing, printing and reproduction of recorded media	22	Low	3,389
Manufacture of chemicals and chemical products	24	Low	10,358
Manufacture of other non-metallic mineral products	26	Low	80,699
Manufacture of basic metals	27	Low	18,392
Manufacture of fabricated metal products, except machinery and equipment	28	Low	46,532
Manufacture of machinery and equipment n.e.c.	29	Low	15,652
Manufacture of office machinery and computers	30	Low	3,573

Industry	Nace Rev 1.1	Classification[1]	Number of People Exposed in the EU 2006[2]
Manufacture of medical, precision and optical instruments, watches and clocks	33	Low	1,098
Manufacture of other transport equipment	35	Low	7,823
Manufacture of furniture, manufacturing n.e.c	36	Low	2,424
Electricity, gas, steam and hot water supply	40	Low	13,171
Collection, purification and distribution of water	41	Low	14,092
Construction	45	**High**	625,761
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	**High**	475,789
Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	Low	31,802
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	Low	55,323
Hotels and restaurants	55	Low	3,0069
Land transport; transport via pipelines	60	**High**	1,549,828
Water transport	61	Low	41,533
Air Transport	62	Low	8,831
Supporting and auxiliary transport activities; activities of travel agencies	63	**High**	283,001
Post and telecommunications	64	Low	22,248
Public Administration and Defence	75	Low	49,306
Health and social work	85	Low	18,290
TOTAL			**3,670,795**

[1] Relevant to 1975 exposure levels
[2] Exposure prevalence estimation methods are described in section 1.3

2.3 LEVEL OF EXPOSURE TO DIESEL ENGINE EXHAUST EMISSIONS

2.3.1 Estimation of exposure levels

Pronk *et al* (2009) published a literature review on DEE exposure levels and determinants of exposure across all major exposure scenarios. As this is the most recent and comprehensive review of DEE exposure estimates the data presented by Pronk *et al* were used to estimate typical exposures in the EU.

Elemental carbon exposure measurements taken between 2000 and 2010 relevant to high exposure industries (NACE groups 10, 13, 14, 45, 60, 50 and 63) were extracted from the Pronk *et al* paper and are presented in Table 2.5. Auto mechanics are included in both NACE 50 (Sale, maintenance and repair of motor vehicles) and NACE

63 (Supporting and auxiliary transport activities) and workers in both groups are expected to have similar exposure profiles. For the purposes of this report NACE groups 50 and 63 were assessed as a single group.

The particle size fraction measured in the studies presented in Table 2.5 varied depending on the data source. The majority measured the respirable fraction (particles small enough to deposit in the gas exchange regions of the lung) but some, including the Swedish studies by Lewné *et al* (2007) measured the inhalable fraction (particles that deposit throughout the respiratory tract following inhalation). The inhalable fraction includes all inhaled dust including the respirable fraction. Ninety-eight percent of DEE particulate is in the respirable size fraction and so it is expected that the majority of EC detected in studies that sampled inhalable dust was in the respirable range and that larger particulate did not contribute significantly to the concentrations reported. Studies that sampled different size fractions of particulate are therefore comparable in this case.

Table 2.5 Elemental carbon exposure measurements relevant to high exposure industries

NACE CODE		Number Of Samples	Geometric Mean (μg/m^3)	Geometric Standard Deviation	Data Source	Country	Assessed Task	Year of sampling
10	Mining of Coal and Lignite	7	62	1.5	Leeming and Dabill (2004)	UK	Mining, not specified (underground)	2004
13	Mining of Metal Ore	27	27†	Not reported	Adelroth *et al* (2006)	Sweden	Mining, NS (underground)	2006
14	Other Mining and Quarrying	6	85	3.5	Leeming and Dabill (2004)	UK	Production (underground)	2004
		4	202	1.8	Boffetta *et al* (2002)	Estonia	Production (underground)	2002
		13	84	4.3	MSHA (2003)	US	Production (underground)	2001-2002
		343	111	1.4-4.8	Cohen *et al* (2002)	US	Production (underground)	2002
		269	66	1.7-4.6	Cohen *et al* (2002)	US	Maintenance (underground)	2002
		164	2	1.8 - 6.2	Cohen *et al* (2002)	US	Production/maintenance (Above Ground)	2002
45	Construction	12	87	2.5	Lewné *et al* (2007)	Sweden	Tunnel	2002-2004
		22	8	2.8	Lewné *et al* (2007)	Sweden	Above Ground	2002-2004

NACE CODE		Number Of Samples	Geometric Mean (µg/m^3)	Geometric Standard Deviation	Data Source	Country	Assessed Task	Year of sampling
60	Land Transport	11	18.3	2	Boffetta *et al* (2002)	Russia	Short haul drivers and assistant drivers	2002
		8	12.3	1.9	Boffetta *et al* (2002)	Russia	Shunting locomotive drivers and assistant drivers	2002
		5	9.3	1.3	Boffetta *et al* (2002)	Estonia	Bus drivers	2002
		20	6	2.9	Lewné *et al* (2007)	Sweden	Bus and truck	2002-2004
		8	7	1.6	Lewné *et al* (2007)	Sweden	Taxi	2002-2004
		48	3	2.4-2.7	Verma *et al* (2003)	Canada	Maintenance rolling equipment	1999-2000
		76	3	1.5-3.5	Verma *et al* (2003)	Canada	Engineer/driver, conductor/trainmen	1999-2000
		47	6	Not reported	Seshagiri (2003)	Canada	Non-operating crew trailing locomotive	2003
		5	3	1.5	Verma *et al* (2003)	Canada	Hostler	1999-2000
		576	1	2.8	Davis *et al* (2007)	US	Truck -local	2001-2005

NACE CODE		Number Of Samples	Geometric Mean (µg/m^3)	Geometric Standard Deviation	Data Source	Country	Assessed Task	Year of sampling
		349	1	2.3	Davis *et al* (2007)	US	Truck - long haul	2001-2005
		39	1.4	3.3	Ramachandran *et al* (2005)	US	Bus Drivers	2002
50	Sale, maintenance and repair of motor vehicles	15	37.6	1.3	Boffetta *et al.* (2002)	Estonia	Bus Mechanics	2002
	AND	53	31	2.1	Groves and Cain (2000)	UK	Bus Mechanics	2000
63	Supporting and auxiliary transport activities	64	17	1.9	Groves and Cain (2000)	UK	Maintenance rolling equipment	2000
		40	11	3.2	Lewné *et al* (2007)	Sweden	Truck and bus mechanics and inspectors	2002-2004
		11	11	1.8	Groves and Cain (2000)	UK	Vehicle Testing	2000
		34	1.1	1.8	Ramachandran *et al* (2005)	US	Parking booth attendant	2002

† Arithmetic Mean

We have selected exposure measurements from the data presented in Table 2.5 that are expected to be most representative of EU DEE exposure levels for each high exposure industry in 2010. In both mining and construction underground work is associated with higher exposure to DEE. In the mining industries we have selected an exposure estimate relevant to underground work as a representative value as most mining industries work underground. In the construction industry we have selected an above ground value as representative is the majority of construction workers work above ground. The selected representative exposure estimates for each high exposure industry and justification for the selection are presented in Table 2.6.

Table 2.6 Selected elemental carbon exposure measurements relevant to high exposure industries

NACE CODE		Geometric Mean (GM) (μg/m^3)	Geometric Standard Deviation (GSD)	Data Source	Reason for Selection of GM and GSD
10	Mining of Coal and Lignite	62	1.5	Leeming and Dabill (2004)	This is the only available study of EC exposures at European coal mines.
13	Mining of Metal Ore	25	3	Adelroth *et al* (2006)	This is the only available study of EC exposures at a European metal ore mine. The figure presented by Adelroth *et al* was an arithmetic mean of 27. This has been adjusted down to create a GM estimate of 25 μg/m^3. Adelroth *et al* reported that the data was log normally distributed and a GSD of 3 has been selected as a typical GSD for log normally distributed exposure data.
14	Other Mining and Quarrying	111	3.1	Cohen *et al* (2002)	The Cohen *et al* study is the largest study of EC exposures among non-metal and non-coal miners. Measurements were taken across 7 non-metal mines in the US. Exposures in the US are expected to be similar to those in the EU. The value for production tasks was selected as a representative value as more miners are expected to be involved in production than maintenance. The midpoint

NACE CODE		Geometric Mean (GM) ($\mu g/m^3$)	Geometric Standard Deviation (GSD)	Data Source	Reason for Selection of GM and GSD
					of the reported range of GSDs from Cohen *et al* (3.1) was selected as a representative GSD. For the purposes of this work we assumed that all miners are exposed underground.
45	Construction	8	2.8	Lewné *et al* (2007)	The exposure distribution for above ground construction work was selected as most construction workers are involved in above ground work and few are involved in tunnelling
60	Land Transport	13.9	1.9	Bofetta *et al* (2002)	The GM and GSD were calculated from all of the data collected by Bofetta *et al* among bus drivers, short haul truck drivers, and locomotive drivers in Russia and Eastern Europe. The measurements presented by Bofetta *et al* include workers in a variety of job types and this work is likely to be representative of the industry. Boffetta *et al* found that EC exposures in Eastern Europe are similar to those in Western Europe.
50	Sale, maintenance and repair of motor vehicles	11	3.2	Lewné *et al* (2007)	The Lewné *et al* GM was selected as a representative estimate as the data used to calculate came from measurements of exposure among both mechanics and inspectors. Other measurements presented in Table 2 were specific to only one job type. This estimate is expected to be representative of exposures across both NACE 50 and 63.
63	Supporting and auxiliary transport activities	11	3.2	Lewné *et al* (2007)	

Due to the limited availability of exposure data we were unable to determine whether there are systematic differences in exposures across the EU. We have assumed that the exposures presented for high exposure groups in Table 2.6 are typical of exposures throughout the EU. The overall weighted GM and GSD was estimated across all high exposure industries across the EU using @Risk © (Palisade Corporation, New York). Exposures were simulated using the GM and GSD for each country. The number of values each industry contributed was weighted according to the number of workers exposed in that industry.

The estimated overall weighted GM exposure across all countries and industries is 13 µg/m^3 with a GSD of 2.7

The exposure distribution for the EU was simulated using Monte Carlo simulation. The distributions for each high exposure industry were based on the GMs and GSDs presented in Table 2.6 and the overall distribution across all industries was based on a GM of 13 µg/m^3 and a GSD of 2.7. The percentage of workers who are expected to be exposed above the typical OEL (100 µg/m^3) was estimated with the simulated distributions (Table 2.7).

Table 2.7 Estimated percentage of workers exposed above the typical EU OEL (100 µg/m^3)

Industry		**Estimated percentage of workers exposed above 100 µg/m^3 (%)**
10	Mining of coal and lignite	12
13	Mining of metal ore	10
14	Other mining and quarrying	54
45	Construction	1
50	Sale, maintenance and repair of motor vehicles	3
60	Land transport	0.1
63	Supporting and auxiliary transport activities	3
OVERALL (All high exposure industries)		2

2.3.2 Temporal change in exposure

Geometric mean exposure estimates presented by Pronk *et al* (2009) were plotted against the year of sampling to assess time trends in exposure among truck and bus operators, mechanics, underground miners, train crews, tunnel construction workers and above ground construction workers. The temporal trend in elemental carbon concentrations was estimated by fitting an exponential regression of the form $y = a.e^{-bx}$ to the data. The regression coefficient was used to calculate the average annual change in concentration over the time period for which data were available (Equation 1)

(1) $$\%\text{ change per year} = 100 * (\exp[b] - 1)$$

The estimated time trends for each occupational group are presented in Table 2.8.

Table 2.8 Estimated temporal trends in elemental carbon exposure concentrations across six occupational groups

Occupational Group	Time period	Annual change in concentration
Truck and bus drivers	1985-2003	-0.6%
Mechanics	1985-2003	+10%
Underground miners	2001-2004	-18%
Train crews	1996-2003	+23%
Tunnel construction workers	1996-2003	-10%
Above ground construction workers	1997-2003	0%

The estimated annual changes in exposure concentrations ranged from a decline of 18% per year for underground miners from 2001 – 2004 to an increase of 23% per year for train crews from 1996-2006. The exposure estimates presented by Pronk *et al* (2009) were based on measurements taken for a variety of purposes (worst case sampling, representative sampling, epidemiology studies) and therefore the different studies are not likely to be directly comparable and the time trends presented in Table 4 should not be seen as typical time trends in exposure to DEE. Two out of six of the assessed occupational groups demonstrated a decrease in exposure over the measurement period and two showed no change or a small change. This suggests that exposures have probably decreased over time in most industries although it is difficult to quantify the rate of decline. The largest decreases were seen for underground workers and no change in exposure or an increase in exposure was seen for surface workers. Pronk *et al* (2009) examined two large studies of truck drivers conducted in the 1980s and from 2001 – 2005. The two studies used identical sampling protocols and analytical methods and were therefore directly comparable. EC exposure levels for truck drivers were about three times lower in the 2001-2005 (Davis *et al*, 2007) study than in the 1980s study (Zaebst *et al*, 1991) with an annual rate of decline of about 7.3%. In the past 15 – 20 years exposures in above ground work (NACE 45, 50, 60, 63) have probably declined at a rate of approximately 7% per year and exposures in underground work (NACE 10, 13, 14) appear to have declined at a rate of approximately 10% per year.

Occupational exposures are expected to decrease in the future in line with increasingly stringent EU emissions standards for diesel engines. The European standards for emission of particulate matter from diesel engine passenger cars and light commercial vehicles (light duty engines) are shown in Table 2.9, the standards for busses and lorries (heavy duty engines) are shown in Table 2.10, and the standards for non-road engines (including drilling rigs, compressors, loaders, bulldozers, excavators, forklifts, road maintenance equipment, snow ploughs, ground support equipment in airports, aerial lifts and mobile cranes) are shown in Table 2.11. The standards shown in Tables

2.9, 2.10 and 2.11 will not apply to equipment already in use at the time of the standard implementation and will only apply to new engines however as old equipment is replaced over time all engines will eventually conform to the emissions standards.

Preliminary projections based on the planned emissions standards have suggested that total $PM_{2.5}$ (particulate matter with aerodynamic diameter smaller than 2.5μm) emissions in the EU from all diesel engine emission sources (including aviation, rail, road, off-road and shipping) will decrease at a rate of approximately 7.4% per year from 2005 to 2030. The rate of decline will decrease after 2030 with a projected rate of decrease in emissions of -0.6% per year between 2030 – 2050.[6] The decreases in particulate emissions will be achieved primarily through increased engine efficiency, improvement of refining methods to reduce the sulphur content of diesel fuel, and filtering of particulate from exhaust. It is reasonable to assume that occupational exposures will decrease at a similar rate to overall emissions.

Table 2.9 European particulate matter (PM) emission standards for passenger cars and light commercial vehicles with diesel engines

		PM Standard g/km			
		Passenger cars	**Light commercial vehicles (in vehicle size categories)**		
Tier	**Date of implementation**		**≤1305 kg**	**1305-1760 kg**	**>1760 kg**
Euro 1	07-1992	0.14 (0.18)*	0.14	0.19	0.25
Euro2	01-1996	0.08	0.08	0.12	0.17
Euro 3	01-2000	0.05	0.05	0.07	0.1
Euro 4	01-2005	0.025	0.025	0.04	0.06
Euro 5	09-2009	0.005	0.005	0.005	0.005
Euro 6	09-2014	0.005	0.005	0.005	0.005

* Value in brackets is a conformity of production limit
Source: http://www.dieselnet.com/standards/eu/ld.php

6 Personal Communication with the Institut für Energiewirtschaft und Rationelle Energieanwendung at the University of Stuttgart

Table 2.10 European particulate matter (PM) emission standards for trucks and lorries with diesel engines

Tier	Date of implementation	PM Standard g/kWh
Euro I	1992*	0.612
	1992**	0.36
Euro II	10-1996	0.25
	10-1998	0.15
Euro III	10-1999†	0.02
	10-2000	0.1
		0.13‡
Euro IV	10-2005	0.02
Euro V	10-2008	0.02
Euro VI	01-2013	0.01

* Engines <85kW
** Engines >85 kW
† Enhanced Environmentally Friendly Vehicles (EEVs) only
‡ For engines of less than 0.75 dm^3 swept volume per cylinder and a rated power speed of more than 3000 min^{-1}
Source: http://www.dieselnet.com/standards/eu/hd.php

Table 2.11 European particulate matter (PM) emission standards for non-road diesel engines

Stage	Category	Net Power – P (kW)	Date of implementation	PM Standard (g/kWh)
I	A	130 ≤ P ≤ 560	01-1999	0.54
	B	75 ≤ P < 130	01-1999	0.7
	C	37 ≤P < 75	04-1999	0.85
II	E	130 ≤ P ≤ 560	01-2002	0.2
	F	75 ≤ P < 130	01-2003	0.3
	G	37 ≤P < 75	01-2004	0.4
	D	18 ≤ P < 37	01-2001	0.8
III A	H	130 ≤ P ≤ 560	01-2006	0.2
	I	75 ≤ P < 130	01-2007	0.3
	J	37 ≤ P < 75	01-2008	0.4
	K	19 ≤ P< 37	01-2007	0.6
III B	L	130 ≤ P ≤ 560	01-2011	0.025
	M	75 ≤ P < 130	01-2012	0.025
	N	56 ≤ P < 75	01-2012	0.025
	P	37 ≤ P < 76	01-2013	0.025
IV	Q	130 ≤ P ≤ 560	01-2014	0.025
	R	56 ≤ P <130	01-2014	0.025

Source: http://www.dieselnet.com/standards/eu/nonroad.php

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

2.4.1 Background data

The occupational cancers associated with exposure to diesel engine exhaust emissions are shown in Table 2.12, along with a summary of the information used in the health impact assessment

Table 2.12 Occupational cancer associated with exposure to DEE

Cancer site	**Lung**		**Bladder**	
ICD-10 code	C33-C34		C67	
IARC group for carcinogen	2A		2A	
Strength of evidence for cancer site [(1)]	Suggestive		Suggestive	
Latency assumption	10-50 yrs		10-50 yrs	
Source of forecast numbers - deaths	Eurostat, 2006		Eurostat, 2006	
Source of forecast numbers - registrations	GLOBOCAN, 2002[7]		GLOBOCAN, 2002	
Exposure levels	***Relative Risk (RR)***	***Source of RR***	***Relative Risk (RR)***	***Source of RR***
"High"	1.47 (1.29, 1.67)	Lipsett and Campleman (1999)	1.24 (1.10, 1.41)	Boffetta and Silverman's (2001)
"Low"	1.09 (1.06, 1.12)	Boffetta *et al* (2001)	1.03 (0.84, 1.26)	Boffetta and Silverman's (2001)
"Background"	1	Default below L/B boundary = 1 □g/m^3	1	Default below L/B boundary = 1 □g/m^3

[(1)] Based on Siemiatycki *et al*, 2004

2.4.2 Exposed numbers and exposure levels

Industry sectors, their NACE codes, classifications to High/Medium/Low/Background exposure as applicable for the mid 1970's and numbers exposed in 2006 are given in Table 2.4 in the previous section on exposure. The estimated average exposure level (GM) and measure of variability (GSD) for NACE industries used are 13 and 2.7 µg/m^3 respectively.

