WORKING FOR A HEALTHY FUTURE

IOM Research Project: P937/2
May 2011

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

Vinyl Chloride Monomer

Authors:

JW Cherrie, M Gorman Ng, A Searl, A Shafrir and M van Tongeren (IOM)

R Mistry, O Warwick and C Corden, (AMEC Environment & Infrastructure UK Ltd)

L Rushton (Imperial College, MRC-HPA Centre for Environment and Health)

S Hutchings (Imperial College)

Other project team members:

M-H Bouhier (AMEC Environment & Infrastructure UK Ltd), T Kaupinnen and P Heikkila (Finnish Institute of Occupational Health), H Kromhout (IRAS, University of Utrecht), L

World Health Organisation Collaborating Centre for Occupational Health

RESEARCH CONSULTING SERVICES

Multi-disciplinary specialists in Occupational and Environmental Health and Hygiene

www.iom-world.org

Levy (IEH, Cranfield University)

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SUMMARY

Workplace exposure to vinyl chloride monomer (VCM) is associated with increased risks of the usually rare form of liver cancer, angiosarcoma (ASL) and possible increased risks of hepatocellular carcinomas (HCC). VCM has been classified as a group 1 carcinogen (Carcinogenic to humans) carcinogen by IARC and as Cat 1 carcinogens in the EU under the classification and labelling legislation[1]. This report considers the likely health, socioeconomic and environmental impacts associated with possible changes to the Carcinogens Directive, in particular, replacing the existing 3 ppm EU-wide OEL for VCM with a more stringent OEL of 1 ppm or 2 ppm.

The main use of VCM is in the manufacture of PVC and most production plants are co-located with PVC batch polymerisation plants. In 2007, 7.2 million tons of VCM were produced in the EU and Norway and used to manufacture 7.2 million tons of PVC in batch polymerisation plants. There was an increase in PVC production (and therefore also VCM production) at a rate of approximately 1% per year from 2000-2007. This trend faltered during the 2008 – 2009 financial crisis but is expected to resume as the EU economy recovers.

We estimate that in 2006 about 19,000 workers in the EU were exposed to VCM with most exposed workers being involved in chemicals manufacture and a smaller proportion of exposed workers being involved in the production of plastic and rubber goods. The estimated geometric mean of current exposure levels is 0.14 mg/m^3 (0.05 ppm) and it is believed that exposures have fallen substantially since the 1970s when reported concentrations frequently exceeded 50 mg/m^3 (19.6 ppm). At the estimated current exposure levels approximately 5% of workers in the EU are exposed above 3 ppm.

We estimate that in 2010 in the EU there will be about 14 deaths from liver cancer and a similar number of registrations that might be attributable to past exposure to VCM, which corresponds to about 0.03% of all liver cancer deaths amongst the exposed workers. If no specific actions are taken to reduce exposure to VCM, based on the assumption that current employment and exposure levels are maintained, the predicted numbers of liver cancer deaths in 2060 attributable to VCM would be 0 with a predicted 3 years loss of life expectancy (YLLs/DALYs). The introduction of an OEL of I or 2 ppm would lead to reductions in the YLLs/DALYs to 0 or 2 respectively. There is no net health benefit estimated to occur from setting an OEL at 2 ppm. The benefits associated with an OEL of 1 ppm are estimated between €1m and €3m.

There is already an EU-wide OEL in place for VCM of 3 ppm and a number of Member States have set national OELs at 1 or 2 ppm. The 90th percentile of exposure in most plants is already below 2ppm, whereas the 90th percentile of exposure is only below 1 ppm in about a quarter of plants for which data are available. Consultation with the industry association (ECVM) indicated that plants located in countries that have recently joined the EU would require the most adaptation in order to comply with an OEL of 1 ppm. The main additional risk management measures required are upgrades to manufacturing equipment and increased maintenance in order to reduce leaks. The main costs associated with these measures arise from lost production time.

[1] http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf

It is judged that under the baseline scenario, firms are already moving towards complying with the 1 ppm OEL. The cost of compliance with an OEL of 2ppm may be in the region of €15m to €30m over the period 2010-69 if there are annual production shutdowns for several days for maintenance. If it is assumed that there are no additional shutdowns, the costs could be lower at around €3m to €5m over the period 2010-69.

It is assumed that the impact of introducing an EU wide OEL of 1ppm is that reductions in exposure would be achieved sooner than would otherwise occur (i.e. investment would be made earlier than planned). It is estimated that the cost of compliance may be in the region of €90m to €185m over the period 2010-69 if there are annual production shutdowns for several days for maintenance. If it is assumed at there are no additional shutdowns, the costs could be lower at around €40 to €65m over the period 2010-69.

There is a ready market for VCM and no plant closures are expected to result from the implementation of a more stringent OEL.

There are no significant environmental impacts foreseen.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

Exposure to vinyl chloride monomer (VCM) in workplace air is associated with increased risks of the usually rare form of liver cancer, angiosarcoma (ASL) and possible increased risks of hepatocellular carcinomas (HCC). VCM has been classified as a group 1 carcinogen (Carcinogenic to humans) carcinogen by IARC and as Cat 1 carcinogens in the EU under the classification and labelling legislation[2]. Vinyl chloride is therefore already regulated as a carcinogen throughout the EU. In this assessment we consider the impacts of reducing the current OEL of 3 ppm to a lower level.

The key objectives of the present study are to identify the technical feasibility and the socioeconomic, health and environmental impacts of reducing the current OEL for VCM of 3 ppm to a lower level, either 1 or 2 ppm.

1.2 OELS/EXPOSURE CONTROL

Existing national Occupational Exposure Limits (OELs) in EU member states and some countries outside the EU are presented in Table 1.1. These are expressed as long-term limits, averaged over an 8-hour working day or short-term exposure limits (STELs), i.e. over a 15-minute period within the work day.

Table 1.1 Occupational Exposure Limits in Various Member States and selected countries outside the EU

Country	OEL – TWA* (ppm)	STEL (ppm)
European Union	3	
Austria	2	4
Belgium	3	
Denmark	1	2
France	1	
Germany	3	
Italy	3	
The Netherlands	3	
Poland	2	11.57
Spain	3	
Sweden	1	
United Kingdom	3	
Canada - Quebec	1	
Japan	2	
Switzerland	2	
USA - OSHA	1	

Source: http://www.dguv.de/bgia/en/gestis/limit_values/index.jsp
*OEL - TWA: Occupational Exposure Limit –Time Weighted Average: 8 hours per day. STEL: Short Term Exposure Limit (15 minutes)

[2] http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf

The OELs for 8hr-time weighted average (TWA) exposure range from 1 to 3 ppm. Only Poland, Belgium and Denmark have Short Term Exposure Limits (STELs). The European Union OEL of 3 ppm (equivalent to approximately 7.6 mg/m^3) will be used as a comparison value for the purposes of this report.

1.3 DESCRIPTION OF DIFFERENT USES

Vinyl Chloride Monomer (VCM) is produced by subjecting 1,2-dichloroethane, to high pressures and temperatures which causes pyrolysis (thermal cracking) of the 1,2-dichloroethane to produce the vinyl chloride monomer. Ninety-five percent of VCM produced worldwide is used in the manufacture of Polyvinyl Chloride (PVC) and its associated polymers. PVC is used to manufacture automotive parts and accessories, furniture, packaging materials, pipes, wall coverings, and wire coatings.

VCM polymerisation is most frequently accomplished by suspension polymerisation. This process includes the following basic process operations:

- <u>Polymerisation</u> in aqueous suspension, to convert VCM into PVC.
- <u>Stripping</u> to remove residual VCM from the suspension slurry after polymerisation.
- <u>Drying</u> to produce a dry PVC powder product from the suspension slurry.
- <u>VCM recovery</u> to recover the residual non-converted VCM from polymerisation and other sources of the process.

Although VCM is used on a small scale in other settings (primarily chlorinated solvent manufacture) the number of workers exposed to VCM outside of PVC manufacturing is small. For example, the Finnish 2000 and Spanish 2004 CAREX updates both estimated VCM exposure prevalence below 0.02% for printing, publishing and allied industries, water transport, research and scientific institutes, financing, insurance, real estate and business services, and education services. This report will therefore focus on exposure in VCM and PVC manufacturing. Employees in these industries are considered to be exposed to VCM and workers in all other industries which use only small quantities of VCM are considered to be unexposed.

1.3.1 Production volume

Information on production volume of VCM and PVC was obtained from the European Council of Vinyl Manufacturers (ECVM). ECVM represents the European PVC resin producing companies and is a division of Plastics*Europe*. Its membership includes the 14 European PVC resin producers which together account for 100% of EU 27 production. Its membership also includes all VCM producers in the EU 27, with the exception of DOW Chemicals.

In 2007, 7.2 million tons of VCM were produced in the EU and Norway (The European Economic Area (EEA)). The 7.2 million tons of VCM produced were used to manufacture 7.2 million tons of PVC in batch polymerisation plants. These plants are usually located in petrochemical manufacturing sites with VCM often being produced on the same site. There has been an increase in PVC production (and therefore also VCM production) at a rate of approximately 1% per year from 2000-2007. This trend was stopped by the 2008 – 2009 financial crisis but the ECVM expects it to resume when the economy recovers.

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

Liver cancer is the 9th commonest malignant neoplasm amongst men in Europe and the 14th in women, accounting for over 42,000 deaths in Europe each year (Ferlay *et al*, 2007). The main risk factors for liver cancer are cirrhosis from alcohol consumption, infection with hepatitis viruses and diabetes. People who are infected with hepatitis B or C virus have a higher risk for liver cancer if they smoke and the IARC have indicated that cigarette smoking is an independent risk factor for hepatocellular carcinoma, the main form of primary liver cancer (Altamirano and Bataller, 2010). Most cases of liver cancer occur in people over the age of 60 years (Nordenstedt *et al*, 2010).

The incidence rates of liver cancer are higher in Italy, Greece and France (more than about 10 per 100,000 in men) with lower rates in United Kingdom, Sweden and Poland (less than 5 per 100,000 in men)[3]. Incidence has been increasing steadily over the last 30 years. About 5% of patients survive for five years after diagnosis, with slightly better survival in women than men and better survival amongst younger patients.

There are a small number of occupational exposures that have been identified by IARC as possible causes of bladder cancer in humans, including: trichloroethylene and ionising radiation.

1.4.2 Summary of the available epidemiological literature on risk

Vinyl chloride exposure is predominantly occupational. The highest exposure is known to occur during the cleaning of the reactors in which VCM is polymerized to make PVC, a process that traditionally was done manually by workers who would have sustained exposures to VC as high as 1000 ppm (2600 mg/m^3) (Anderson *et al*, 1980, Barnes, 1976, Purchase *et al*, 1987, Xu *et al*, 1996). A report by Creech and Johnson (1974) detailing cases of the usually rare form of liver cancer, angiosarcoma (ASL), among workers exposed to vinyl chloride lead to the identification of a causal association between VCM exposure and risk of developing this type of cancer. As a consequence, in 1975 many countries reduced occupational VCM exposure levels to <1-5ppm (<2.2-13 mg/m^3) while, in 1974, the Association of Plastic Manufacturers in Europe were prompted to set up a register to record all cases of ASL resulting from exposure to VCM worldwide. In Britain Baxter *et al*, (1980) reported an increased risk of ASL in the electrical and plastics fabrication industry during the period 1963 – 1977, although, of the 35 cases of ASL reported for the 14 year period, only 2 could be attributed to heavy exposure to VCM.

In a review by Kielhorn *et al*, (2000), epidemiologic studies of mortality amongst VCM/PVC workers from several countries were combined (Table 1.2). The authors reported a 5-fold excess of liver cancer amongst workers that was primarily due to an excess risk of ASL, with a 45-fold increase in ASL being seen in workers exposed to >10,000 ppm-years compared with workers exposed to <2000 ppm years.

[3] Available at: http://globocan.iarc.fr/

Table 1.2 Summary findings for liver cancer[*] from epidemiologic studies on workers exposed to VCM[**]

Liver Cancer[2]	European Cohort	US Cohort	German Cohort	Russian Cohort	Canadian Cohort	French Cohort	All Studies
Reference	Simonato *et al* (1991)	Wong *et al* (1991)	Weber *et al* (1981)	Smulevich *et al* (1988)	Theriault and Allard (1981)	Laplanche *et al* (1992)	-
O/E	24/8.4	37/5.77	12/0.9		8/0.14	3	81/19.21
SMR	2.76	6.41	15.23	0/n.a	57.14	3 ASL	5.33
CI	1.83-4.25[a]	4.5-8.84[b]			8 ASL[c]		4.23-6.62

n.a = not available
***** Including ASL
****** Adapted from Kielhorn *et al*, (2000)
[a] of 17 liver cancers confirmed histologically, 16 were ASL.
[b] 15 cases of ASL from death certificates and 21 from international register.
[c] plus 2 undiagnosed ASL cases.

An association between occupational VCM exposure and other forms of liver cancer is less well defined. Ward *et al* (2001) observed a marked exposure-response relationship for all liver cancers. However, the study included only a small number of hepatocellular carcinomas (HCC) cases and confounding factors, such as alcohol consumption and viral infection, were not adjusted for. In addition, Wong *et al*, (2003) have suggested a possible interaction between VCM exposure and HBV infection in the development of liver cancer. Similar suggestions have been made by Mastrangelo *et al*, (2004); these authors noted that VCM exposure appears to be an independent risk factor for HCC that synergistically interacts with alcohol consumption and additively with viral hepatitis infection.