A background exposure level boundary, below which it was assumed that excess risk disappeared (RR=1) was chosen for DEE to reflect exposure levels in daily life. The study by Adams *et al* (2002) notes that "The small number of EC concentration measurements taken as part of the calibration curve field campaign within this study show London daytime urban background concentrations of approximately 6 µg/m^3 and kerbside concentrations of approximately 15 µg/m^3. Average background levels in studies in Birmingham and Leeds, UK; have been reported as approximately 3 and 6 µg/m^3, respectively (QUARG, 1996). Kendall *et al* (2000) measured weekly background EC in total suspended particles (TSP) at two sites in London during 1994–1995. At an

[7] IARC, GLOBOCAN database, available at: http://www-dep.iarc.fr/globocan/database.htm

urban background site (the top of St Paul's Cathedral) in central London the geometric mean of weekly samples was 2.6 µg/m^3 (range 1.2–4.3 µg/m^3),and at a suburban site in North London the mean concentration was 2.0 µg/m^3 (range 0.7– 4.2 µg/m^3)." On this basis a background exposure level of around 0.001 or 0.002 µg/m^3 seemed reasonable, and 0.001µg/m^3 was chosen as the L/B boundary below which RR was set to 1 for both cancers.

We present data for a "baseline" scenario which for all industries assumes a 7.4% annual decline in exposure levels and standard change in employed numbers up to the 2021-30 estimation interval and constant levels thereafter.

2.4.3 Forecast cancer numbers

Separate estimates for total numbers of deaths for lung (ICD10 C32-C34 larynx, trachea, bronchus and lung) and for bladder (C67) cancer by age band are available from EUROSTAT for the 27 countries of the EU, for 2006, and for registrations for lung and bladder cancers from GLOBOCAN for 2002. The forecast numbers of deaths and registrations by country used to estimate attributable numbers are in Appendix 8.2.

2.4.4 Results

The cancer deaths and registrations attributed to occupational exposure to DEE for the baseline scenario are presented per year for the target years given and are based on the all working age cohort of currently (2006) exposed workers. Attributable fractions and numbers of deaths and registrations, and Years of Life Lost (YLLs), Years of Lived with Disability (YLDs) and Disability Adjusted Life Years (DALYs), are estimated.

As the exposure data suggests that exposure declines over time, a dynamic baseline scenario has been used.

A summary of the results for the total EU is in Table 2.13 below.

Table 2.13 Results for the baseline forecast scenario, total EU (27 countries), men plus women

Scenario	**All scenarios**		**Baseline (trend) scenario (1) - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.**			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	11,966,411	13,465,650	15,564,562	17,590,873	19,035,347	19,931,080
Proportion of the population exposed	3.312%	3.537%	4.003%	4.466%	4.856%	5.190%
Lung cancer						
Attributable Fraction	1.514%	1.302%	1.035%	0.784%	0.632%	0.577%
Attributable deaths	4,242	4,273	3,913	3,295	2,805	2,594
Attributable registrations 'Avoided' cancers	4,698	4,681	4,208	3,461	2,889	2,643
YLLs	64,221	62,852	55,046	43,990	35,823	32,257
DALYs	67,064	65,651	57,522	45,998	37,483	33,766
Bladder cancer						
Attributable Fraction	0.760%	0.640%	0.479%	0.326%	0.232%	0.197%
Attributable deaths	314	322	291	236	189	168
Attributable registrations 'Avoided' cancers	1,031	1,013	870	652	485	415
YLLs	3,613	3,583	3,121	2,401	1,840	1,599
DALYs	4,704	4,646	4,026	3,074	2,338	2,023

The estimated attributable deaths in the EU 2010 from previous DEE exposure are large with 4,242 deaths from lung cancer and 314 deaths from bladder cancer. The estimated deaths and cancer registrations decrease over the following 50 years so that by 2060 there are 2,594 predicted deaths from lung cancer and 168 predicted deaths from bladder cancer. The corresponding estimate attributable fraction for both cancers decreases from 2010 to 2060: from 1.514% to 0.577% for lung cancer and from 0.760% to 0.197% for bladder cancer. DALYs also decrease in the baseline scenario – from 67,064 years in 2010 to 33,766 years in 2060 for lung cancer and from 4,704 years in 2010 to 2,023 years in 2060 for bladder cancer.

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

The health data (cancer registrations and Years of Life Lost - 'YLL') for the baseline in which there are no further modifications to the Carcinogens Directive were described above in Section 2.4. These data indicate that there are predicted to be a high number of cancer registrations (around 226,000 over the period 2010-2070[8]) and YLLs (around 3,000,000 over the period 2010-2070[8]) from bladder and lung cancer resulting from future exposure to DEE.

[8] Note health estimates are provided for "snap-shot" years; 2010, 2020, 2030 etc. Results for a "snap-shot" year are assumed to be representative for the relevant time period (i.e. 2010 is also representative for 2010-2019) so impacts are multiplied by 10.

There is a predicted decline in registrations and YLLs over the time period of this study (2010-2070) under the baseline scenario as a result of predicted exposure reduction owing to implementation of existing and ongoing risk management measures across the EU, as described above.

Method in brief

Using the health data (cancer registrations and YLL), it is possible to monetise the costs under the baseline by estimating the:

- Life years lost – This is calculated by using the YLL and multiplying this by a valuation of the Value of Life Year Lost (VLYL). This gives a value for the time (in years) lost as a result of premature death.
- Cost of Illness (COI) – This is a monetary cost of the time spent with cancer. In this study, a unit COI estimate is multiplied by the number of cancer registrations to give a total value for COI. (COI is often the main market-based approach in relation to health impact[9]). COI includes the direct and indirect costs of cancer but not the intangible costs (see below).
- Willingness to Pay (WTP) to avoid cancer – WTP is used as an alternative method (high cost scenario) based on publically available, peer reviewed studies on what people would be willing to pay to avoid having cancer. This includes various intangible costs (e.g. disfigurement, functional limitations, pain and fear) and in some cases also includes the costs associated with life years lost.

The cost variables used in this study are presented in Table 2.14 in 2010 prices. For the purposes of this study, valuations are increased by 2% each year in the future in part to present costs in real terms (i.e. adjusting for inflation in prices) and to reflect the increasing value society's attaches to its health (as economic growth typically increases over a long period of time)[10].

Table 2.14 Summary of cost variables used in this study (€ 2010 prices)

Cost/benefit elements	Low scenario	High scenario
VLYL - Each year lost	€ 50,393	€ 0 (note 1)
COI or WTP - Unit cost (per cancer registration)	€ 49,302 (COI)	€ 1,793,776 (WTP)

(Note 1) – By using WTP (€1.8m) in the high scenario instead of COI, the WTP can include the costs of premature death and therefore there was a risk of double counting benefits if VLYL costs were included.

[9] ECHA (2008) "Applying SEA as part of restriction proposals under REACH" Available at: http://echa.europa.eu/doc/reach/sea_workshop_proceedings_20081021.pdf

[10] This is consistent with some other European Commission studies and is standard practice for air quality under the Clean Air for Europe (CAFE) programme.

All costs and benefits over time in this study are discounted using a 4% discount rate as recommended by the European Commission's Impact Guidelines[11]. In order to assess the effect that discounting has on the results ('sensitivity analysis'), we have also presented estimates that take into consideration a declining discount rate for impacts occurring after 30 years and no discounting.

The health data shown in section 2.4 are snap-shots (i.e. estimation for the initial year of a ten year period) of the number of cancer registrations, deaths, YLLs in future years at 10 year intervals. In calculating the costs associated with these effects, each snap-shot result is multiplied by 10 in order to derive an estimate for the whole assessment time period (for example, 2020 results are multiplied by 10 to give results over the period 2020-2029). This assumes that each snap-shot year is representative of the following 10 years.

The method to valuing health benefits is explained in more detail in the method paper titled *"Valuing health benefits – Method paper".*

Results

The health costs under the baseline scenario are presented in Table 2.15. The main costs are predicted to occur in 2010-2040, which are predominantly the result of past exposure. Health costs are predicted to decrease over time, accounted for by risk management measures (RMMs) already imposed over the past 10-20 years. In Section 2.4 the numbers of cancer registrations and YLLs were estimated to decrease over time.

Table 2.15 sets out the range of annual health costs for each representative decade. The ranges are based on the high and low cost scenarios (see Table 2.14). The results are also illustrated in Figure 2.1.

It is important to recognise that these estimates are based on numbers of cancer registrations, which are expected to be over 4,000 per year in 2010. Since there is a large difference in the unit cost (low and high estimates) used for WTP to avoid cancer (see Table 2.14), in addition to the large number of cancer registrations forecasted without further intervention, this explains why there is a large difference between the low and high cost estimates under the baseline scenario.

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[11] European Commission impact Assessment Guidelines (Jan 2009) - http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_en.pdf

Table 2.15 Health costs - baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	Total
Female	2,371 to 4,225	1,912 to 3,441	1,411 to 2,621	972 to 1,865	664 to 1,307	480 to 962	7,810 to 14,421
Male	28,022 to 72,962	22,721 to 59,819	16,539 to 44,289	10,979 to 30,076	7,384 to 20,743	5,462 to 15,709	91,107 to 243,598
Total	30,440 to 77,187	24,673 to 63,260	17,981 to 46,910	11,973 to 31,942	8,063 to 22,050	5,954 to 16,671	99,084 to 258,020

Notes:

- All costs are presented in present value using a discount rate of 4%. The low range is based on low estimates for costs of illness and life years lost. The upper range of costs relate to WTP estimates to avoid having cancer, which include intangible costs associated with having cancer.

- Totals may not match to sums of females and male costs due to underlying small differences in raw data and rounding to whole number

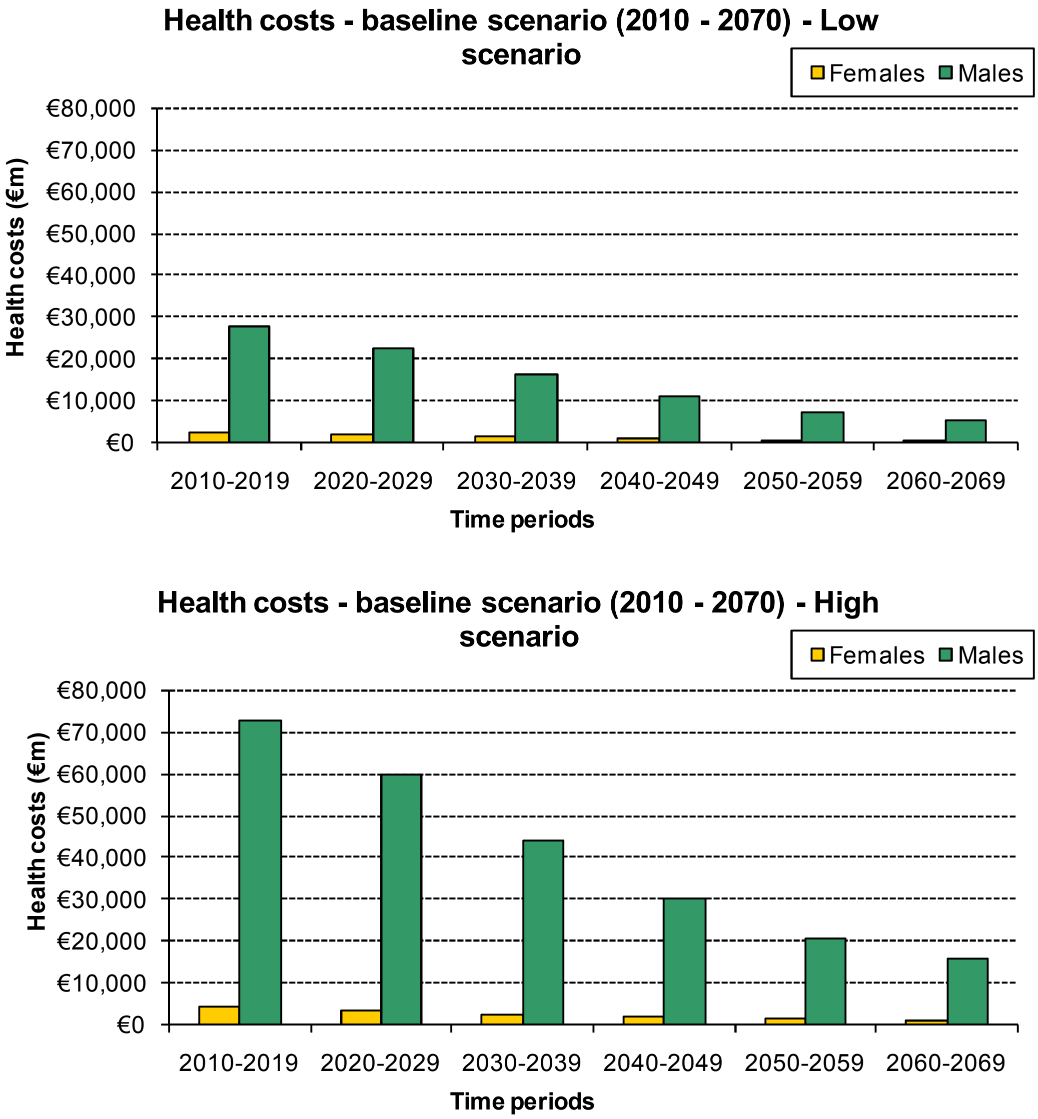


Figure 2.1 Health costs - baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

These predicted health costs will affect Member States differently depending upon the overall number of workers within affected industry groups, existing RMMs and the proportion of males and females within these groups. Figure 2.3 shows that France, Germany, Spain and Italy are predicted to have relatively high health costs, followed by Poland and the UK. The industrial sector estimated to be most affected under the baseline is land transport. There are also notable impacts in construction; the sale, maintenance and repair of motor vehicles (including motor cycles); and supporting and auxiliary transport activities. This is shown in Figure 2.5.

Detailed tables are included in Appendix Section 8.3.