A follow-up mortality analysis to 2003 carried out on a previous UK study cohort of 1700 male workers exposed to PVC during or prior to 1979 (IOM, 2006) found 6 cases of liver cancer (expected number 2.2) of which 2 were ASL.

A recent Policy Watch report (Grosse *et al*, 2007) summarises the findings of an IARC working group that concluded that exposure to VCM substantially increased the relative risk for development of ASL, with risk increasing with duration of exposure. The Working Group also concluded that an increase the risk of HCC was associated with cumulative exposure to vinyl chloride. The Working Group advised that vinyl fluoride and vinyl bromide should be considered to 'act similarly to the human carcinogen, vinyl chloride' (IARC 2008).

1.4.3 Choice of risk estimates to assess health impact

The review by Kielhorn *et al*, (2000) provides a robust summary and analysis of epidemiologic studies on workers exposed to VCM in several countries, including studies of workers employed pre-1975 prior to the introduction of occupational exposure level. The authors reported a 5-fold excess of liver cancer following occupational exposure to VCM, reporting an SMR of 5.33 (95% CI: 4.32-6.62) for all studies combined; this increase was, reported as being primarily due to an excess of

ASL (45-fold excess risk) and not HCC. However, it is not clear how the authors calculated the 'all studies' SMR which could be heavily influenced by that reported for the Canadian cohort (SMR = 57.14). We therefore have selected the European cohort (Simonato *et al*, 1991) included in the review by Kielhorn *et al* (2000) as most relevant for comparison with workers in Europe exposed to VCM; histological analysis was performed and 16 of the 24 cases of liver cancer in the study cohort were verified as ASL. The SMR for liver and biliary tract cancer for workers in the European cohort was found to be 2.86 (95% CI: 1.83 – 4.25) and has been used for AF calculation. Due to the absence of sufficient dose-response data specific to VCM an RR = 1 has been used for the background exposure level category.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

In 2007, 7.2 million tonnes of VCM was produced in the EEA[4] (specific import and export volumes are not known). It is estimated that there are between 30-40 plants producing VCM within the EU and Norway. According to ECVM, in 2008 VCM was produced in Belgium, the Czech Republic, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Romania, Slovakia, Spain, Sweden and the UK. The installed production capacity in the EU (in 2008) was roughly divided in the following way:

- Eastern Europe (Czech Republic, Hungary, Poland, Romania and Slovakia): 15%
- Central and Northern Europe (Germany and Sweden): 38%
- Western Europe (Benelux, France and UK): 35%
- Southern Europe (Italy and Spain): 12%

Table 1.2 shows the 14 leading European producers of PVC[5]. The production of PVC is often located on the same site as the production of VCM.

The ECVM estimates a total PVC production capacity of 7 million tonnes per year. The PVC industry is located across 12 EU countries and Norway. Individual plant capacities are in the range of 135,000-1,400,000 tonnes per annum.

[4] Questionnaire response from the European Council of Vinyl Manufacturers on the 2nd November 2009.
[5] SolVay (2006) 'SolVin's answers to the challenging global PVC market' presentation

Table 2.1 PVC producers in Europe

Companies	Countries in which they operate	Capacity (kt/y)[1]
Anwil	Poland	300
Arkema	France (4 sites), Spain	960
Borsodchem	Hungary	400
Ineos Vinyls	Germany, UK, Norway, Sweden	1440
Oltchim	Romania	350
LVM N.V.	Belgium, France, Netherlands	520
Novacke Chemicke Zavody	Slovakia	not known
Shin-Etsu PVC	Netherlands	450
SolVin	Belgium, France, Germany, Italy, Spain	1375
Spolana A.S.	Czech Republic	135
Vestolit GmbH & Co KG	Germany	370
Vinnolit GmbH & Co. KG	Germany	655
Norsk Hydro		596
Sayanskkhimplast	Russia	250
TOTAL		**7801**

[1] Source: SolVay (2006) 'SolVin's answers to the challenging global PVC market' presentation

2.2 PREVALENCE VINYL CHLORIDE MONOMER EXPOSURE IN EU

Communication with industry has indicated that the number of exposed workers at each VCM manufacturing or polymerisation site is typically around 50 – 100. Given that there are approximately 100 such sites, the total number of exposed workers in the EU and Norway is in the range of 5,000 – 10,000. Based on the production proportion estimates reported above, it is estimated that the number of workers exposed in different EU regions is as follows:

- Eastern Europe: 750 – 1500 (15%)
- Central and Northern Europe: 1900 – 3800 (38%)
- Western Europe: 1750 – 3500 (35%)
- Southern Europe: 600 – 1200 (12%)

The majority of VCM exposure occurs in the manufacturing industry. The Labour Force Survey available on the Eurostat database includes information on the number of male and female employees in the manufacturing industry (NACE D). When managers, salespeople and office clerks are excluded, 71% of workers in the manufacturing industry in the EU are male and 29% are female therefore we estimate that 3550 – 7100 males and 1450 – 2900 females are exposed to VCM in the EU.[6]

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

Classification of Industries by Exposure Level

Industries in which exposure to VCM occurs have been classified as high or background 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 2.2.

Table 2.2 Classification of industries by exposure level

Industry	NACE (rev 1.1)	Historical Exposure Classification[1]	Number of People Exposed 2006[2]
Manufacture of chemicals and chemical products	24	High	14876
Manufacture of rubber and plastic products	25	Background	2126
Water transport	61	Background	559
Supporting and auxiliary transport activities; activities of travel agencies	63	Background	965
Research and development	74	Background	461
Total			18987

2.3 LEVEL OF EXPOSURE TO VINLY CHLORIDE MONOMER

2.3.1 Estimation of exposure levels

In 2008, a dataset of VCM exposure at 36 VCM and PVC manufacturing plants across the EU was analyzed. The dataset comprised results of 6,883 exposure measurements. These data were provided by each plant to an external consultant for analysis. 69 plants provided data and data from 36 of those plants were deemed eligible for use. Data were only considered eligible if they were taken from personal air sampling and if raw data points were provided. The results of this analysis were provided by the consultant in a report to the Vinyl Chloride REACH consortium. The ECVM has provided us with the results of this study as they are not publically available.

The analysis indicated that over 95% of the exposure to VCM was below the EU OEL of 3 ppm (equivalent to 7.67 mg/m^3). The distribution of the collected data is demonstrated in Figure 2.1.[7]

[7] Information provided by the ECVM

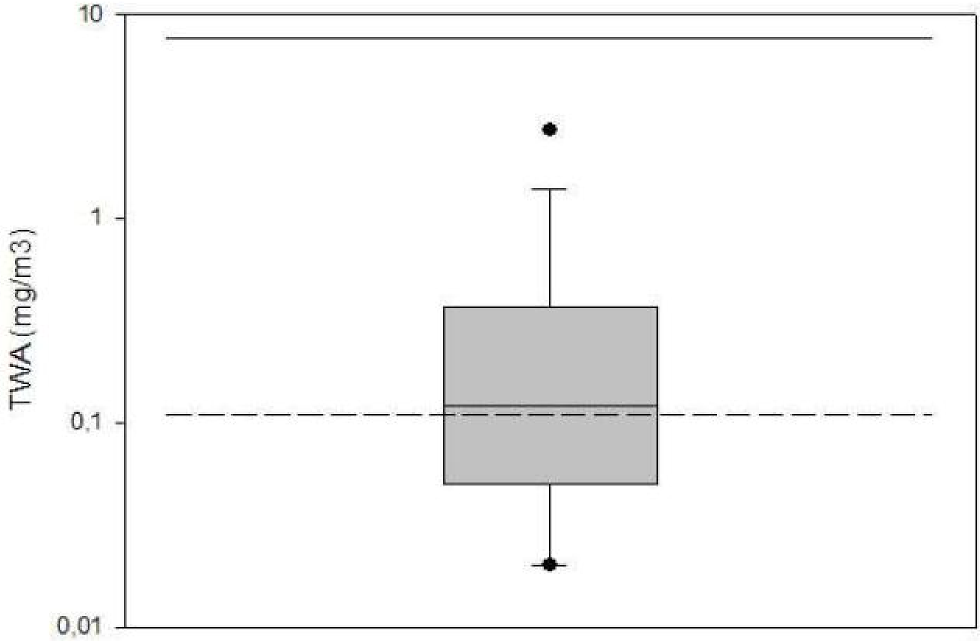


Figure 2.1 Box plot of data collected for a European VCM exposure assessment. The solid line indicates the current EU OEL while the dotted line indicates the derived minimal effect level (DMEL) for VCM based on REACH guidance.

Exposures were generally higher in PVC production compared to VCM production. The geometric mean and 75th percentile exposures for each similar exposure group (SEG) monitored at VCM production sites are shown in Figure 2.2, and those for PVC production sites are shown in Figure 2.3. The highest average exposure was seen among laboratory operators in PVC production sites (GM: 0.52 mg/m^3 or 0.2 ppm, 75th percentile: 1.9 mg/m^3 or 0.74 ppm). Information on differences in exposure levels between companies of different sizes is not currently available; however, the GM and 90th percentile TWA exposure for each plant included in the dataset is presented in Figure 2.4. The GM exposures (and in most cases 90th percentile exposures) for all plants are less than a third of the current European OEL. No information is available on the size of each plant.

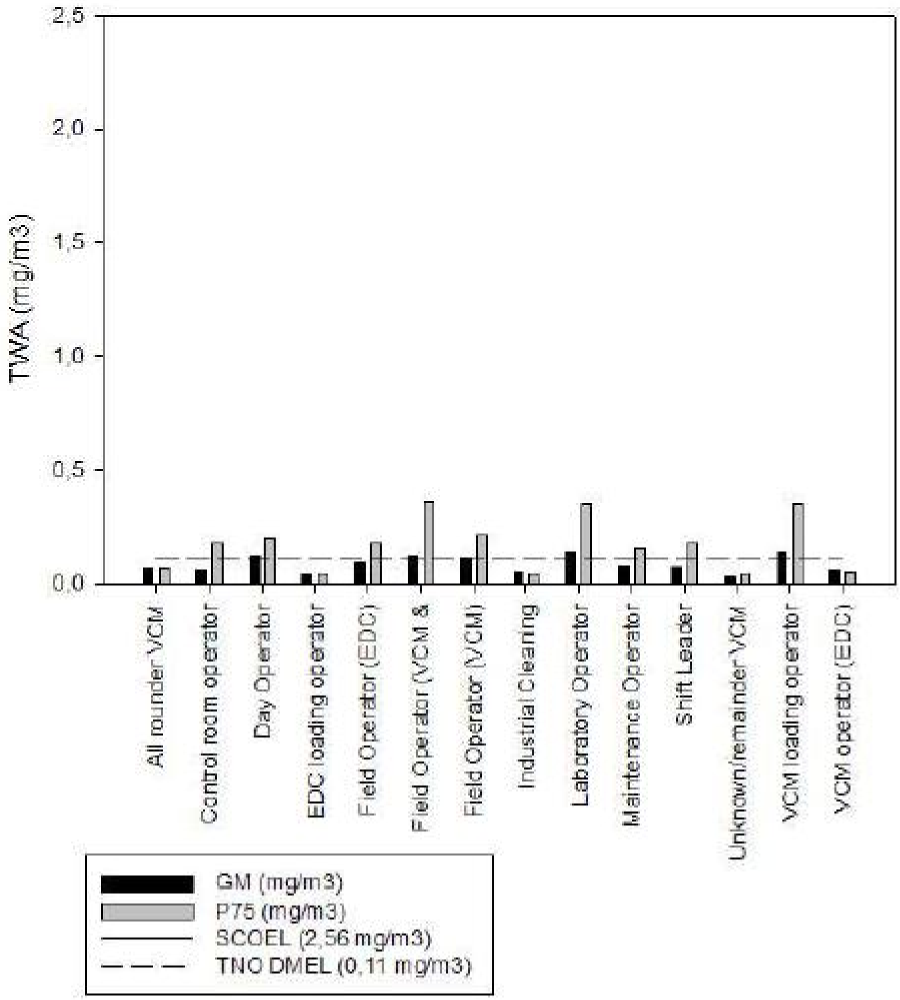


Figure 2.2 GM and 75th percentile personal TWA exposures to VCM per similar exposure groups during VCM production. Guidance DMEL indicates the derived minimal effect level for VCM based on REACH guidance.