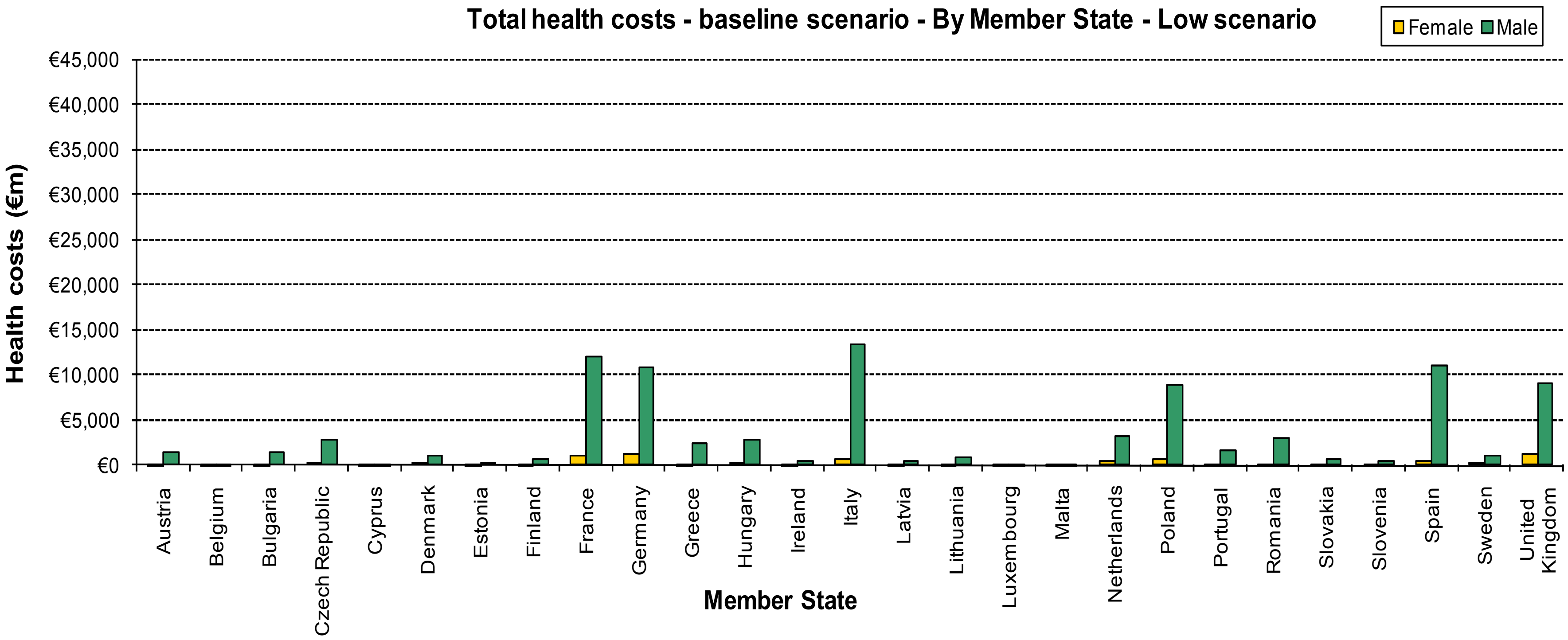


Figure 2.2a Total health costs- baseline scenario – By Member State (Present Value – 2010 €m prices)

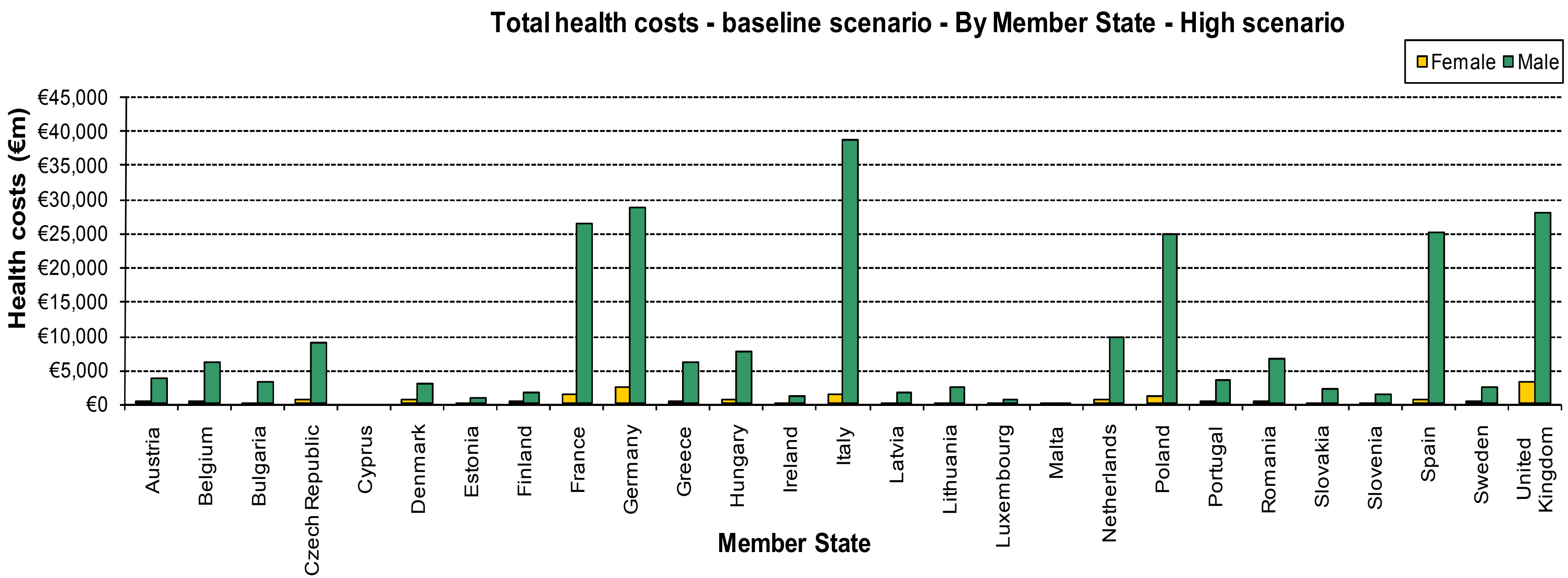


Figure 2.3b Total health costs- baseline scenario – By Member State (Present Value – 2010 €m prices)

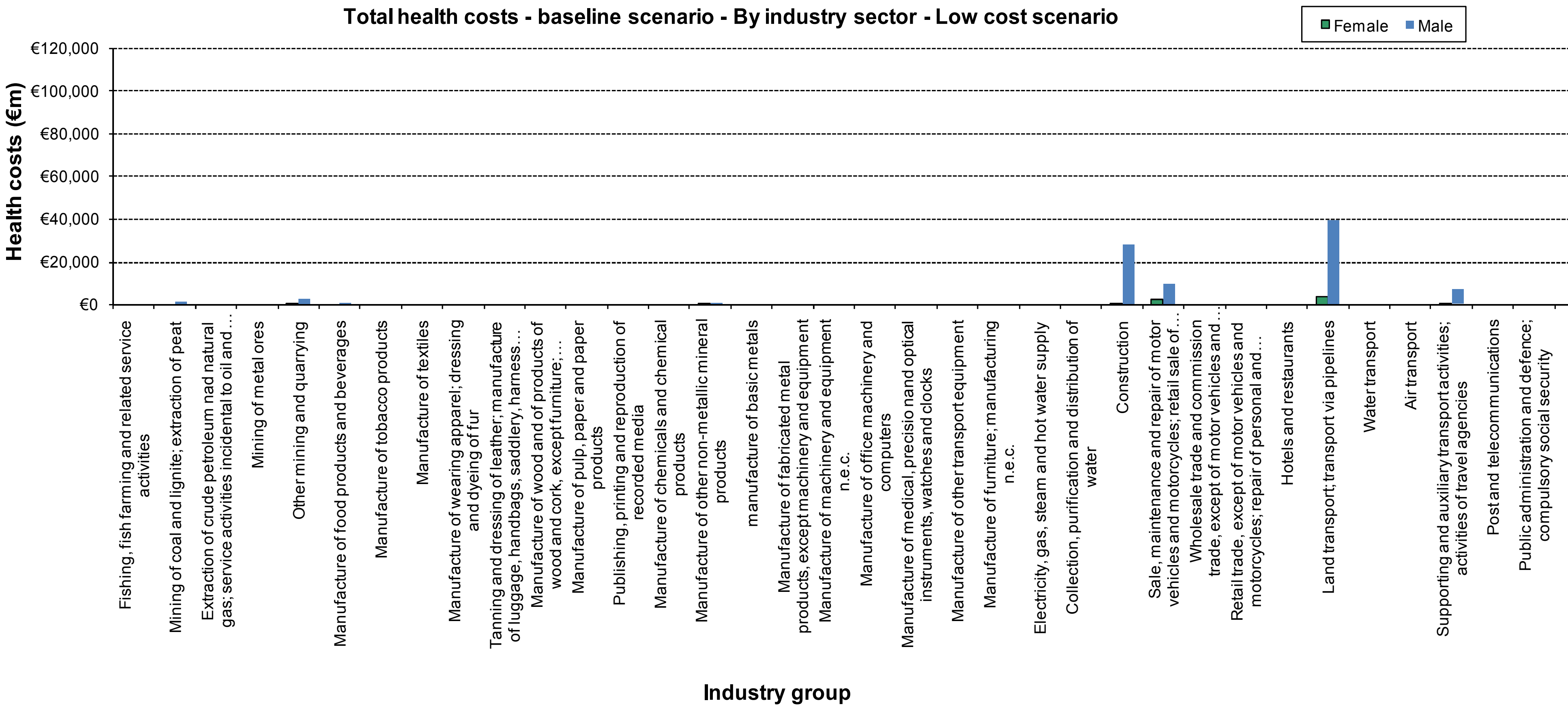


Figure 2.4a Total health costs - baseline scenario - by industry group (Present Value – 2010 €m prices)

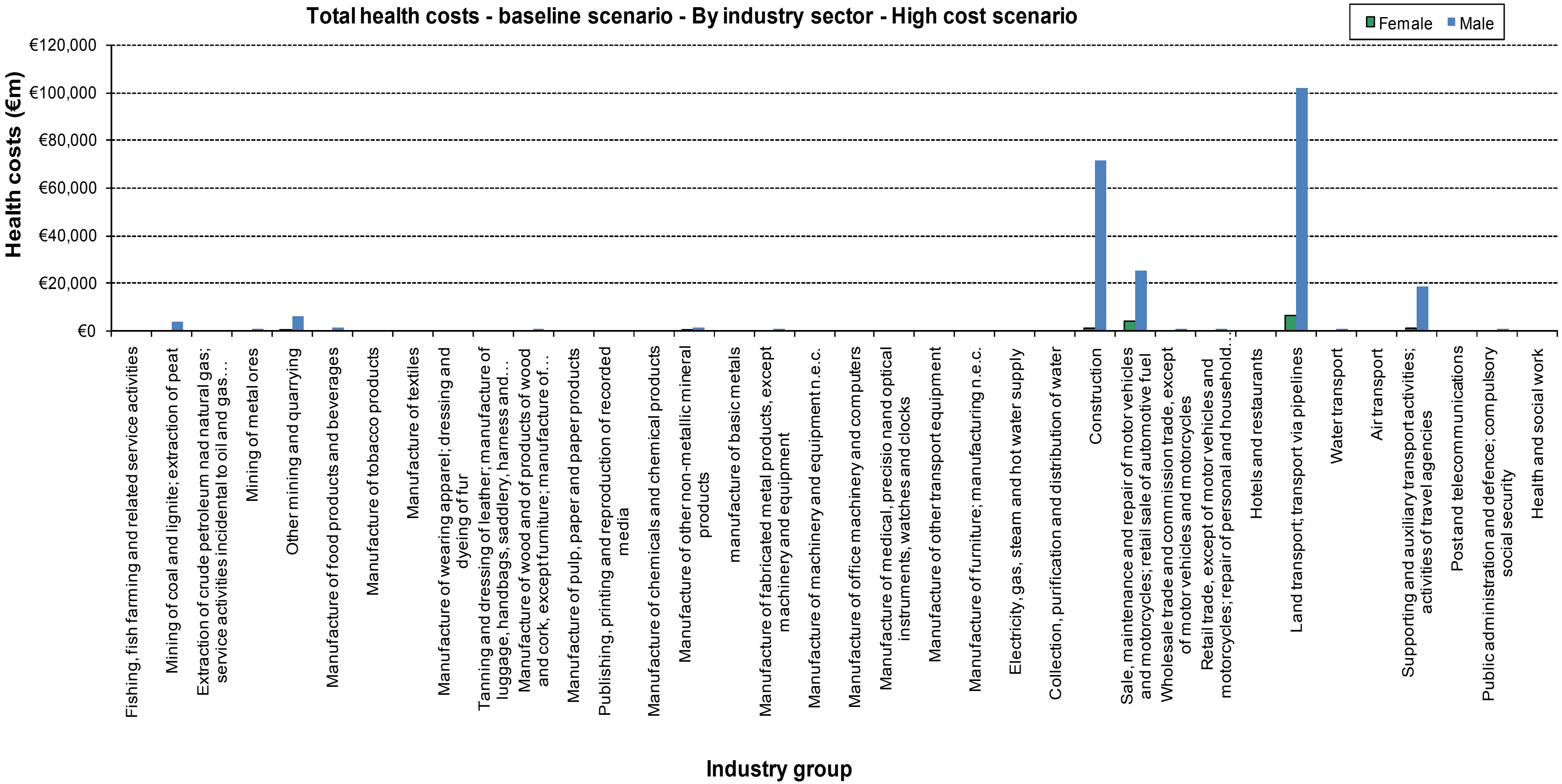
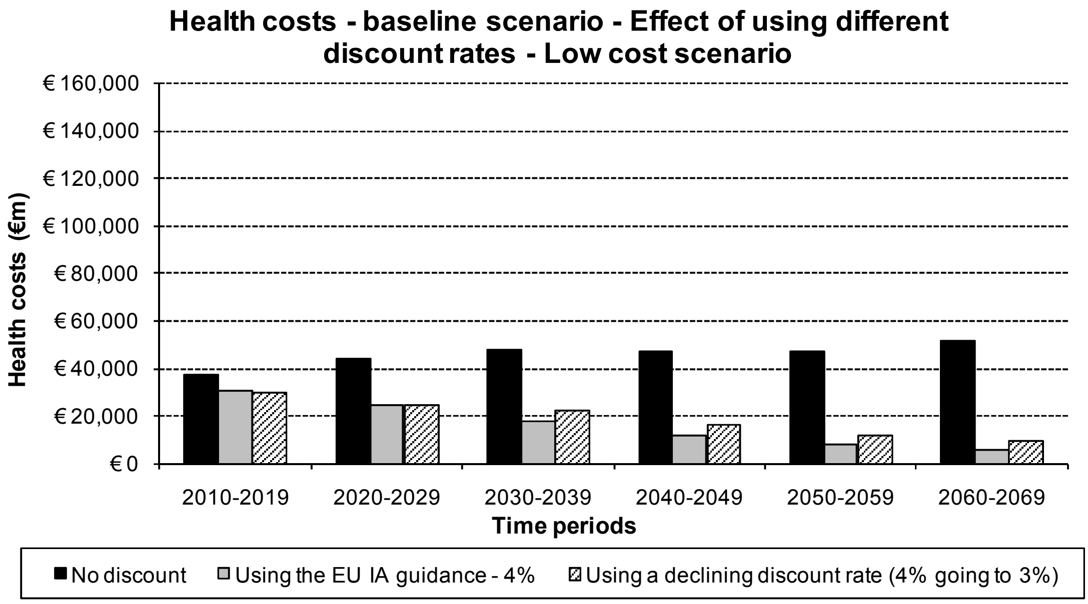


Figure 2.5b Total health costs - baseline scenario - by industry group (Present Value – 2010 €m prices)

In order to present all socio-economic costs and benefits consistently in present value terms, all future costs and benefits have been discounted. The primary approach was to apply the European Commission IA recommended 4% discount rate. Since most health impacts occur over a long period of time relative to costs, the impacts of discounting are significant. In Figure 2.6 the effects of different discount rates on the overall results are shown, indicating that the impacts of discounting become more pronounced over time.



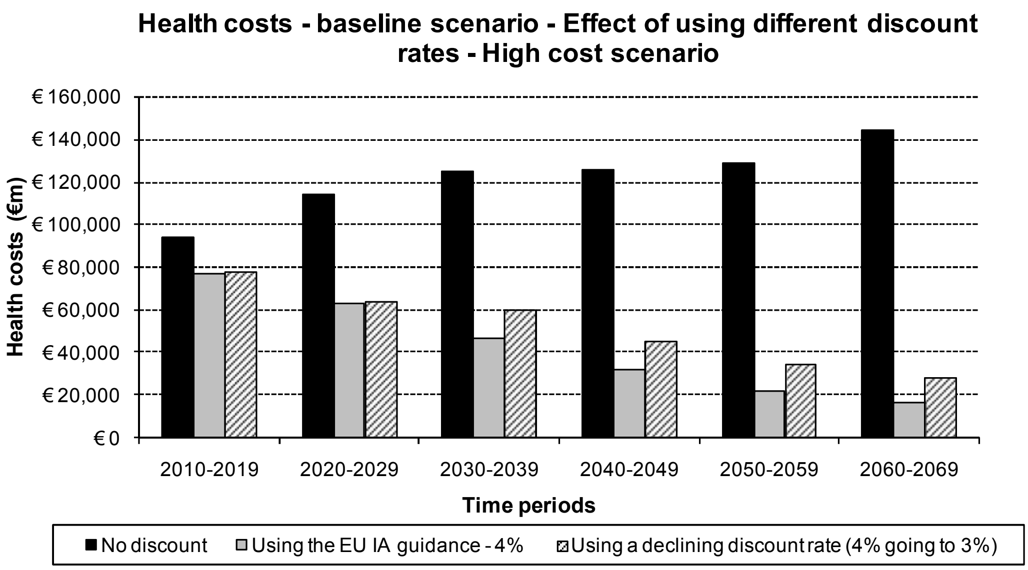


Figure 2.6 Impacts of discounting

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

In their review of occupational exposures to diesel exhaust Pronk *et al* (2009) identified the following determinants of exposure to diesel engine exhaust emissions:

- Open windows have been associated with higher exposure to vehicle operators. Windows are more likely to be open during warm weather conditions;
- Workers who work in closed cab vehicles typically have EC exposures that are lower than EC concentrations outside the cab;
- Colder weather has been associated with increased exposure to mechanics, repair shop workers, and depot workers. This has been attributed to decreased ventilation and closed doors and windows;
- Work underground has been associated with higher exposures than work above ground (the highest exposures across all industries have been reported in underground mining and tunnel construction);
- In construction work some diesel powered machinery has been associated with higher exposure levels than others (crane>generator>lift>earth mover);
- Increasing distance from the DEE source is associated with lower exposure;
- Increasing numbers of diesel sources in use in an area is associated with increasing exposure levels.

In addition to the above determinants of exposure, Groves and Cain (2000) found that poorly maintained engines and insufficient ventilation were associated with increased EC exposure.

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

A number of exposure controls for reducing occupational exposures to DEE have been described in the literature and by regulatory agencies (Dabill, 2005; Grove and Cain, 2000, HSE, 2004). The controls listed fall into three general categories: engineering controls, work practices, and respiratory protective equipment.

Engineering Controls

- Lower emission or more efficient engines (for example, engines with catalysed converters);
- Engine exhaust filters to remove particulate from exhaust;
- Regular maintenance of vehicles and regular monitoring of tailpipe emissions to assure adequately controlled emission levels;
- Use of low sulphur fuels or biodiesels - both of which have been associated with decreased particulate;
- Effective and well maintained ventilation systems in mines and tunnels;
- Effective and well maintained general ventilation in bus and railway depots, motor vehicle repair and testing facilities, and warehouses;
- Local exhaust ventilation at exhaust tailpipes in motor vehicle repair and vehicle testing facilities;
- Closed cabs for vehicle operators.

Work Practices

- Turning off the engines of vehicles that are not in use;
- Avoiding working downwind of operating diesel engines;
- Limiting the number of operating diesel engines in enclosed areas;
- Vehicles operating in mines should have the engine trailing the driver when travelling against the ventilation airflow. When travelling with the airflow drivers should have the engine leading them and avoid travelling at the same velocity as the ventilation airflow;
- Job rotation.

Respiratory Protective Equipment

- Although exposure to DEE is typically best controlled at the source, the use of respiratory protective equipment is sometimes necessary, particularly in underground work.

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

Data for the “intervention” scenario as described in Table 4.1 below were compared to the baseline trend scenario described in section 2.4.1. For DEE, an OEL of 100 µg/m^3 is to be tested. Lung and bladder cancer numbers will therefore be estimated given full compliance[12] to this OEL. Baseline for all industries assumes a 7.4% annual decline in exposure levels and standard change in employed numbers up to the 2021-30 estimation interval and constant levels thereafter.

Table 4.1 Baseline and intervention scenarios

Carcinogen Intervention scenarios[(1)]	**DEE**
Baseline (trend) scenario (1)	Linear employment and exposure level trends assumed to 2021-30, constant thereafter.
Intervention scenario (2)	Full compliance with an OEL = 100 g/m^3
Intervention scenario (3)	Full compliance with an OEL = 100 g/m^3 in the mining sector

[(1)] All intervention scenarios are estimated as change to (1) the baseline scenario

We have assessed the potential impact of introducing an OEL of 100 µg/m^3. However, because the estimated exposures are all low and it is not expect that more than 1% of workers are currently exposed above the typical OEL (i.e. our modelling assumption for full compliance) there are no predicted health benefits from introducing the limit.

[12] Full compliance is assumed in the intervention scenarios; however, due to modelling restrictions full compliance is modelled as 99% compliance.

However, the structure of the exposed sectors is rather unusual in the case of DEE since a high proportion of those assumed to be above the proposed OEL will be employed in the mining sector. It seems likely that introducing an OEL of 100 µg/m^3 in this sector would have a positive health benefit, although unfortunately from the analysis we have undertaken is not possible to quantify this impact.

4.1.2 Monetised health benefits

The available exposure data suggests that workers' DEE exposures are generally controlled well below 100 µg/m^3 elemental carbon. Although only one Member State (Austria) currently has an 8h TWA exposure limit of 100 µg/m^3 or less, it is likely that DEE exposures are maintained well below 100 µg/m^3. Given this, it is concluded – based on the exposure assessment – that there would be zero human health benefits of introducing an OEL from 2010 at 100 µg/m^3. Therefore no monetised health benefits are expected.

4.2 ECONOMIC IMPACTS

4.2.1 Operating costs and conduct of business

Compliance Costs

In Section 2.2 it was estimated that there are approximately 3.67 million people typically exposed to DEE in the EU in total (including both low and high exposure sectors). The number of workers potentially exposed to DEE (in high exposure industries) is 3.07 million. It is recognised that this estimate is an overestimate which is based on the sum of all employees in the high exposure industries. However, it is very difficult to get a better estimate due to a lack of data and furthermore, this has not been pursued further because there are not quantified benefits of the OEL at 100 µg/m^3.

In Table 2.7 it was estimated that only 2% of workers are exposed above the proposed OEL of 100 µg/m^3, many of whom will probably be in the mining sector. This percentage alongside Eurostat data on the number of enterprises has been used to estimate the number of enterprises that may be affected by the proposed OEL. This is set out below (Table 4.2).

Table 4.2 Estimates of the number of enterprises affected

Number of employees	Average number of workers per class size (rounded)	Average composition of enterprises for all affected NACE sectors with high exposure to DEE *	Number of workers potentially exposed	Estimated number of enterprises affected by band size
Between 1 and 9	5	83%	50,659	10,132
Between 10 and 19	15	7%	4,573	305
Between 20 and 49	25	5%	3,373	135
Between 50 and 250	150	3%	1,886	13
Greater than 250	500	1%	874	2
Total	-	100 %	61,365	10,586

Notes:
* - The average composition of enterprises within each category is based on Eurostat data for NACE code sectors: 10, 13, 14, 50, 60, 63.

As shown above it is estimated that around 10–11,000 enterprises could be affected by the introduction of an EU-wide OEL of 100 μg/m^3. In the absence of any further intervention, it is thought that these firms will reduce exposures over time (under the baseline it is assumed that exposures decline by 7.4% per year). The introduction of an EU-wide OEL would probably mean these enterprises requiring some form of control measures earlier than planned for.

General control measures

Measures required to control exposure to DEE vary between industrial sectors and the nature of operations conducted. There are however general controls that are applicable across sectors to reduce diesel emissions from vehicles and non-road mobile. These include:

- Fit a catalytic converter to reduce carbon monoxide, aldehydes, and hydrocarbons in diesel fumes. These devices must be used in tandem with low sulphur fuels (costs are provided below).
- Ventilate wherever diesel equipment operates indoors. The UK Health Safety Executive (HSE) recommends at least 10 air changes per hour[13]. Roof vents, open doors and windows, roof fans, or other mechanical systems can be used to move fresh air through work areas. This could be achieved by providing air-conditioned control area or refuges rather than ventilating the whole work area.
- Provide filtered air into the cabs of vehicles.
- Connect a tailpipe exhaust scavenge system during static running of vehicles and exhaust the fumes outside.

[13] UK HSE (2006) SR14: Vehicle exhaust fumes (in warehouses, garages, etc.)

- Retrofitting engines with an exhaust filtration device to capture PM before it enters the workplace.

- Regular maintenance of diesel engines to keep exhaust emissions down. Follow engine manufacturers' recommended maintenance schedule and procedures.

- Using low-sulphur diesel fuel (less than 0.05% sulphur) reduces sulphur emissions, associated odours and engine-wear maintenance costs.

- Work practices and training can help reduce exposure. For example:

  a. Turning off the engine when the vehicle is not needed.

  b. Training diesel-equipment operators to perform routine inspection and maintenance. For instance, operators should know when to change exhaust filtration devices.

Efficient ventilation and engine exhaust filters are thought to be the most common methods applied across the affected sectors to reduce the risk of exposure to DEE. It is difficult to provide costs for ventilation as it depends on the unique requirements of the workplace. For instance, bus depots and railway locomotive depots tend to use a combination of general ventilation, local exhaust ventilation and roof extraction, but many use general ventilation only.

The most common exhaust filtration devices are disposable diesel exhaust paper filters and diesel particulate ceramic filters. Diesel particulate filters (DPFs) have been fitted successfully to construction machinery for many years. Filters can be fitted to ensure that a machine's operation is unaffected and the operator's visibility is not impaired. Broad cost data for diesel particulate filters (based on EIC[14] indicative prices for fitting a DPF including installation) are shown in Table 4.3.

Table 4.3 Estimated costs per unit of diesel particulate filters (DPFs)

DPF Power band	Low (£)	High (£)
37kW to 60kW	2,875	4,910
60kW to 112kW	3,875	5,945
112kW to 165kW	4,075	7,175
165kW to 225kW	4,775	7,910
225kW to 285kW	4,875	9,630
285kW to 375kW	5,075	12,580

Source: EIC (2009)

It is noted that for the motor vehicle repair (MVR) and vehicle testing sector, whilst diesel exhaust filters are found at specialist test facilities, they are not normally found in average motor vehicle testing and MVR premises.

[14] EIC (2009) – Environmental Industries Commission – " The lowdown on diesel particulate filters" – 08th September 2009

Compliance through just improving existing work practices

It is possible that enterprises exposed above the possible OEL (around 10,600) could meet the limit through improving work practises and training alone, without additional engineering controls.

If this were the case, there are expected to be relatively low costs for enterprises to implement improved work practices and training, which in any case may be considered as ‘best practice’. There may be initial costs associated with familiarisation with new requirements but in general it is assumed that costs will range between €100-1000 per year per enterprise (including additional costs of time spent on inspection, maintenance, training and administration). Costs of the proposed OEL is summarised below in Table 4.4.

Table 4.4 Estimated cost of compliance through improving existing work practices (2010 prices)

Number of enterprises affected	Annual cost per enterprise (2010)		Total annual cost in millions (2010)		Total cost 2010-2070 in millions*	
	Low	High	Low	High	Low	High
10,586	€ 100	€ 1,000	€ 1	€ 11	€ 25	€ 249

*- Costs over time have been discounted using a 4% discount rate
Note: Costs are based on the assumption all affected enterprises can achieve compliance with the OEL through just improving existing working practices. In practice, some enterprises may require additional engineering controls, and therefore costs are likely to be an underestimate.

In the sections below, more consideration is given to specific measures required by individual sectors.

Measures specific to the mining sector (NACE Codes 10, 13, 14)

Various mine activities such as using diesel-powered equipment, blasting with explosives and the ore body itself create noxious gases (typically NO_x, SO_2, methane, CO_2 and CO) which need to be diluted. Contaminant prevention includes methods to reduce contaminants entering the mine air (e.g. general DEE reduction measures mention in the section above such as improving engine maintenance, utilising diesel exhaust filters, fitting catalytic converters and using low sulphur fuels) and also ventilation techniques.

Mine ventilation systems have been designed, built and installed for many years. The technology is well documented; textbooks and handbooks are readily available (Hartman *et al*, 1997). Mines rely on a combination of natural ventilation and strategically placed auxiliary fans (NIOSH, 2002). Natural ventilation is created by difference in densities of air columns between the ambient outside air and mine air. However, given that these densities are temperature dependent, natural ventilation changes frequently. As a result, natural ventilation alone is unreliable and needs to be supplemented. The main components of an auxiliary mine ventilation system are:

- Power Supply
- Motor

- Coupling
- Fans
- Flow Control Devices
- Ducts, Passageways and other System Hardware
- Construction (Papar *et al*, 1999)

While the main fan, or combination of main fans, handles all of the air that circulates through the underground network of airways, underground booster fans serve specific areas only. The distribution of airflow may further be controlled by ventilation doors, stoppings, air crossings and regulators (McPherson, 1993).

The largest component of the operating cost for mine ventilation is electricity to power the ventilation fans, which may account for one third of a typical underground mine's entire electrical power cost.

EU legislation does not contain a general regulation of mining as such, nor on mining safety. Instead each Member State has specific legislation to govern mining safety standards. For instance, in the UK, the Coal Mines (Control of Inhalable Dust) Regulations were introduced in 2007. In general, however, ventilation is incorporated as an integral part of planning a mine. A mine may take years to be fully developed but the mine ventilation system is usually designed, built and installed up-front (Papar *et al*, 1999). Ventilation may be improved through appropriate fan selection and operation used in conjunction with air coursing using manmade and in-situ rock stoppings (NIOSH, 2002). However, the design of a major underground ventilation system is a complex process with many interacting features and components (McPherson, 1993). This makes it difficult to estimate the cost of either a new ventilation system or making potential upgrades to an existing system. Therefore, no quantitative estimate has been derived.

<u>Measures specific to construction</u>

The Non-Road Mobile Machinery Exhausts Emissions Directive includes construction machinery. The Directive is intended ultimately to cover almost all engines used for mobile applications that are not subject to vehicle approval requirements. Implementation is staggered. Stage I was implemented in 1999. Stage IIIB was implemented at the beginning of 2011 and continues until 2013. Depending on the engine power the reduction in particulate matter (PM) is about 90% or more compared to Stage IIIA and will require a DPF (see Table 4.5 and Table 4.6).

Table 4.5 Stage III A standards for non-road mobile machinery

Category	Net power (kW)	Date (placing on the market)	CO (g/kWh)	NOx + HC (g/kWh)	PM (g/kWh)
H	130 < P <560	01/ 2006	3.5	4.0	0.2
I	75 < P <130	01/ 2006	5.0	4.0	0.3
J	37 < P < 75	01/ 2006	5.0	4.7	0.4
K	19 < P < 37	01/ 2006	5.5	7.5	0.6

Table 4.6 Stage III B standards for non-road mobile machinery

Category	Net power (kW)	Date (placing on the market)	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)
L	130 < P <560	01/ 2011	3.5	0.19	2.0	0.025
M	75 < P <130	01/ 2011	5.0	0.19	3.3	0.025
N	37 < P < 75	01/ 2011	5.0	0.19	3.3	0.025
P	19 < P < 37	01/ 2011	5.0	4.7		0.025

Construction workers can be exposed to diesel exhaust as they operate or work around equipment including generators, rough-terrain forklifts, compressors, concrete trucks, packers, bobcats, cranes, front-end loaders, powered elevating work platforms and welding machines. Although every construction site is unique, some common actions can be taken to reduce exposure to diesel exhaust[15]. For instance, using enclosed, climate-controlled cabs pressurized and equipped with high efficiency particulate air (HEPA) filters to reduce operators' exposure to diesel fumes.

Potential for closure for companies

Only 2% of workers exposed to DEE (in high exposure sectors) are estimated to be exposed above the most commonly adopted OEL of 100 µg/m^3. Therefore there is unlikely to be any significant change in risks of closures. If compliance with the possible OEL can be achieved just by improving existing work practices, then the cost of compliance per enterprise (€100-1000) is not thought to be prohibitive. If specific engineering control measures are required then the costs of compliance is likely to be higher which may be of more concern to SMEs. However it is not known to what extent these costs can be passed on to customers through the service they provide.

Potential impacts for specific types of companies

Only 2% of workers exposed to DEE (in high exposure sectors) are estimated to be exposed above the most commonly adopted OEL of 100 µg/m^3. The majority of the sector is therefore unaffected by the introduction of an EU wide OEL. However, having an EU-wide OEL would remove any EU competitive distortions between EU Member States.

The sectors affected are predominately made up of SMEs so compliance with 'best practice' is likely to be more difficult to enforce. If compliance with the OEL can be achieved by just improving existing work practices, then the cost of compliance per enterprise (€100-1000) is not thought to be prohibitive, and many SMEs may already have many of the measures in place (in full or partially).

[15] Sahai (2002) Diesel Exhaust

Administrative costs to employers and public authorities

The following table (Table 4.7) describes the administrative burden to employers by the substance being included on the Carcinogens Directive.

Table 4.7 Administrative burdens to employers

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Familiarisation costs with the Directive and requirements for full compliance	-	Individual(s) responsible for health and safety and training will need to familiarise themselves with the requirements of the Directive. This is largely a one-off cost with some periodic costs for training of new trainers.	Low
2. Time for R&D and exploration of suitable alternatives to reduce and replace use of the substance so far as technically feasible 3. Document findings	4 – Reduction and replacement	Largely one-off cost but findings may need to be updated annually. Many large size firms are likely to already be investing in R&D and alternatives. As part of the CLP Regulation (EC) No 1272/2008 and Chemicals Agents Directive (CAD) risks must be eliminated or reduced to a minimum. Substitution is preferred and, if that isn't possible, there is a hierarchy of controls (e.g. workplace changes, general protective equipment, PPE, etc).	Low
4. Change in practice to use of closed systems when using the substance.	5 – Prevention and reduction of exposure	These costs are already estimated in the cost of compliance section. This will only affect those firms that do not have or use closed systems	Estimated elsewhere

Type of administrative cost	Relevant article(s)	Type of cost	Significance
5. Upon request, employers will need make information available to competent authorities on activities/processes carried out and why the substance is used, quantities used, number of workers exposed and protective measures and equipment used to reduce exposure	6 – Information for the competent authority	As this information is only required upon request (with the frequency of requests unknown), the administrative costs are likely to be low given much of this information should be readily available to the firms concerned.	Low
6. Develop/update health and safety and best practice guidance for: o Minimising use and exposure to workers to the substance o Redesign work processes and engineering controls to avoid/minimise release of carcinogens or mutagens o Hygiene measures, in particular regular cleaning of floors, walls and other surfaces o Information for workers o Warnings and safety signs o Drawing up plans to deal with emergencies likely to result in abnormally high exposure	5 – Prevention and reduction of exposure 7 – Unforeseen exposure 8 – Foreseeable exposure 9 – Access to risk areas 10 – Hygiene and individual protection	Some firms may only incur a one-off cost from updating existing guidance and training material. Some firms may need to redesign work practices to minimise exposure to workers and the number of workers exposed. The costs of implementing controls on exposure (such as LEV or PPE) are already estimated in the costs of compliance section. Firms should already be doing many of these good practices as part of the CLP Regulation and the CAD.	Low-Medium
7. Additional costs of training new and existing staff in line with requirements of the Directive 8. Additional costs of making information available to employees 9. Consultation with employees on compliance with the Directive	11 – Information and training of workers 12 – Information for workers 13 – Consultation and participation with workers	Largely one-off cost but training may need to be repeated periodically if necessary. Periodic training should typically be carried out as best practice so largely one-off cost of updating training material.	Low/medium

Type of administrative cost	Relevant article(s)	Type of cost	Significance
9. Record keeping for 40 years of list of workers engaged in activities where they are exposed to the substance and individual medical records when health surveillance is carried out.	15 – Record keeping Reference to 12(c) and 14(4)	Likely to be a small annual cost to ensure personnel files are kept up to date and information is correctly stored.	Low

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

The following table (Table 4.8) describes the administrative burden to competent authorities by the substance being included on the Carcinogens Directive.