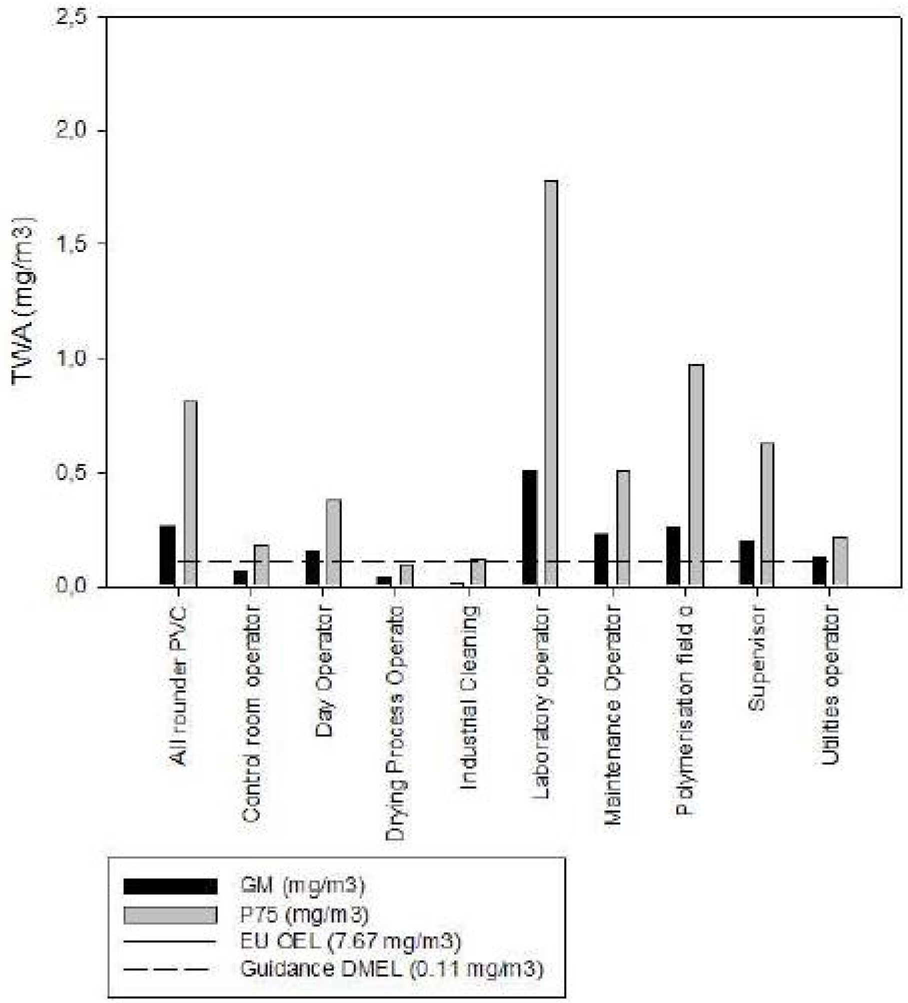


Figure 2.3 GM and 75th percentile personal TWA exposures to VCM per similar exposure group during PVC production. Guidance DMEL indicates the derived minimal effect level for VCM based on REACH guidance.

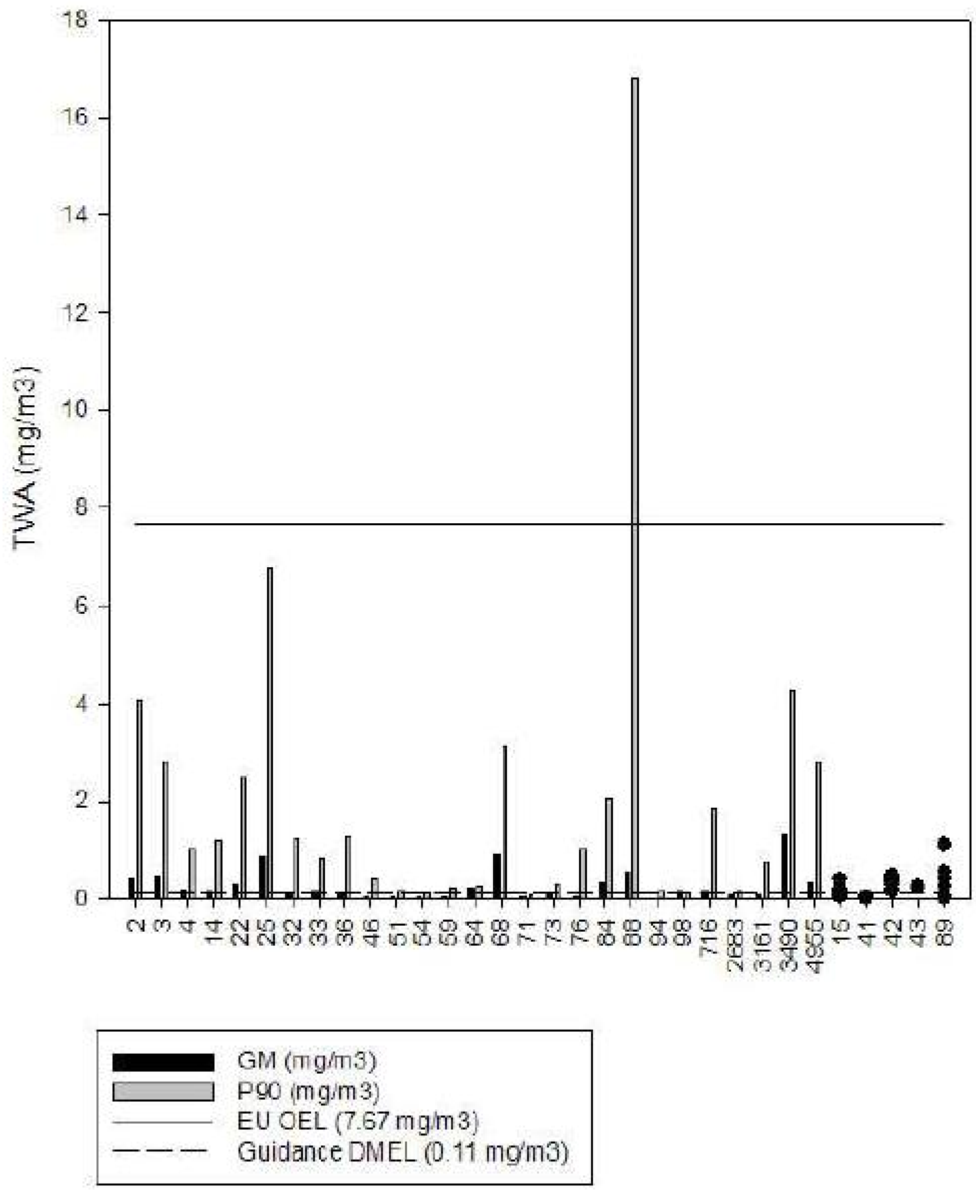


Figure 2.4 GM and 90th percentile time weighted average exposures to VCM per plant. Guidance DMEL indicates the derived minimal effect level for VCM based on REACH guidance.

The exposure distribution across all exposed workers in the EU was estimated based on the GM and GSD for each plant and weighted by the number of measurements carried out in each plant (as the number of workers in each plant was not available). This is equivalent to the directly estimated GM and GSD using all measurements. The GM was 0.14 mg/m^3 (0.05 ppm) with a GSD of 5.28. If it was assumed that an equal number of workers were employed at each plant than the GM and GSD weighted by number of workers (rather than number of measurements) were 0.15 mg/m^3 (0.06 ppm) and 5.38.

2.3.2 Temporal change in exposure

The 2008 IARC monograph on vinyl chloride[8] includes a summary of VCM exposures reported in the peer-reviewed and gray literature. The exposure data from EU countries have been extracted and are shown in Table 2.3.