Table 4.8 Administrative burdens to Competent Authorities

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Familiarisation costs with the Directive and requirements for full compliance	-	Individual(s) responsible will need to familiarise themselves with the requirements of the directive. This is largely a one-off cost with some periodic costs for new/replacement staff.	Low
2. Establishing, in accordance with national laws and/or practice, arrangements for carrying out relevant health surveillance of workers for whom the results of the assessment referred to in Article 3(2) reveal a risk to health or safety.	14 – Health Surveillance	The annual costs will depend on the number visits undertaken.	Low – High
3. Communication with the Commission on provisions in national law to enforce the Directive. 4. Time and costs of implementing Directive into national law (consultation process)	19 – Notifying the commission 20 – Repeal	Largely one-off cost of transposing the Directive into national law	Medium (one-off cost)

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

Third countries

Only 2% of workers exposed to DEE (to some level) are estimated to be exposed above the most commonly adopted OEL of 100 μg/m^3. Therefore there is unlikely to be any significant change in impacts for third countries from the introduction of an EU-wide OEL.

If compliance with the OEL can be achieved by just improving existing work practices, then the cost of compliance per enterprise (€100-1000) is not thought to be prohibitive and there would not expected to be any significant impacts to third countries compared to those that might occur under the baseline scenario. If specific engineering control measures are required then the cost of compliance is likely to be higher and there may be some impacts at a firm level, especially for SMEs. However, there are not expected to be significantly impacts on third countries given the small number of enterprises affected.

4.2.2 Impact on innovation and research

Given that industry is predominately made up of smaller companies it is considered likely that these companies would tend to adopt products and compliance techniques that are already being applied within other parts of the industry.

Furthermore, given that no health benefits are predicted from the introduction of an EU-wide OEL at 100 μg/m^3, it is considered unlikely that this would stimulate further R&D in reducing risks of exposure from DEEs.

4.2.3 Macroeconomic impact

Since there are not expected to be any significant economic or health impacts, there is not expected to be any significant change in macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL at 100 μg/m^3. However, job patterns may be altered as it is recognised that in order to meet best practice, behavioural change amongst employees and updating health and safety training would be required.

4.3.2 Changes in end products

There are not expected to be any noticeable changes to the end products since control measures are not expected to change the characteristics of the products that DEE are used to manufacture. Since there is not expected to be any closure of companies, there should not be any change in supply of products relative to the baseline scenario.

4.4 ENVIRONMENTAL IMPACTS

Only 2% of workers exposed to DEE (to some level) are estimated to be exposed above the most commonly adopted OEL of 100 µg/m^3 and therefore most workplaces are unlikely to be affected.

However, where there is a need to reduce exposure to DEE earlier than otherwise might have been planned, this may have environmental benefits. Improvements to engines, proper maintenance and use of diesel particulate filters will have environmental benefits through reductions in emissions of PM in particular. Additionally, improvements in working practices (i.e. reduced exposure of the public by not having engines running when not in use) should also lead to reduced emissions to the environment (air).

5 COMPARISON OF OPTIONS

The main impacts discussed in more detail in section 4 are summarised in the tables below, which are broken down by the main types of impacts (health, economic, social, macroeconomic and environmental).

Table 5.1 Comparison of health impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		**Intervention scenario (2) – Assumes full compliance for OEL = 100 µg/m^3**	
Health Costs	**Health Benefits**	**Health Costs**	**Health Benefits**
As set out in section 2.5, the health costs of cancer (bladder and lung) over the period 2010-70 are estimated to be: - Females: €7bn to €14bn - Males: €91bn to €244bn - Total: €99bn to €258bn This range takes into consideration tangible costs (e.g. lost income, lost output from reduced productivity, medical costs, life years lost) and intangible costs (e.g. emotional and physical suffering from having cancer).	It is assumed that exposures fall by 7.9% per year in the future, continuing the historical trend in reduced exposure. Therefore there is expected to be some reduction in health costs going forward in the absence of further regulatory intervention	None There are not expected to be any costs in addition to those being incurred under the baseline scenario	None Only 2% of workers exposed to DEE (to some level) are estimated to be exposed above the most commonly adopted OEL of 100 µg/m^3. Factoring in a declining exposure under the baseline, there is not expected to be any further reduction in cancer registrations or life years lost and therefore no cost saving e.g. from avoided health care and reduced cost of illness.

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.2 Comparison of economic impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 100 µg/m^3	
Economic Costs	**Economic Benefits**	**Economic Costs**	**Economic Benefits**
There are expected to be costs to sectors exposed to DEE due to expected further spending on control measures to reduce exposure. These costs might relate to improving working practice or installation and use of engineering control measures (e.g. filters, closed systems, improved ventilation).	-	It is estimated that around 10,600 enterprises could be affected by the introduction of an EU-wide OEL of 100 µg/m^3. This might mean these enterprises requiring some form of control measures earlier than planned for without intervention. If compliance with the OEL can be achieved for just improving existing work practices, then the annual cost of compliance per enterprise (€100-1000) is not thought to be prohibitive. This is approximately €11-249m for all enterprises over the period 2010-2070. However, if specific engineering control measures are required then the cost of compliance is likely to be higher which may be of more concern to SMEs. However it is not known to what extent these costs can be passed on to customers through the service they provide.	Having an EU-wide OEL would avoid any EU competitive distortions between EU Member States if they adopted different national limits in the future.

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.3 Comparison of social impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 100 µg/m³	
Social Costs	**Social Benefits**	**Social Costs**	**Social Benefits**
There are not expected to be any noticeable social impacts under the baseline scenario at an EU level.		There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL. However, job patterns may be altered as it is recognised that in order to meet best practice, behavioural change amongst employees and updating health and safety training will be required.	

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.4 Comparison of macro-economic impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 100 µg/m³	
Marco-economic Costs	**Marco-economic Benefits**	**Marco-economic Costs**	**Marco-economic Benefits**
There are not expected to be any noticeable macroeconomic impacts under the baseline scenario.		Since there are not expected to be any significant economic or health impacts, there is not expected to be any significant change in macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.	

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

Table 5.5 Comparison of environmental impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 100 µg/m^3	
Environmental Costs	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**
Only 2% of workers exposed to DEE (to some level) are estimated to be exposed above the most commonly adopted OEL of 100 µg/m^3 and therefore most workplaces are unlikely to be affected/require further changes to their existing working practice. Therefore there are not estimated to be any significant changes in environmental impacts.		Where there is a need to reduce exposure to DEE earlier than otherwise might have been planned, this may have environmental benefits. Improvements to engines and proper maintenance and use of diesel particulate filters will have environmental benefits through reductions in emissions of PM in particular. Additionally, improvements in working practices (e.g. reduced exposure to the general public through not having engines running when not in use) should also lead to reduced emissions to the environment (air).	

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

6 CONCLUSIONS

This report has considers the likely health, socioeconomic and environmental impacts associated with possible changes to the Carcinogens Directive, in particular the possible introduction of an occupational exposure limit (OEL) of 100 $\mu g/m^3$ for DEE measured as elemental carbon (EC).

The sources of occupational exposure to DEE include motor vehicles, locomotives and diesel powered heavy equipment such as tractors and forklifts. Workers may either be exposed because they operate equipment that has a diesel engine or because their work takes them into environments where diesel engines are operating. DEE makes up an important part of the particulate air pollution found in European cities and towns. A large proportion of the working population are exposed to DEE and so this is an important potential risk factor for occupational cancer.

It is estimated that there are 3.6 million workers in the EU potentially exposed to DEE above background levels. In general, exposures are relatively low. The overall distribution of exposure levels across all industries in the EU gave an estimated geometric mean of 13 $\mu g/m^3$ with a geometric standard deviation of 2.7. The percentage of workers who may be exposed above the typical OEL (100 $\mu g/m^3$) was estimated between 0.1% and 3% in sectors other than mining, and between 10% and 54% in underground mining.

Over about the last 20 years EU legislation has required engine manufacturers to reduce emissions from vehicles and, for example, the permitted particulate emissions from trucks and lorries will decreased by a factor of more than 50 times between 1992 and 2013. Despite the increase in the proportion of diesel vehicles in the EU the exposure to DEE has probably been decreasing (we assume 7.4% decline per annum). Note this figure broadly agrees with a separate assessment of the decline of particulate air pollution levels in European cities.

From a review of the epidemiological literature carried out in 2001 a relative risk (RR) of 1.24 was identified for bladder cancer incidence amongst high exposed work groups and 1.03 for low exposed workers. A pooled RR estimate for lung cancer was identified for high exposed workers from a review where the data were adjusted for smoking habits (RR=1.47) and for low exposed workers of 1.09. The RR for background-exposed workers was set to 1.

The number of people that are estimated to ever be exposed to DEE is projected to increase from about 12 million in 2010 to almost 20 million in 2060. This trend, in addition to the increased number of cancers that are expected to occur in the general population because of increasing life expectancy tends to reduce the impact of reductions in the level of exposure. In 2010 it is estimated that in the EU there will be 4,698 incident cases of lung cancer (4,242 deaths) and 1,031 cases of bladder cancer (314 deaths) from past exposure to DEE. Over the following fifty years the annual number of attributable cases of lung cancer is estimated to decrease to 2,643 (2,594 deaths) and bladder cancer to 415 cases (168 deaths). Annual DALYs for lung cancer decrease from 67,064 to 33,766 years and from 4,704 to 2,023 years for bladder cancer. Total estimated health costs associated with inaction for the period up to 2069 range from €99,084m to €258,020m.

Current exposures in the EU are judged to be mostly below 100 $\mu g/m^3$ and so there are no predicted health benefits and no important costs associated with compliance with the suggested OEL (between €25m and €249m). There are also no social or macro-economic costs associated with introducing an OEL at this level.

To have an effect on the expected number of lung and bladder cancers the OEL would need to be much lower than is typically set in the EU (i.e. less than 100 $\mu g/m^3$) and the approach to controlling exposures more extensive. It would probably be necessary to make greater use of air-conditioned cabs in vehicles or ventilation in workplaces, and to consider the use of personal respiratory protection where other means of control were impracticable or uneconomic.

It is likely that there would be a positive health impact from introducing an OEL of 100 $\mu g/m^3$ in the mining sector, although it has not been possible of us to quantify the effect from the present analysis.

There are no significant environmental impacts foreseen from introducing an OEL at 100 $\mu g/m^3$.

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8 APPENDIX

8.1 ESTIMATED NUMBER OF EMPLOYEES IN EACH INDUSTRY GROUP – MEMBER STATE BREAKDOWN – MALES AND FEMALES

Table 8.1.1 Number of workers exposed to diesel engine exhaust emissions by Member State and NACE code – male sand females

	NACE Code														
		5			10			11			13			14	
	Total	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**	**Males**	**Females**	**Total**	**Males**	**Females**
Austria		Not Available[1]		20	20	1		Not Available			Not Available		1803	1748	54
Belgium	7269	4943	2326		Not Available			Not Available			Not Available			Not Available	
Bulgaria		Not Available		2488	2139	348	20	18	3	3518	3025	492	2797	2406	392
Cyprus	1870	1870	0	0	0	0	0	0	0	0	0	0	221	221	0
Czech Republic		Not Available		5310	4938	372		Not Available		16	15	1	2461	2288	172
Denmark	190	185	6		Not Available			Not Available		0	0	0	487	385	102
Estonia		Not Available			Not Available			Not Available		0	0	0	324	301	23
Finland		Not Available		0	0	0	0	0	0	209	200	8	578	555	23
France	2873	2643	230	571	479	91	94	79	15	188	158	30	10648	8945	1704
Germany		Not Available		7445	6775	670	255	232	23	0	0	0	13297	12100	1197
Greece	157	132	25		Not Available			Not Available		393	381	12	2313	2243	69
Hungary		Not Available		46	44	2	44	42	2		Not Available		1676	1592	84
Ireland		Not Available			Not Available			Not Available			Not Available		1369	1314	55
Italy	3026	2754	272	0	0	0	1663	1530	133		Not Available			Not Available	
Latvia	34	32	2	328	259	69	0	0	0	0	0	0	300	237	63
Lithuania		Not Available		218	185	33	20	17	3	0	0	0	620	527	93
Luxembourg		Not Available		0	0	0	0	0	0	0	0	0	125	125	0
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	
Netherlands		Not Available		7	6	1	229	192	37	0	0	0	814	684	130
Poland		Not Available		23033	21190	1843	101	93	8		Not Available			Not Available	
Portugal	566	526	40	0	0	0	0	0	0	573	556	17	5231	5074	157
Romania	874	734	140	3491	3072	419	2835	2495	340	4740	4171	569	4179	3677	501

	NACE Code														
		5			10			11			13			14	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Slovakia		Not Available		914	887	27	46	45	1		Not Available		914	886	27
Slovenia		Not Available			Not Available			Not Available			Not Available			Not Available	
Spain	0	0	0	4390	4171	220	0	0	0	257	244	13	9189	8729	459
Sweden		Not Available		113	100	12	0	0	0	2865	2550	315	1001	891	110
United Kingdom		Not Available		1019	897	122	1274	1121	153	0	0	0	11377	10012	1365
TOTAL	**16858**	**13818**	**3040**	**49393**	**44493**	**4900**	**6583**	**5841**	**741**	**12759**	**11301**	**1458**	**71724**	**63746**	**7978**

[1] Indicates that the number of employee data were not available on the Eurostat database

	NACE Code														
		15			16			17			18			19	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	987	799	187		Not Available		15	12	3	24	19	5	5	4	1
Belgium	1251	1014	238	2	2	0	31	25	6	22	18	4	2	1	0
Bulgaria	1425	741	684	6	3	3	34	18	16	420	218	201	22	11	10
Cyprus	165	124	41	0	0	0	1	0	0	4	3	1	0	0	0
Czech Republic		Not Available			Not Available		46	30	16	101	65	35	11	7	4
Denmark		Not Available			Not Available		6	4	2	7	5	2		Not Available	
Estonia	223	123	100	0	0	0	9	5	4	32	18	14	2	1	1
Finland	480	355	125	0	0	0	0	0	0	0	0	0	0	0	0
France	8439	6498	1941	4	3	1	77	59	18	202	156	46	31	24	7
Germany	10682	8225	2457	12	9	3	102	78	23	164	126	38	20	16	5
Greece	1115	847	268	3	2	1	19	14	4	112	85	27	6	4	1
Hungary	1584	998	586	2	1	1	20	12	7	116	73	43	14	9	5
Ireland	643	482	161	1	1	0	3	2	1	4	3	1	0	0	0
Italy	10029	7522	2507	18	14	5	1030	772	257	1927	1446	482	722	541	180
Latvia	457	265	192	0	0	0	8	4	3	39	23	16	1	0	0
Lithuania	668	347	321		Not Available		18	9	9	97	50	46	2	1	1
Luxembourg		Not Available			Not Available			Not Available			Not Available		0	0	0
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	

	NACE Code														
		15			16			17			18			19	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Netherlands	1650	1353	297	4	4	1	14	12	3	12	10	2	2	2	0
Poland	5824	3902	1922	7	5	2	83	56	28	460	308	152	37	25	12
Portugal	1392	821	571	1	1	0	76	45	31	334	197	137	62	37	26
Romania	2676	1445	1231	2	1	1	71	38	33	772	417	355	97	52	45
Slovakia	610	391	220		Not Available		14	9	5	73	46	26	17	11	6
Slovenia	253	167	86		Not Available		10	7	3	32	21	11	6	4	2
Spain	1404	1095	309	0	0	0	0	0	0	0	0	0	0	0	0
Sweden		Not Available			Not Available		7	6	2	5	4	1	1	1	0
United Kingdom	5727	4639	1088	5	4	1	78	63	15	113	92	22	11	9	2
TOTAL	**57684**	**40016**	**17668**	**67**	**46**	**21**	**1771**	**1262**	**509**	**5072**	**3371**	**1701**	**1070**	**757**	**314**

	NACE Code														
		20			21			22			24			26	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	887	719	169	176	143	34	51	42	10	133	108	25	1557	1261	296
Belgium	318	258	60	142	115	27	69	56	13	345	280	66	1419	1149	270
Bulgaria	460	239	221	110	57	53	34	18	16	128	67	62	1291	671	620
Cyprus	72	54	18	8	6	2	5	4	1	9	7	2	148	111	37
Czech Republic	1689	1098	591	200	130	70	89	58	31	205	133	72	3382	2198	1184
Denmark	346	253	93	75	55	20	73	53	20	147	108	40	796	581	215
Estonia	446	245	201	19	10	8	13	7	6	15	8	7	253	139	114
Finland	284	210	74	318	235	83	167	124	43	18	13	5	51	38	13
France	2004	1543	461	785	604	180	378	291	87	1358	1045	312	6089	4689	1401
Germany	3294	2536	758	1436	1106	330	727	560	167	2260	1741	520	10637	8190	2446
Greece	334	253	80	75	57	18	57	43	14	90	68	22	1126	856	270
Hungary	620	391	229	172	108	64	68	43	25	158	100	58	1261	795	467
Ireland	161	121	40	34	25	8	31	23	8	122	92	31	481	361	120
Italy	8030	6022	2007	663	497	166	281	211	70	2347	1760	587	29705	22279	7426

	NACE Code														
		20			21			22			24			26	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Latvia	739	429	310	16	9	7	19	11	8	22	13	9	279	162	117
Lithuania	761	396	365	23	12	11	24	13	12	30	16	15	525	273	252
Luxembourg	14	12	2		Not Available			Not Available		5	5	1	129	112	17
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	
Netherlands	458	376	83	217	178	39	161	132	29	315	258	57	1288	1056	232
Poland	3169	2123	1046	442	296	146	194	130	64	533	357	176	6210	4161	2049
Portugal	1072	632	439	120	71	49	73	43	30	106	63	43	2655	1567	1089
Romania	1856	1002	854	163	88	75	74	40	34	241	130	111	2657	1435	1222
Slovakia	339	217	122	76	49	27	22	14	8	63	41	23	924	591	333
Slovenia	278	184	95	53	35	18	19	13	7	69	46	23	424	280	144
Spain	1229	959	270	563	439	124	0	0	0	365	285	80	1559	1216	343
Sweden	977	762	215	411	320	90	100	78	22	215	168	47	894	697	197
United Kingdom	1964	1591	373	735	596	140	659	534	125	1058	857	201	4957	4015	942
TOTAL	**31800**	**21965**	**9835**	**7031**	**4955**	**2076**	**3389**	**2393**	**995**	**10358**	**7313**	**3045**	**80699**	**56757**	**23942**

	NACE Code														
		27			28			29			30			33	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	497	403	94	717	581	136	326	264	62	29	23	5	16	13	3
Belgium	507	411	96	679	550	129	175	142	33	22	18	4	8	7	2
Bulgaria	337	175	162	417	217	200	281	146	135	54	28	26	7	4	3
Cyprus	5	4	1	38	29	10	4	3	1	0	0	0	0	0	0
Czech Republic	863	561	302	1671	1086	585	653	424	229	269	175	94	36	24	13
Denmark	81	59	22	474	346	128	251	183	68	28	20	7	18	13	5
Estonia	6	3	3	129	71	58	22	12	10	7	4	3	2	1	1
Finland	91	68	24	92	68	24	175	130	46	22	16	6	0	0	0
France	1500	1155	345	4294	3307	988	1223	942	281	204	157	47	137	105	31
Germany	3865	2976	889	7889	6075	1815	4226	3254	972	1019	785	234	327	252	75

	NACE Code														
		27			28			29			30			33	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Greece	206	157	50	403	306	97	91	69	22	22	17	5	2	2	1
Hungary	288	181	107	746	470	276	275	173	102	232	146	86	20	13	7
Ireland	37	28	9	131	98	33	46	35	12	334	251	84	26	19	6
Italy	4604	3453	1151	17125	12844	4281	3461	2596	865	43	32	11	238	179	60
Latvia	54	31	23	97	56	41	29	17	12	4	3	2	2	1	1
Lithuania	14	7	7	184	96	88	44	23	21	11	5	5	4	2	2
Luxembourg	91	79	12	43	37	6	10	8	1	0	0	0	2	2	0
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	
Netherlands	314	258	57	985	808	177	358	294	64	136	112	25	26	21	5
Poland	1080	724	357	2778	1861	917	829	556	274	168	112	55	51	34	17
Portugal	145	85	59	882	521	362	191	112	78	22	13	9	7	4	3
Romania	911	492	419	1028	555	473	413	223	190	112	60	51	16	8	7
Slovakia	398	255	143	345	221	124	181	116	65	38	24	14	7	5	3
Slovenia	137	90	46	341	225	116	109	72	37	19	13	7	7	5	2
Spain	560	436	123	864	674	190	697	544	153	9	7	2	0	0	0
Sweden	703	548	155	851	664	187	469	366	103	111	87	25	27	21	6
United Kingdom	1097	889	208	3326	2694	632	1112	901	211	657	532	125	111	90	21
TOTAL	**18392**	**12756**	**5636**	**46532**	**32882**	**13650**	**15652**	**10759**	**4893**	**3573**	**2437**	**1136**	**1098**	**759**	**339**

	NACE Code														
		35			36			40			41			45	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	102	83	19	44	35	8	288	250	37	99	86	13	10860	10317	543
Belgium	85	69	16	24	19	4	166	145	22	228	198	30	11302	10963	339
Bulgaria	102	53	49	34	18	16	384	334	50	678	589	88	7967	7569	398
Cyprus	1	1	0	2	2	1		Not Available			Not Available		1481	1422	59
Czech Republic	196	127	69	67	43	23	371	315	56	738	627	111	16907	15724	1183
Denmark	71	52	19	26	19	7	138	110	28	122	97	24	8724	8200	523

	NACE Code														
		35			36			40			41			45	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Estonia	26	14	12	12	6	5	67	60	7	59	53	6	2151	1957	194
Finland	15	11	4	0	0	0	0	0	0	0	0	0	2315	2199	116
France	1336	1029	307	141	109	32	1599	1232	368	1301	1002	299	71016	68176	2841
Germany	1255	966	289	230	177	53	2347	2042	305	1536	1337	200	64447	61224	3222
Greece	126	96	30		Not Available			Not Available			Not Available		13317	13051	266
Hungary	73	46	27	31	19	11	329	276	53	786	660	126	10318	10008	310
Ireland	34	26	9		Not Available			Not Available		0	0	0	3117	3086	31
Italy	878	659	220	1122	841	280	2588	2252	336	2879	2505	374	172682	167502	5180
Latvia	49	28	21	14	8	6	131	106	25	74	60	14	3146	2926	220
Lithuania	65	34	31	28	15	14	194	149	45	223	172	51	5368	5046	322
Luxembourg		Not Available		0	0	0	9	9	1	4	4	0	1536	1521	15
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	
Netherlands	226	186	41	37	30	7	192	154	38	179	143	36	20691	19863	828
Poland	640	429	211	204	137	67	1569	1334	235	1754	1491	263	30112	28908	1204
Portugal	96	56	39	57	34	23	105	92	14	493	429	64	21230	21018	212
Romania	543	293	250	106	57	49	960	797	163	1309	1086	222	18379	16908	1470
Slovakia	66	42	24	17	11	6	259	220	39	477	406	72	3101	2977	124
Slovenia	24	16	8	15	10	5	77	65	12	148	124	24	3085	2931	154
Spain	290	226	64	0	0	0	0	0	0	0	0	0	50915	49387	1527
Sweden	200	156	44	47	37	10	292	233	58	40	32	8	11676	11209	467
United Kingdom	1325	1073	252	167	135	32	1106	940	166	964	819	145	59919	58121	1798
TOTAL	**7823**	**5519**	**2304**	**2424**	**1717**	**708**	**13171**	**10621**	**2550**	**14092**	**11599**	**2492**	**625761**	**595123**	**30638**

	NACE Code														
		50			51			52			55			60	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	9889	6131	3758	602	373	229	985	611	374	728	451	277	34407	28214	6193
Belgium	9065	6799	2266	688	516	172	896	672	224	498	373	124	27126	23871	3255
Bulgaria	5767	5190	577	442	398	44	750	675	75	345	310	34	26725	24320	2405
Cyprus	1016	823	193	60	49	11	103	84	20	116	94	22	1356	1058	298
Czech Republic	10291	7204	3087	724	507	217	1080	756	324	475	333	143	60072	49860	10212
Denmark	7018	5474	1544	520	406	114	661	516	145	314	245	69	22248	18021	4227
Estonia	1405	885	520	123	77	45	135	85	50	56	35	21	6578	5065	1513
Finland	3669	2348	1321	0	0	0	0	0	0	0	0	0	22456	18189	4267
France	50871	35609	15261	3255	2278	976	5329	3730	1599	2746	1922	824	208328	164579	43749
Germany	81230	50363	30868	3852	2388	1464	8305	5149	3156	3947	2447	1500	191645	164815	26830
Greece	12090	9551	2539	1016	803	213	1556	1229	327	911	720	191	36235	33336	2899
Hungary	9108	3279	5829	509	183	326	995	358	637	381	137	244	46541	41422	5120
Ireland	4659	3681	978	263	208	55	565	446	119	422	333	89	8644	7866	778
Italy	39110	29333	9778	3233	2425	808	5354	4015	1338	3346	2510	837	128316	109068	19247
Latvia	2429	1190	1239	166	81	85	312	153	159	92	45	47	13621	10761	2860
Lithuania	5203	3226	1977	236	146	90	430	267	164	116	72	44	18597	15250	3347
Luxembourg	932	699	233	44	33	11	61	45	15	46	35	12	3700	3256	444
Malta		Not Available			Not Available			Not Available			Not Available			Not Available	
Netherlands	16980	12056	4924	1438	1021	417	2253	1599	653	1035	735	300	55877	47496	8382
Poland	29979	20686	9294	2182	1506	676	3727	2571	1155	694	479	215	139832	123052	16780
Portugal	14634	6878	7756	879	413	466	1315	618	697	828	389	439	29927	26335	3591
Romania	12326	8259	4068	1063	712	351	1504	1007	496	364	244	120	59392	52265	7127
Slovakia	1853	1242	612	266	178	88	258	173	85	65	44	21	17629	15161	2468
Slovenia	1803	1118	685	131	81	50	159	98	60	96	60	36	9144	7864	1280
Spain	66708	48697	18011	5847	4268	1579	8887	6488	2400	6297	4597	1700	181519	157922	23598
Sweden	9695	7756	1939	694	556	139	846	677	169	373	298	75	38790	32583	6206
United Kingdom	68059	49002	19056	3567	2569	999	8858	6378	2480	5780	4161	1618	161123	141788	19335
TOTAL	**475789**	**301484**	**174306**	**31802**	**20943**	**10858**	**55323**	**35744**	**19579**	**30069**	**19805**	**10264**	**1549828**	**1271671**	**278156**

	NACE Code														
		61			62			63			64			75	
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	101	82	18	233	191	42	6360	5215	1145	339	278	61	759	478	281
Belgium	397	350	48	139	123	17	5710	5025	685	534	470	64	1267	798	469
Bulgaria	1257	1144	113	62	56	6	4437	4038	399	315	287	28	674	485	189
Cyprus	1115	870	245	57	44	12	781	609	172	29	23	6	90	60	30
Czech Republic	171	142	29		Not Available		4691	3893	797	500	415	85	977	518	459
Denmark	3418	2768	649	141	114	27	3716	3010	706	392	317	74	500	275	225
Estonia	247	190	57	18	14	4	1248	961	287	56	43	13	117	46	71
Finland	2000	1620	380	0	0	0	2077	1682	395	250	202	47	229	110	119
France	3919	3096	823	1810	1430	380	30570	24150	6420	2962	2340	622	7221	3611	3611
Germany	7655	6583	1072	1389	1194	194	56807	48854	7953	4540	3905	636	8630	4142	4487
Greece	4159	3826	333	95	87	8	4593	4226	367	282	259	23	1142	776	365
Hungary	282	251	31	67	59	7	3519	3132	387	431	384	47	858	420	437
Ireland		Not Available			Not Available		2247	2045	202	196	178	18	314	217	97
Italy	4499	3824	675	1731	1471	260	28796	24477	4319	4086	3473	613	9238	6190	3049
Latvia	170	134	36	28	22	6	1861	1470	391	104	82	22	264	132	132
Lithuania	402	330	72	21	17	4	1745	1431	314	115	94	21	227	120	107
Luxembourg	35	31	4	94	83	11	300	264	36	31	27	4	67	50	17
Malta		Not Available			Not Available			Not Available			Not Available		42	25	17
Netherlands		Not Available			Not Available		10064	8554	1510	863	733	129	1692	1032	660
Poland	929	818	112	139	122	17	8648	7610	1038	1196	1052	144	2752	1459	1293
Portugal	547	482	66	243	214	29	4347	3825	522	232	204	28	1063	691	372
Romania	906	797	109	88	78	11	7677	6755	921	610	536	73	1456	888	568
Slovakia	175	151	25	20	18	3	1223	1052	171	193	166	27	486	238	248
Slovenia	60	51	8	17	14	2	992	853	139	87	75	12	171	94	77
Spain	1886	1640	245	0	0	0	41792	36359	5433	0	0	0	2199	1231	967
Sweden	3537	2971	566	187	157	30	6639	5576	1062	578	486	93	757	356	401
United Kingdom	3667	3227	440	2253	1983	270	42164	37104	5060	3327	2928	399	6116	3364	2752
TOTAL	**41533**	**33311**	**8221**	**8831**	**7116**	**1714**	**283001**	**226832**	**56169**	**22248**	**17733**	**4515**	**49306**	**26166**	**23140**

	NACE Code					
		85			Grand Total	
	Total	Males	Females	Total	Males	Females
Austria	319	77	243	**73356**	**59031**	**14325**
Belgium	457	114	343	**70847**	**59494**	**11353**
Bulgaria	151	41	110	**63939**	**55709**	**8231**
Cyprus	13	4	9	**8772**	**7578**	**1194**
Czech Republic	299	60	239	**114559**	**93754**	**20805**
Denmark	468	84	383	**51454**	**41958**	**9496**
Estonia	36	4	33	**13834**	**10445**	**3389**
Finland	0	0	0	**35494**	**28373**	**7121**
France	2776	749	2026	**436278**	**347924**	**88355**
Germany	3809	1066	2704	**509279**	**411688**	**97553**
Greece	191	69	122	**82234**	**73566**	**8668**
Hungary	259	62	197	**81827**	**65888**	**15939**
Ireland	193	37	157	**24078**	**20977**	**3101**
Italy	2270	726	1543	**495040**	**425721**	**69319**
Latvia	48	8	40	**24936**	**18758**	**6177**
Lithuania	102	14	87	**36333**	**28361**	**7972**
Luxembourg	18	5	13	**7297**	**6442**	**855**
Malta	11	2	9	**53**	**27**	**26**
Netherlands	1192	250	942	**119709**	**99606**	**20104**
Poland	808	162	646	**270166**	**227748**	**42418**
Portugal	312	56	256	**89816**	**72102**	**17715**
Romania	368	85	283	**134258**	**110906**	**23351**
Slovakia	144	27	117	**31215**	**25912**	**5304**
Slovenia	54	11	43	**17819**	**14625**	**3195**
Spain	0	0	0	**387426**	**329615**	**57811**
Sweden	694	118	576	**83797**	**70466**	**13331**
United Kingdom	3300	891	2409	**406976**	**344019**	**62957**
TOTAL	**18290**	**4188**	**14101**	**3670795**	**2927201**	**743594**

8.2 ESTIMATED DEATHS AND REGISTRATIONS IN THE EU FROM LUNG AND BLADDER CANCER

Table 8.2.1 Forecast number of lung and bladder cancers in ages 25+ (ages 15+ for registrations), based on projected EU country populations

Lung cancer deaths	*MEN*						*WOMEN*					
FTY	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Austria	2,698	3,346	3,956	4,483	4,711	4,745	1,129	1,290	1,459	1,611	1,705	1,687
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	3,127	3,202	3,344	3,500	3,456	3,149	590	604	627	634	624	588
Cyprus	146	199	257	320	389	456	38	50	66	82	96	113
Czech Republic	4,741	5,771	6,660	7,492	8,086	8,078	1,582	1,790	2,024	2,204	2,278	2,323
Denmark	2,342	2,915	3,363	3,606	3,695	3,745	1,819	2,137	2,380	2,529	2,552	2,563
Estonia	610	666	751	847	937	982	154	166	172	182	189	183
Finland	1,686	2,167	2,617	2,783	2,822	2,923	592	693	786	824	818	817
France	24,854	29,288	33,628	36,549	38,217	39,689	6,697	7,502	8,353	9,042	9,293	9,389
Germany (including ex-GDR from 1991)	33,102	39,458	44,318	48,341	48,129	46,049	12,629	14,018	14,868	15,581	15,458	14,585
Greece	5,779	6,593	7,578	8,628	9,275	9,333	1,070	1,265	1,388	1,542	1,665	1,705
Hungary	6,068	6,634	7,398	8,125	8,599	8,624	2,437	2,557	2,746	2,803	2,814	2,785
Ireland	1,175	1,595	2,112	2,691	3,299	3,759	720	932	1,209	1,512	1,815	2,051
Italy	29,397	34,515	40,206	46,091	49,731	49,259	7,857	8,917	9,911	10,930	11,683	11,548
Latvia	1,025	1,091	1,220	1,355	1,483	1,502	220	231	239	256	265	264
Lithuania	1,384	1,538	1,764	1,982	2,138	2,164	267	286	313	344	352	350
Luxembourg	176	228	291	350	386	413	52	61	75	89	96	102
Malta	146	192	235	255	275	299	20	21	22	23	24	23
Netherlands	7,177	9,325	11,423	12,679	12,877	12,754	3,444	4,079	4,583	4,835	4,782	4,720
Poland	19,813	24,204	28,329	31,413	34,266	34,929	5,717	6,552	7,274	8,001	8,124	7,952
Portugal	3,111	3,600	4,173	4,708	5,070	5,188	677	778	878	977	1,046	1,073
Romania	8,342	9,179	10,368	11,480	11,726	11,057	1,935	2,100	2,335	2,521	2,626	2,589