Historic exposures appear to have been significantly higher than present levels. In 1974 TWA exposures above 65 mg/m^3 (25 ppm) were measured in Germany, Norway, Poland and Sweden. If it is assumed that exposures of 65 mg/m^3 (25 ppm) are typical of exposures in 1974 then, based on a 2007 average exposure of 0.23 mg/m^3 (0.09 ppm), exposures have decreased 99.6% from 1974 to 2007 suggesting an annual decrease of 15.7%. This approach may overestimate the typical exposures in the 1970's since in the same decade mean exposures of 2.3-7.3 mg/m^3 (0.9 – 2.86 ppm) were measured in France and in the early 1980's average exposures of 1.6 mg/m^3 (0.63 ppm) were measured in Finland. However, based on the data presented in the literature summarised by the IARC monograph it does appear that exposures above 50 mg/m^3 (20 ppm) were common throughout the EU in the 1970's.

The most recent concentration reported in Table 2.3 is from 1993 in Finland. The mean TWA exposure measured was 0.3 mg/m^3 (0.12 ppm). Average exposures of 0.2 mg/m^3 (0.08 ppm) were measured in Poland in 1990 and a German study of 46 plants from 1989 to 1991 found a 90th percentile exposure of 0.1 mg/m^3 (0.04 ppm). These data suggest that the majority of exposure reductions occurred in the 1980's and that average VCM exposure concentrations have not greatly changed since the early 1990's. For the purposes of this report we will assume that there is no annual decrease in exposure levels from 2010 onwards.

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

2.4.1 Background data

The occupational cancers associated with exposure to vinyl chloride monomer are shown in Table 2.4 along with a summary of the information used in the health impact assessment.

[8] IARC (International Agency for Research on Cancer). Vinyl Chloride Vol. 97. 2008

Table 2.3 Summary of results of VCM exposure studies in the EU (Source: IARC, 2008)

Year of study	Country	Workplace	Concentration (mg/m^3)
1974	Germany	PVC production department	<65-81
'Early days'	United Kingdom	PCV production plant (full-	7800
1977	Germany	PVC production plant	1.3-91
1977	Germany	PVC production plant	1.3-91
1974	Norway	PVC plant	65
1977-78	France	PVC production palnt	2.3-7.3 (range of montly means)
1979	Germany	PVC production plant	12 (12-h TWA, stationery) 15.5 (12-h TWA, personal)
1974-81	Sweden	PVC production plant	0.26-114 (8-h TWA)
1974-80			0.26-5.7 (6-h TWA)
1981-84	Germany	24 plants	3% of 33 samples >5 (90th percentile <1) (shift means)
1989-1992		46 plants	All of 117 samples <5 (90th percentile <0.1) (shift means)
1976-77	The Netherlands	PVC plant	2.6-26 (8-h TWA)
1974 1975 1976 1977 1978 1979 1981 1982	Poland	Vinyl chloride /PVC plant (several departments)	(30-600)[3] (30-270)[3] (15-60)[3] (6-150)[3] (1-30)[3] (1-15)[3] (0.1-36)[3] (0.1-12)[3]
1974 1982		(autoclave cleaners)	(900)[3] (9-180)[3]
1950-85	Italy	Vinyl chloride PVC plants	<13-≥1300
1986 1987 1988 1989 1990	Poland	Vinyl chloride synthesis mechanical breathing zone	21.3 66.9 43.7 0.7 0.2
1981-85 1986-89 1993	Finland	PVC production plant	1.6 (8h TWA); range <0.3-57 1.6 (8h TWA); range <0.3-46 0.3 (8h TWA); range <0.3-26

Table 2.4 Occupational cancers associated with exposure to vinyl chloride monomer

Cancer site	**Liver**	
ICD-10 code	C22	
IARC group for carcinogen	1	
Strength of evidence for cancer site [1]	Strong (Angiosarcoma) Suggestive (Hepatocellular)	
Latency assumption	10-50 yrs	
Source of forecast numbers - deaths	Eurostat, 2006	
Source of forecast numbers - registrations	GLOBOCAN, 2002[9]	
Exposure levels	**Relative Risk (RR)**	**Source of RR**
"High"	2.86 (1.83,4.25)	Kielhorn *et al*, 2000
"Background"	1	Default

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

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

2.4.2 Exposed numbers and exposure levels

Industry sectors, their NACE codes, classifications to exposure categories High/Medium/Low/Background exposure as applicable for the mid 1970's and numbers exposed in 2006 are given by country in Table 2.2 in the previous section on the exposure. The estimated average exposure levels (GM) and measures of variability (GSD) used were 0.14 mg/m^3 (0.05 ppm) and 5.28 respectively.

We present data for a "baseline" scenario, which for all industries assumes no annual decline in exposure levels and standard change in employed numbers up to the 2021-2030 estimation interval and constant levels thereafter.

2.4.3 Forecast cancer numbers

Separate estimates for total numbers of deaths for liver cancer by age band are available from EUROSTAT for the 27 countries of the EU, for 2006, and for registrations from GLOBOCAN for 2002. The forecast numbers of deaths and registrations by country used to estimate attributable numbers are in Appendix 8.1.

2.4.4 Results

The cancer deaths and registrations attributed to occupational exposure to VCM 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 Lived with Disability (YLDs) and Disability Adjusted Life Years (DALYs), are estimated.

As the exposure data suggests that there is no change in exposure over time, a static baseline scenario has been used.

A summary of the results for liver cancer for the total EU is in Table 2.5.

The attributable deaths in the EU 2010 from previous VCM exposures were relatively small: 14 deaths from liver cancer. The estimated deaths and cancer registrations decrease to zero over the following 50 years for liver cancer with zero attributable cancer deaths and registrations in 2060. The corresponding estimated attributable fraction (AF) decreases from 0.03% in 2010 to 0.00% in 2060. Additionally, DALYs are expected to decline in the baseline scenario from 210 years in 2010 to 3 years in 2060.

Table 2.5 Results for the baseline forecast scenario, total EU (27 countries), men plus women[10]

Scenario	All scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m**3)			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	85,029	88,452	92,092	94,072	94,982	94,982
Proportion of the population exposed	0.024%	0.023%	0.024%	0.025%	0.025%	0.026%
Liver cancer						
Attributable Fraction	0.03%	0.02%	0.01%	0.00%	0.00%	0.00%
Attributable deaths	14	11	4	1	0	0
Attributable registrations	14	10	4	1	0	0
YLLs	204	146	59	12	3	3
DALYs	208	149	60	12	3	3

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

Introduction

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 are described in section 2.4 of this report. These data indicate that there are predicted to be a significant number of cancer registrations (310 over the period 2010-2070[11]) and YLLs (4,270 over the period 2010-2070[11]) from liver cancer resulting from future exposure to VCM. There is a predicted decline in registrations and YLLs over the time period of this study (2010-2070) as a result of predicted exposure reduction due to the implementation of existing and ongoing risk management measures across the EU.