Lung cancer deaths	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Slovakia	1,963	2,488	3,057	3,508	3,884	3,932	438	508	608	709	742	773
Slovenia	944	1,168	1,406	1,545	1,581	1,552	282	317	353	379	379	370
Spain	20,051	24,629	30,491	36,512	40,400	40,734	2,942	3,503	4,051	4,536	4,903	5,021
Sweden	2,078	2,503	2,886	3,122	3,340	3,542	1,659	1,862	2,064	2,198	2,302	2,390
United Kingdom	21,915	26,107	30,805	34,784	38,234	41,219	15,291	17,180	19,778	22,297	24,098	25,562
European Union (27 countries)	210,064	249,072	289,493	323,680	342,919	348,763	70,053	79,186	88,770	96,845	100,598	100,564

Lung cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Ages 15+												
Austria	3,195	3,838	4,514	4,960	5,120	5,164	1,214	1,357	1,526	1,653	1,691	1,679
Belgium	7,322	8,692	10,013	10,852	11,262	11,628	1,292	1,445	1,593	1,703	1,753	1,779
Bulgaria	2,684	2,717	2,857	2,967	2,899	2,741	513	529	545	553	541	514
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	5,691	6,740	7,663	8,472	8,896	8,764	1,447	1,647	1,808	1,937	2,003	1,988
Denmark	2,325	2,806	3,129	3,278	3,289	3,392	1,648	1,877	2,063	2,137	2,166	2,201
Estonia	630	684	762	847	921	949	142	148	156	161	163	163
Finland	1,681	2,142	2,375	2,420	2,462	2,527	609	716	780	795	789	788
France	26,745	31,101	34,491	36,630	37,854	39,219	5,039	5,699	6,221	6,585	6,689	6,754
Germany (including ex-GDR from 1991)	38,324	44,013	49,121	51,188	50,140	48,059	11,541	12,457	13,257	13,586	13,278	12,593
Greece	6,094	6,934	7,896	8,787	9,161	8,965	1,059	1,189	1,307	1,413	1,454	1,415
Hungary	6,802	7,380	8,170	8,966	9,417	9,471	2,371	2,499	2,628	2,710	2,719	2,683
Ireland	1,252	1,689	2,180	2,721	3,274	3,530	716	932	1,193	1,470	1,747	1,894
Italy	34,941	40,490	46,453	51,486	52,717	51,737	7,555	8,466	9,366	10,142	10,308	9,994
Latvia	951	1,015	1,110	1,226	1,296	1,278	181	183	191	198	200	196

Lung cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Lithuania	1,385	1,524	1,745	1,956	2,094	2,138	226	238	261	277	279	278
Luxembourg	252	326	405	467	507	544	60	73	86	97	107	114
Malta	146	186	213	228	246	256	25	30	34	35	37	38
Netherlands	8,745	11,124	12,938	13,657	13,484	13,607	2,635	3,038	3,312	3,421	3,423	3,370
Poland	22,877	27,302	31,024	34,644	36,831	36,566	5,119	5,745	6,372	6,806	6,831	6,624
Portugal	2,875	3,318	3,829	4,280	4,552	4,608	628	711	793	859	897	892
Romania	7,766	8,440	9,584	10,539	10,779	10,354	1,701	1,842	2,018	2,197	2,264	2,208
Slovakia	2,512	3,125	3,739	4,299	4,667	4,649	456	534	616	676	706	697
Slovenia	988	1,219	1,418	1,534	1,555	1,485	284	317	347	361	357	341
Spain	21,064	25,941	31,814	36,979	39,486	38,712	2,341	2,769	3,238	3,632	3,854	3,807
Sweden	1,965	2,314	2,570	2,754	2,899	3,067	1,342	1,479	1,609	1,701	1,772	1,816
United Kingdom	27,363	32,395	37,148	40,910	43,779	47,708	16,430	18,564	21,109	23,352	24,834	26,443
European Union (27 countries)	234,922	275,404	314,082	343,072	356,383	358,425	66,807	75,248	83,431	89,518	91,591	90,888

Bladder cancer deaths FTY	MEN 2010	2020	2030	2040	2050	2060	WOMEN 2010	2020	2030	2040	2050	2060
Austria	372	488	623	791	957	951	172	189	230	280	334	331
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	387	404	445	490	531	548	119	125	136	142	147	149
Cyprus	32	44	59	77	96	115	3	5	7	9	12	15
Czech Republic	586	762	1,011	1,166	1,353	1,569	233	274	329	359	390	420
Denmark	408	536	672	754	810	811	175	210	252	279	295	294
Estonia	64	73	87	106	124	146	31	35	37	42	45	46
Finland	185	245	322	353	359	376	71	86	107	121	123	121
France	3,879	4,718	5,888	6,875	7,459	7,820	1,230	1,400	1,675	2,007	2,167	2,193
Germany (including ex-GDR from 1991)	4,075	5,444	6,257	7,520	8,350	7,819	2,005	2,360	2,572	2,989	3,319	3,069
Greece	921	1,098	1,264	1,532	1,792	1,942	200	256	283	334	385	410
Hungary	568	652	766	897	1,013	1,145	240	268	300	332	345	375
Ireland	138	192	267	354	458	569	67	84	113	149	188	234
Italy	4,620	5,650	6,689	7,945	9,277	9,511	1,257	1,474	1,668	1,918	2,236	2,314
Latvia	126	138	157	185	210	234	57	62	65	72	77	83
Lithuania	194	223	266	332	393	436	56	63	69	82	89	91
Luxembourg	22	30	40	54	64	70	8	9	10	14	17	19
Malta	34	47	68	81	86	101	8	11	15	17	18	20
Netherlands	900	1,196	1,600	1,869	2,025	1,974	367	441	555	646	690	673
Poland	2,446	3,056	3,942	4,731	5,213	5,936	649	768	928	1,113	1,141	1,238
Portugal	560	674	808	981	1,149	1,279	207	253	295	351	406	445
Romania	1,011	1,131	1,330	1,577	1,810	1,931	307	340	397	451	510	551
Slovakia	199	253	350	446	523	614	75	90	116	139	153	172
Slovenia	101	136	175	215	235	246	45	53	62	73	77	78
Spain	4,148	5,075	6,370	8,147	9,959	10,917	870	1,033	1,238	1,545	1,886	2,106

Bladder cancer deaths	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Sweden	491	608	759	837	924	987	181	205	250	276	299	317
United Kingdom	3,481	4,249	5,260	6,126	7,001	7,473	1,691	1,873	2,260	2,638	3,019	3,190
European Union (27 countries)	30,722	37,976	46,330	55,274	62,497	65,778	10,637	12,330	14,440	16,995	18,957	19,638

Bladder cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Austria	1,715	2,072	2,518	2,815	2,916	2,960	559	625	732	810	835	834
Belgium	2,030	2,449	2,895	3,176	3,304	3,430	548	627	724	793	823	842
Bulgaria	636	656	695	736	753	730	171	177	183	186	183	175
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	1,759	2,186	2,488	2,787	3,040	3,050	636	736	809	873	918	915
Denmark	784	971	1,101	1,174	1,168	1,207	255	300	338	360	362	368
Estonia	156	170	191	213	236	248	55	59	62	64	66	67
Finland	686	882	983	1,001	1,019	1,048	220	266	293	299	297	298
France	10,183	12,430	14,253	15,519	16,066	16,701	2,158	2,575	2,959	3,250	3,310	3,336
Germany (including ex-GDR from 1991)	22,629	26,022	29,785	31,514	30,871	29,765	7,445	8,054	8,924	9,346	9,152	8,754
Greece	2,311	2,632	3,018	3,441	3,670	3,591	467	529	590	658	693	673
Hungary	1,456	1,630	1,809	2,016	2,201	2,256	540	582	613	640	662	661
Ireland	476	636	814	1,006	1,199	1,290	171	223	285	348	411	445
Italy	18,441	21,391	24,656	27,696	28,472	27,931	3,718	4,172	4,682	5,204	5,339	5,171
Latvia	205	217	243	270	293	304	72	73	78	81	83	84
Lithuania	351	382	450	510	552	583	105	111	124	133	136	136
Luxembourg	118	156	202	240	261	281	35	42	51	59	65	69
Malta	61	81	94	100	110	116	18	23	26	27	28	30
Netherlands	4,771	6,115	7,167	7,614	7,495	7,568	1,111	1,340	1,545	1,643	1,631	1,618
Poland	6,023	7,376	8,506	9,448	10,301	10,435	1,303	1,524	1,731	1,834	1,919	1,925

Bladder cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Portugal	1,695	1,958	2,269	2,570	2,754	2,790	467	532	601	666	699	695
Romania	2,508	2,757	3,134	3,579	3,840	3,818	678	738	809	890	929	916
Slovakia	522	675	833	961	1,088	1,120	165	201	240	265	287	294
Slovenia	182	233	281	309	324	313	50	57	65	70	72	69
Spain	12,477	15,309	18,883	22,192	23,633	23,079	1,710	2,022	2,425	2,846	3,090	3,035
Sweden	1,792	2,133	2,376	2,559	2,687	2,868	593	672	742	797	828	871
United Kingdom	9,713	11,527	13,260	14,634	15,638	17,095	3,654	4,144	4,754	5,296	5,627	6,031
European Union (27 countries)	102,412	121,289	140,370	155,410	162,871	164,733	26,842	30,599	34,652	37,902	39,265	39,223

8.3 SUPPLEMENTARY TABLES - COSTS UNDER THE BASELINE SCENARIO

Table 8.3.1 Health costs – baseline scenario – Member State breakdown - Based on a 4% discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 188	€ 1,433	€ 1,620	Austria	€ 386	€ 3,776	€ 4,163
Belgium	€ 6	€ 164	€ 170	Belgium	€ 206	€ 5,972	€ 6,178
Bulgaria	€ 49	€ 1,481	€ 1,530	Bulgaria	€ 93	€ 3,048	€ 3,141
Czech Republic	€ 275	€ 2,797	€ 3,317	Czech Republic	€ 554	€ 8,916	€ 9,470
Cyprus	€ 4	€ 147	€ 73	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 273	€ 1,112	€ 1,384	Denmark	€ 524	€ 2,848	€ 3,372
Estonia	€ 28	€ 314	€ 343	Estonia	€ 61	€ 909	€ 970
Finland	€ 76	€ 591	€ 667	Finland	€ 167	€ 1,542	€ 1,709
France	€ 1,072	€ 12,117	€ 13,189	France	€ 1,358	€ 26,460	€ 27,818
Germany	€ 1,263	€ 10,869	€ 12,132	Germany	€ 2,259	€ 28,747	€ 31,006
Greece	€ 62	€ 2,513	€ 2,574	Greece	€ 140	€ 6,130	€ 6,270
Hungary	€ 331	€ 2,885	€ 3,216	Hungary	€ 633	€ 7,706	€ 8,338
Ireland	€ 47	€ 398	€ 445	Ireland	€ 98	€ 1,051	€ 1,149
Italy	€ 647	€ 13,443	€ 14,090	Italy	€ 1,269	€ 38,744	€ 40,013
Latvia	€ 42	€ 566	€ 607	Latvia	€ 87	€ 1,464	€ 1,550
Lithuania	€ 47	€ 859	€ 906	Lithuania	€ 99	€ 2,310	€ 2,409
Luxembourg	€ 10	€ 191	€ 201	Luxembourg	€ 22	€ 617	€ 638
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 1	€ 1
Netherlands	€ 440	€ 3,191	€ 3,631	Netherlands	€ 625	€ 9,681	€ 10,306
Poland	€ 598	€ 9,004	€ 9,602	Poland	€ 1,043	€ 24,900	€ 25,943
Portugal	€ 92	€ 1,674	€ 1,767	Portugal	€ 172	€ 3,381	€ 3,553
Romania	€ 172	€ 3,115	€ 3,287	Romania	€ 330	€ 6,629	€ 6,959
Slovakia	€ 35	€ 678	€ 713	Slovakia	€ 80	€ 2,176	€ 2,256
Slovenia	€ 40	€ 500	€ 540	Slovenia	€ 78	€ 1,219	€ 1,297
Spain	€ 440	€ 11,054	€ 11,494	Spain	€ 598	€ 25,038	€ 25,637
Sweden	€ 213	€ 990	€ 1,203	Sweden	€ 347	€ 2,327	€ 2,674
United Kingdom	€ 1,363	€ 9,019	€ 10,382	United Kingdom	€ 3,194	€ 28,008	€ 31,201
TOTAL	€ 7,810	€ 91,107	€ 99,084	**TOTAL**	€ 14,421	€ 243,598	€ 258,020

Table 8.3.2 Health costs - baseline scenario - Industry group breakdown - Based on a 4% discount rate

Low	Female	Male	Total
Fishing, fish farming and related service activities	€ 21.7	€ 188.3	€ 210.0
Mining of coal and lignite; extraction of peat	€ 85.4	€ 1,578.6	€ 1,663.9
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	€ 5	€ 67	€ 71
Mining of metal ores	€ 29	€ 396	€ 425
Other mining and quarrying	€ 151	€ 2,402	€ 2,553
Manufacture of food products and beverages	€ 96	€ 470	€ 566
Manufacture of tobacco products	€ 0	€ 1	€ 1
Manufacture of textiles	€ 3	€ 14	€ 17
Manufacture of wearing apparel; dressing and dyeing of fur	€ 10	€ 37	€ 47

Low	Female	Male	Total
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	€ 2	€ 8	€ 10
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	€ 55	€ 246	€ 302
Manufacture of pulp, paper and paper products	€ 11	€ 57	€ 68
Publishing, printing and reproduction of recorded media	€ 5	€ 29	€ 34
Manufacture of chemicals and chemical products	€ 16	€ 86	€ 102
Manufacture of other non-metallic mineral products	€ 134	€ 650	€ 784
manufacture of basic metals	€ 30	€ 148	€ 178
Manufacture of fabricated metal products, except machinery and equipment	€ 74	€ 383	€ 457
Manufacture of machinery and equipment n.e.c.	€ 25	€ 127	€ 151
Manufacture of office machinery and computers	€ 6	€ 30	€ 36
Manufacture of medical, precision and optical instruments, watches and clocks	€ 2	€ 9	€ 11
Manufacture of other transport equipment	€ 13	€ 65	€ 78
Manufacture of furniture; manufacturing n.e.c.	€ 4	€ 20	€ 24
Electricity, gas, steam and hot water supply	€ 13	€ 123	€ 136
Collection, purification and distribution of water	€ 13	€ 131	€ 145
Construction	€ 514	€ 28,099	€ 28,613
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	€ 2,209	€ 9,764	€ 11,973
Wholesale trade and commission trade, except of motor vehicles and motorcycles	€ 47	€ 218	€ 264
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	€ 82	€ 378	€ 460
Hotels and restaurants	€ 43	€ 207	€ 250
Land transport; transport via pipelines	€ 3,375	€ 39,491	€ 42,866
Water transport	€ 30	€ 353	€ 384
Air transport	€ 7	€ 75	€ 82
Supporting and auxiliary transport activities; activities of travel agencies	€ 606	€ 7,203	€ 7,809
Post and telecommunications	€ 16	€ 190	€ 206
Public administration and defence; compulsory social security	€ 105	€ 279	€ 384
Health and social work	€ 66	€ 47	€ 114
TOTAL	€ 7,904	€ 93,572	€ 101,476

High	Female	Male	Total
Fishing, fish farming and related service activities	€ 40.5	€ 480.5	€ 521.0
Mining of coal and lignite; extraction of peat	€ 159.4	€ 4,031.4	€ 4,190.9
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	€ 9	€ 172	€ 181
Mining of metal ores	€ 54	€ 1,011	€ 1,065
Other mining and quarrying	€ 281	€ 6,128	€ 6,409
Manufacture of food products and beverages	€ 181	€ 1,211	€ 1,392
Manufacture of tobacco products	€ 0	€ 1	€ 2
Manufacture of textiles	€ 6	€ 37	€ 43
Manufacture of wearing apparel; dressing and dyeing of fur	€ 19	€ 96	€ 115
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	€ 4	€ 22	€ 25
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	€ 105	€ 635	€ 740
Manufacture of pulp, paper and paper products	€ 20	€ 147	€ 167

High	Female	Male	Total
Publishing, printing and reproduction of recorded media	€ 10	€ 75	€ 85
Manufacture of chemicals and chemical products	€ 30	€ 223	€ 253
Manufacture of other non-metallic mineral products	€ 253	€ 1,679	€ 1,932
Manufacture of basic metals	€ 56	€ 383	€ 439
Manufacture of fabricated metal products, except machinery and equipment	€ 141	€ 987	€ 1,128
Manufacture of machinery and equipment n.e.c.	€ 47	€ 327	€ 374
Manufacture of office machinery and computers	€ 11	€ 77	€ 88
Manufacture of medical, precision and optical instruments, watches and clocks	€ 3	€ 24	€ 27
Manufacture of other transport equipment	€ 24	€ 168	€ 192
Manufacture of furniture; manufacturing n.e.c.	€ 8	€ 51	€ 59
Electricity, gas, steam and hot water supply	€ 24	€ 318	€ 343
Collection, purification and distribution of water	€ 25	€ 339	€ 364
Construction	€ 960	€ 71,661	€ 72,620
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	€ 4,166	€ 25,135	€ 29,301
Wholesale trade and commission trade, except of motor vehicles and motorcycles	€ 89	€ 567	€ 656
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	€ 156	€ 983	€ 1,139
Hotels and restaurants	€ 83	€ 538	€ 621
Land transport; transport via pipelines	€ 6,365	€ 101,654	€ 108,020
Water transport	€ 58	€ 920	€ 978
Air transport	€ 13	€ 196	€ 208
Supporting and auxiliary transport activities; activities of travel agencies	€ 1,144	€ 18,540	€ 19,684
Post and telecommunications	€ 31	€ 496	€ 527
Public administration and defence; compulsory social security	€ 202	€ 727	€ 928
Health and social work	€ 127	€ 123	€ 250
TOTAL	€ 14,905	€ 240,161	€ 255,066

Table 8.3.3 Health costs – baseline scenario – Member State breakdown - Based on a declining discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 224	€ 1,698	€ 1,922	Austria	€ 463	€ 4,511	€ 4,974
Belgium	€ 7	€ 194	€ 201	Belgium	€ 245	€ 7,073	€ 7,318
Bulgaria	€ 58	€ 1,740	€ 1,798	Bulgaria	€ 110	€ 3,613	€ 3,723
Czech Republic	€ 328	€ 3,327	€ 3,949	Czech Republic	€ 667	€ 10,698	€ 11,364
Cyprus	€ 5	€ 175	€ 87	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 324	€ 1,310	€ 1,634	Denmark	€ 625	€ 3,377	€ 4,002
Estonia	€ 34	€ 375	€ 408	Estonia	€ 73	€ 1,091	€ 1,164
Finland	€ 91	€ 707	€ 797	Finland	€ 200	€ 1,850	€ 2,050
France	€ 1,264	€ 14,110	€ 15,374	France	€ 1,613	€ 30,959	€ 32,571
Germany	€ 1,500	€ 12,876	€ 14,376	Germany	€ 2,706	€ 34,281	€ 36,987
Greece	€ 74	€ 2,985	€ 3,059	Greece	€ 168	€ 7,327	€ 7,495
Hungary	€ 393	€ 3,426	€ 3,820	Hungary	€ 759	€ 9,231	€ 9,990
Ireland	€ 57	€ 479	€ 536	Ireland	€ 120	€ 1,273	€ 1,393
Italy	€ 774	€ 15,776	€ 16,550	Italy	€ 1,529	€ 45,625	€ 47,154
Latvia	€ 50	€ 678	€ 728	Latvia	€ 104	€ 1,763	€ 1,867

Low	Female	Male	Total	High	Female	Male	Total
Lithuania	€ 56	€ 1,031	€ 1,086	Lithuania	€ 120	€ 2,796	€ 2,916
Luxembourg	€ 12	€ 227	€ 239	Luxembourg	€ 26	€ 736	€ 762
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 1	€ 1
Netherlands	€ 522	€ 3,792	€ 4,314	Netherlands	€ 747	€ 11,568	€ 12,315
Poland	€ 713	€ 10,778	€ 11,492	Poland	€ 1,257	€ 30,047	€ 31,304
Portugal	€ 110	€ 1,961	€ 2,071	Portugal	€ 207	€ 3,995	€ 4,202
Romania	€ 205	€ 3,682	€ 3,887	Romania	€ 397	€ 7,919	€ 8,316
Slovakia	€ 42	€ 816	€ 858	Slovakia	€ 97	€ 2,650	€ 2,747
Slovenia	€ 47	€ 596	€ 643	Slovenia	€ 94	€ 1,469	€ 1,563
Spain	€ 528	€ 13,479	€ 14,007	Spain	€ 728	€ 30,765	€ 31,493
Sweden	€ 252	€ 1,168	€ 1,420	Sweden	€ 413	€ 2,758	€ 3,170
United Kingdom	€ 1,616	€ 10,507	€ 12,124	United Kingdom	€ 3,806	€ 32,740	€ 36,546
TOTAL	€ 9,285	€ 107,896	€ 117,382	**TOTAL**	€ 17,274	€ 290,115	€ 307,389

Table 8.3.4 Health costs – baseline scenario – Industry group breakdown - Based on a declining discount rate

Low	Female	Male	Total
Fishing, fish farming and related service activities	€ 25	€ 215	€ 240
Mining of coal and lignite; extraction of peat	€ 97	€ 1,815	€ 1,912
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	€ 6	€ 81	€ 86
Mining of metal ores	€ 33	€ 454	€ 487
Other mining and quarrying	€ 170	€ 2,743	€ 2,913
Manufacture of food products and beverages	€ 115	€ 569	€ 684
Manufacture of tobacco products	€ 0	€ 1	€ 1
Manufacture of textiles	€ 4	€ 17	€ 21
Manufacture of wearing apparel; dressing and dyeing of fur	€ 12	€ 46	€ 58
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	€ 2	€ 10	€ 13
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	€ 67	€ 299	€ 366
Manufacture of pulp, paper and paper products	€ 13	€ 69	€ 82
Publishing, printing and reproduction of recorded media	€ 6	€ 35	€ 41
Manufacture of chemicals and chemical products	€ 19	€ 105	€ 124
Manufacture of other non-metallic mineral products	€ 162	€ 792	€ 954
manufacture of basic metals	€ 36	€ 180	€ 216
Manufacture of fabricated metal products, except machinery and equipment	€ 90	€ 466	€ 556
Manufacture of machinery and equipment n.e.c.	€ 30	€ 154	€ 184
Manufacture of office machinery and computers	€ 7	€ 36	€ 43
Manufacture of medical, precision and optical instruments, watches and clocks	€ 2	€ 11	€ 13
Manufacture of other transport equipment	€ 15	€ 79	€ 94
Manufacture of furniture; manufacturing n.e.c.	€ 5	€ 24	€ 29
Electricity, gas, steam and hot water supply	€ 15	€ 150	€ 165
Collection, purification and distribution of water	€ 16	€ 159	€ 175
Construction	€ 583	€ 32,054	€ 32,637
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	€ 2,633	€ 11,729	€ 14,363
Wholesale trade and commission trade, except of motor vehicles and motorcycles	€ 59	€ 277	€ 335

Low	Female	Male	Total
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	€ 103	€ 480	€ 583
Hotels and restaurants	€ 55	€ 263	€ 318
Land transport; transport via pipelines	€ 4,024	€ 47,437	€ 51,461
Water transport	€ 38	€ 451	€ 489
Air transport	€ 8	€ 96	€ 104
Supporting and auxiliary transport activities; activities of travel agencies	€ 723	€ 8,651	€ 9,374
Post and telecommunications	€ 21	€ 243	€ 263
Public administration and defence; compulsory social security	€ 133	€ 356	€ 490
Health and social work	€ 84	€ 60	€ 144
TOTAL	€ 9,413	€ 110,604	€ 120,017

Table 8.3.5 Summary of health costs

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	2371 to 4225	1912 to 3441	1796 to 3337	1363 to 2616	1025 to 2019	817 to 1636
Male	28022 to 72962	22721 to 59819	21057 to 56390	15397 to 42178	11405 to 32040	9293 to 26726
Total	30440 to 77187	24673 to 63260	22894 to 59727	16791 to 44794	12455 to 34059	10129 to 28362

Table 8.3.6 Health costs – baseline scenario – Member State breakdown - Based on a no discounting approach

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 531	€ 3,981	€ 4,512	Austria	€ 1,118	€ 10,773	€ 11,890
Belgium	€ 16	€ 459	€ 475	Belgium	€ 581	€ 16,686	€ 17,267
Bulgaria	€ 131	€ 3,985	€ 4,116	Bulgaria	€ 259	€ 8,487	€ 8,746
Czech Republic	€ 777	€ 7,856	€ 9,344	Czech Republic	€ 1,622	€ 25,860	€ 27,482
Cyprus	€ 12	€ 414	€ 207	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 763	€ 3,042	€ 3,805	Denmark	€ 1,497	€ 7,955	€ 9,452
Estonia	€ 80	€ 895	€ 975	Estonia	€ 178	€ 2,648	€ 2,825
Finland	€ 215	€ 1,691	€ 1,907	Finland	€ 482	€ 4,468	€ 4,950
France	€ 2,932	€ 31,695	€ 34,626	France	€ 3,803	€ 70,385	€ 74,188
Germany	€ 3,548	€ 30,266	€ 33,813	Germany	€ 6,533	€ 81,889	€ 88,421
Greece	€ 178	€ 7,045	€ 7,223	Greece	€ 412	€ 17,588	€ 18,000
Hungary	€ 925	€ 8,061	€ 8,987	Hungary	€ 1,835	€ 22,261	€ 24,095
Ireland	€ 142	€ 1,172	€ 1,314	Ireland	€ 305	€ 3,165	€ 3,471
Italy	€ 1,874	€ 36,305	€ 38,179	Italy	€ 3,753	€ 106,013	€ 109,766
Latvia	€ 120	€ 1,636	€ 1,756	Latvia	€ 255	€ 4,309	€ 4,564
Lithuania	€ 135	€ 2,486	€ 2,620	Lithuania	€ 295	€ 6,921	€ 7,216
Luxembourg	€ 28	€ 531	€ 559	Luxembourg	€ 63	€ 1,748	€ 1,811
Malta	€ 0	€ 1	€ 1	Malta	€ 1	€ 3	€ 3
Netherlands	€ 1,225	€ 8,936	€ 10,161	Netherlands	€ 1,787	€ 27,611	€ 29,398
Poland	€ 1,698	€ 25,967	€ 27,666	Poland	€ 3,070	€ 73,924	€ 76,994
Portugal	€ 264	€ 4,465	€ 4,729	Portugal	€ 506	€ 9,322	€ 9,828

Low	Female	Male	Total	High	Female	Male	Total
Romania	€ 482	€ 8,576	€ 9,057	Romania	€ 969	€ 19,012	€ 19,982
Slovakia	€ 103	€ 1,997	€ 2,099	Slovakia	€ 245	€ 6,685	€ 6,930
Slovenia	€ 112	€ 1,411	€ 1,523	Slovenia	€ 227	€ 3,591	€ 3,818
Spain	€ 1,267	€ 33,554	€ 34,822	Spain	€ 1,805	€ 78,144	€ 79,950
Sweden	€ 591	€ 2,718	€ 3,310	Sweden	€ 978	€ 6,483	€ 7,460
United Kingdom	€ 3,802	€ 23,639	€ 27,441	United Kingdom	€ 9,058	€ 74,310	€ 83,367
TOTAL	€ 21,952	€ 252,785	€ 275,229	**TOTAL**	€ 41,635	€ 690,240	€ 731,875

Table 8.3.6 Health costs – baseline scenario – Industry group breakdown - Based on a no discounting approach

Low	Female	Male	Total
Fishing, fish farming and related service activities	€ 50	€ 446	€ 497
Mining of coal and lignite; extraction of peat	€ 205	€ 3,918	€ 4,123
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	€ 13	€ 195	€ 208
Mining of metal ores	€ 70	€ 972	€ 1,042
Other mining and quarrying	€ 348	€ 5,814	€ 6,162
Manufacture of food products and beverages	€ 273	€ 1,366	€ 1,639
Manufacture of tobacco products	€ 0	€ 2	€ 2
Manufacture of textiles	€ 9	€ 43	€ 52
Manufacture of wearing apparel; dressing and dyeing of fur	€ 30	€ 112	€ 142
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	€ 6	€ 26	€ 32
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	€ 160	€ 727	€ 887
Manufacture of pulp, paper and paper products	€ 31	€ 165	€ 196
Publishing, printing and reproduction of recorded media	€ 15	€ 82	€ 97
Manufacture of chemicals and chemical products	€ 46	€ 253	€ 300
Manufacture of other non-metallic mineral products	€ 389	€ 1,938	€ 2,327
manufacture of basic metals	€ 86	€ 439	€ 525
Manufacture of fabricated metal products, except machinery and equipment	€ 217	€ 1,137	€ 1,354
Manufacture of machinery and equipment n.e.c.	€ 71	€ 375	€ 446
Manufacture of office machinery and computers	€ 16	€ 85	€ 101
Manufacture of medical, precision and optical instruments, watches and clocks	€ 5	€ 27	€ 32
Manufacture of other transport equipment	€ 36	€ 186	€ 222
Manufacture of furniture; manufacturing n.e.c.	€ 12	€ 59	€ 71
Electricity, gas, steam and hot water supply	€ 36	€ 361	€ 397
Collection, purification and distribution of water	€ 38	€ 385	€ 423
Construction	€ 1,215	€ 67,928	€ 69,142
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	€ 6,290	€ 28,537	€ 34,827
Wholesale trade and commission trade, except of motor vehicles and motorcycles	€ 154	€ 737	€ 891
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	€ 272	€ 1,279	€ 1,551
Hotels and restaurants	€ 144	€ 700	€ 844
Land transport; transport via pipelines	€ 9,611	€ 115,406	€ 125,017
Water transport	€ 102	€ 1,216	€ 1,318
Air transport	€ 22	€ 259	€ 282

Low	Female	Male	Total
Supporting and auxiliary transport activities; activities of travel agencies	€ 1,726	€ 21,047	€ 22,774
Post and telecommunications	€ 55	€ 657	€ 712
Public administration and defence; compulsory social security	€ 355	€ 965	€ 1,320
Health and social work	€ 223	€ 163	€ 386
TOTAL	€ 22,333	€ 258,008	€ 280,342

High	Female	Male	Total
Fishing, fish farming and related service activities	€ 96	€ 1,160	€ 1,256
Mining of coal and lignite; extraction of peat	€ 392	€ 10,224	€ 10,617
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	€ 25	€ 514	€ 539
Mining of metal ores	€ 133	€ 2,535	€ 2,669
Other mining and quarrying	€ 664	€ 15,148	€ 15,812
Manufacture of food products and beverages	€ 530	€ 3,595	€ 4,125
Manufacture of tobacco products	€ 1	€ 4	€ 5
Manufacture of textiles	€ 17	€ 114	€ 132
Manufacture of wearing apparel; dressing and dyeing of fur	€ 57	€ 296	€ 353
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	€ 11	€ 68	€ 79
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	€ 310	€ 1,915	€ 2,225
Manufacture of pulp, paper and paper products	€ 60	€ 435	€ 495
Publishing, printing and reproduction of recorded media	€ 29	€ 217	€ 246
Manufacture of chemicals and chemical products	€ 89	€ 667	€ 757
Manufacture of other non-metallic mineral products	€ 756	€ 5,109	€ 5,865
manufacture of basic metals	€ 167	€ 1,158	€ 1,325
Manufacture of fabricated metal products, except machinery and equipment	€ 420	€ 2,998	€ 3,418
Manufacture of machinery and equipment n.e.c.	€ 138	€ 987	€ 1,125
Manufacture of office machinery and computers	€ 31	€ 223	€ 254
Manufacture of medical, precision and optical instruments, watches and clocks	€ 9	€ 71	€ 81
Manufacture of other transport equipment	€ 70	€ 490	€ 560
Manufacture of furniture; manufacturing n.e.c.	€ 23	€ 155	€ 178
Electricity, gas, steam and hot water supply	€ 71	€ 950	€ 1,020
Collection, purification and distribution of water	€ 74	€ 1,013	€ 1,088
Construction	€ 2,324	€ 176,989	€ 179,313
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	€ 12,206	€ 75,249	€ 87,456
Wholesale trade and commission trade, except of motor vehicles and motorcycles	€ 302	€ 1,956	€ 2,258
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	€ 533	€ 3,394	€ 3,926
Hotels and restaurants	€ 283	€ 1,858	€ 2,140
Land transport; transport via pipelines	€ 18,652	€ 304,311	€ 322,963
Water transport	€ 201	€ 3,230	€ 3,431
Air transport	€ 44	€ 689	€ 733
Supporting and auxiliary transport activities; activities of travel agencies	€ 3,350	€ 55,500	€ 58,851
Post and telecommunications	€ 108	€ 1,747	€ 1,854
Public administration and defence; compulsory social security	€ 696	€ 2,564	€ 3,259
Health and social work	€ 437	€ 433	€ 870

TOTAL	€ 43,311	€ 677,965	€ 721,277

Table 8.3.7 Summary of health costs

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	2885 to 5141	3444 to 6197	3760 to 6988	3835 to 7361	3877 to 7635	4150 to 8314
Male	34094 to 88770	40920 to 107731	44089 to 118067	43324 to 118683	43130 to 121163	47229 to 135826
Total	37035 to 93910	44434 to 113927	47934 to 125055	47248 to 126045	47098 to 128797	51479 to 144140

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