Method in brief

Using the health data (cancer registrations and Years of Life Lost - 'YLL'), it is possible to monetise the costs under the baseline by estimating the:

[10] Deaths and registrations are rounded to the nearest whole number. Where YLLs/YLDs/DALYs appear in association with zero deaths/registrations, this is due to rounding of the deaths/registrations down to zero.

[11] 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.

- 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[12]). 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 2.6 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 attaches to its health (as economic growth typically increases over a long period of time).[13]

Table 2.6 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.

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[14]. 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.

[12] Source: European Chemicals Agency: http://echa.europa.eu/

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

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

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 2.7. Health costs are predicted to decline over time and are predominantly the result of past exposure. In Section 2.4 the number of cancer registrations and YLLs are estimated to decline over time, accounted for by risk management measures already imposed over the past 10-20 years.

The introduction of an EU-wide OEL is not therefore expected to have significant impacts in the short term given that the main Member States already have a national OEL in place (the stringency varies by Member State). Table 2.7 sets out the range of health costs for each representative decade. The ranges are based on the high and low cost scenarios (see Table 2.6). The results are also illustrated in Figure 2.6.

Table 2.7 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	21 to 45	12 to 27	4 to 9	1 to 2	0 to 0	0 to 0	21 to 84
Male	85 to 207	50 to 126	17 to 44	3 to 8	1 to 2	0 to 1	156 to 387
Total	106 to 252	63 to 153	21 to 53	4 to 10	1 to 2	1 to 2	194 to 471

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

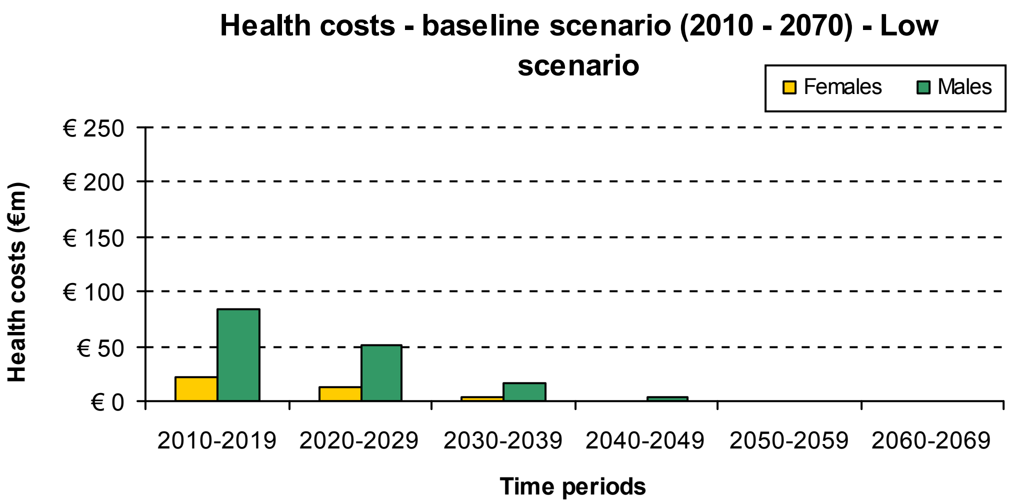


Figure 2.5 Health costs – baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

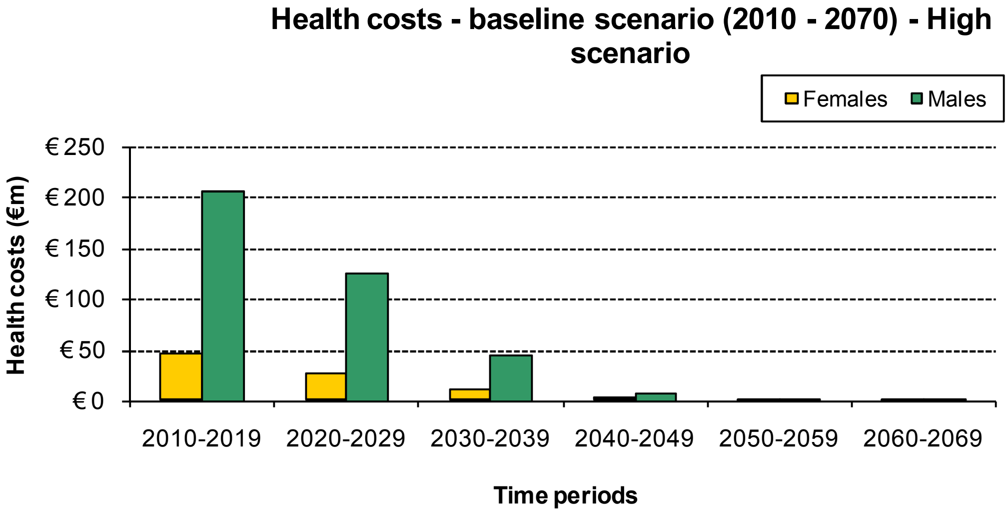


Figure 2.6 Health costs – baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

These predicted health costs will affect Member States differently depending upon the overall number of workers within affected industry groups, existing risk management measures and the proportion of males and females within these groups. Figure 2.7 shows that France, Germany and Italy are predicted to have relatively high health costs. The industrial sector estimated to be affected under the baseline is the manufacture of chemicals and chemicals products. This is shown in Figure 2.8.

Detailed tables are included in Appendix 8.2.

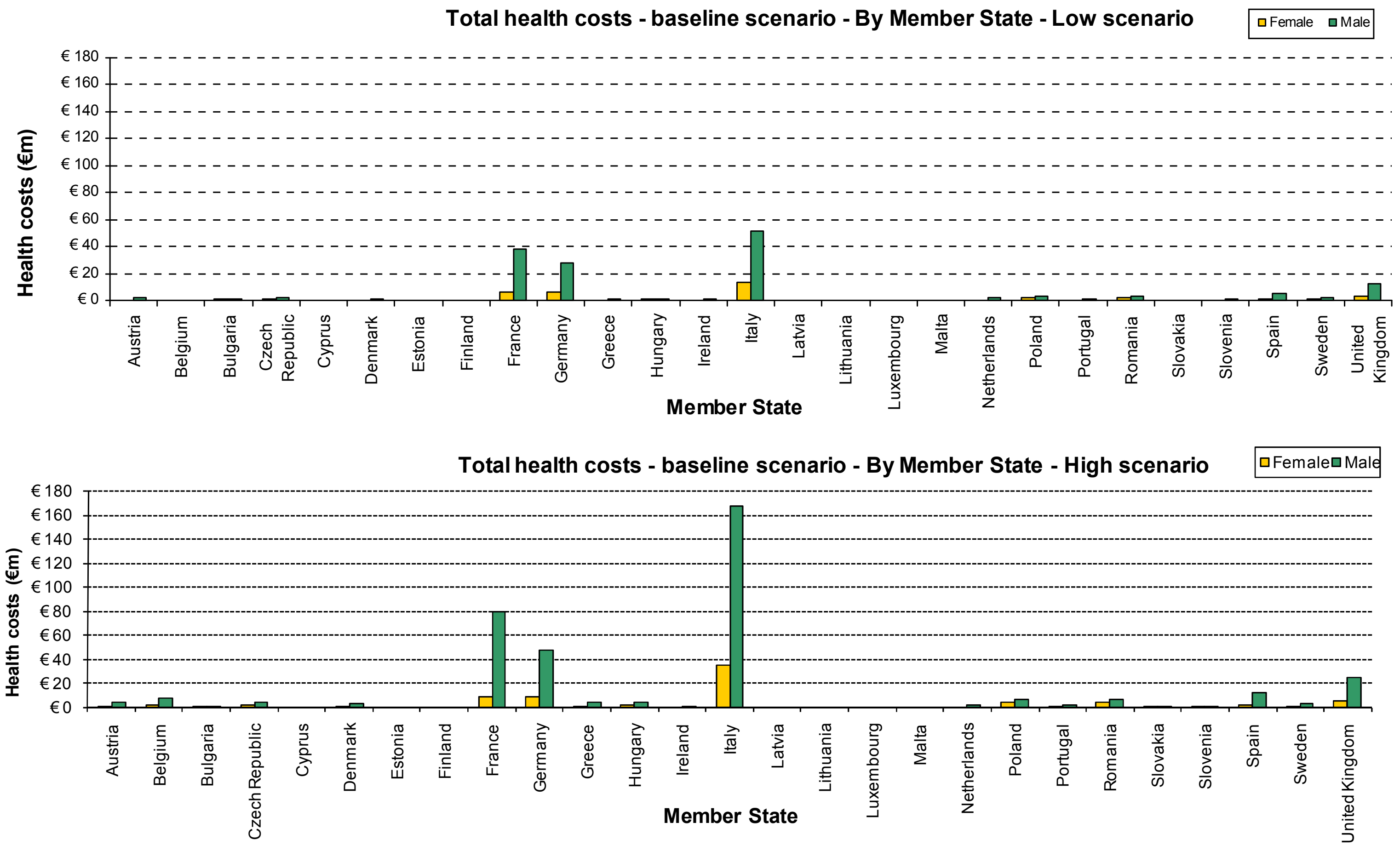


Figure 2.7 Total health costs – baseline scenario – By Member State (Present Value – 2010 €m prices)

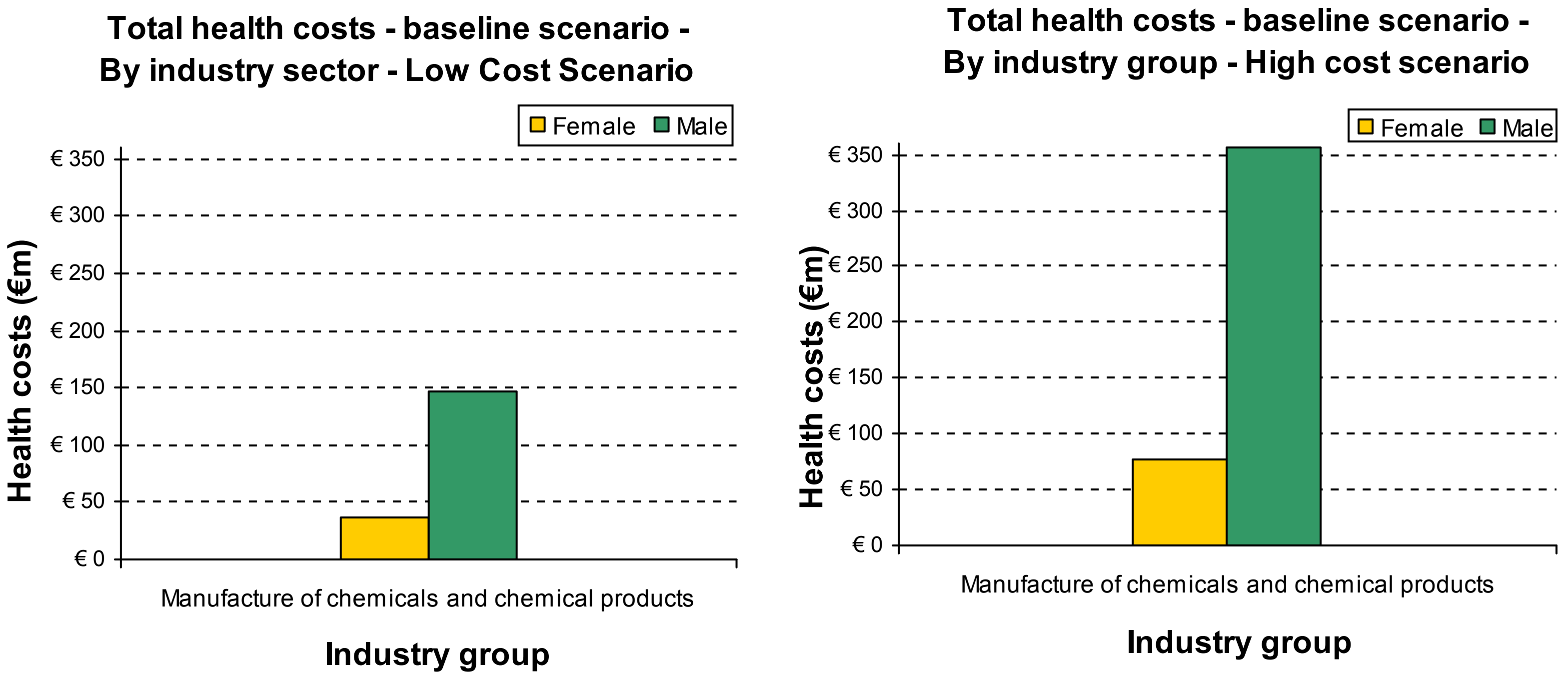


Figure 2.8 Total health costs – baseline scenario – by Industry Group (Present Value – 2010 €m prices)[15]

[15] Charts exclude industries for which zero costs are estimated

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 2.9 the effects of different discount rates on the overall results are shown, indicating that the impacts of discounting are more pronounced in the second assessment period (2020-2029). As the number of registrations and YLLs decline over time, the difference between using discounting and with no discounting becomes less evident. However, when there are more significant registrations and YLLs (as seen in years between 2010 and 2030) the impacts of discounting become more apparent.

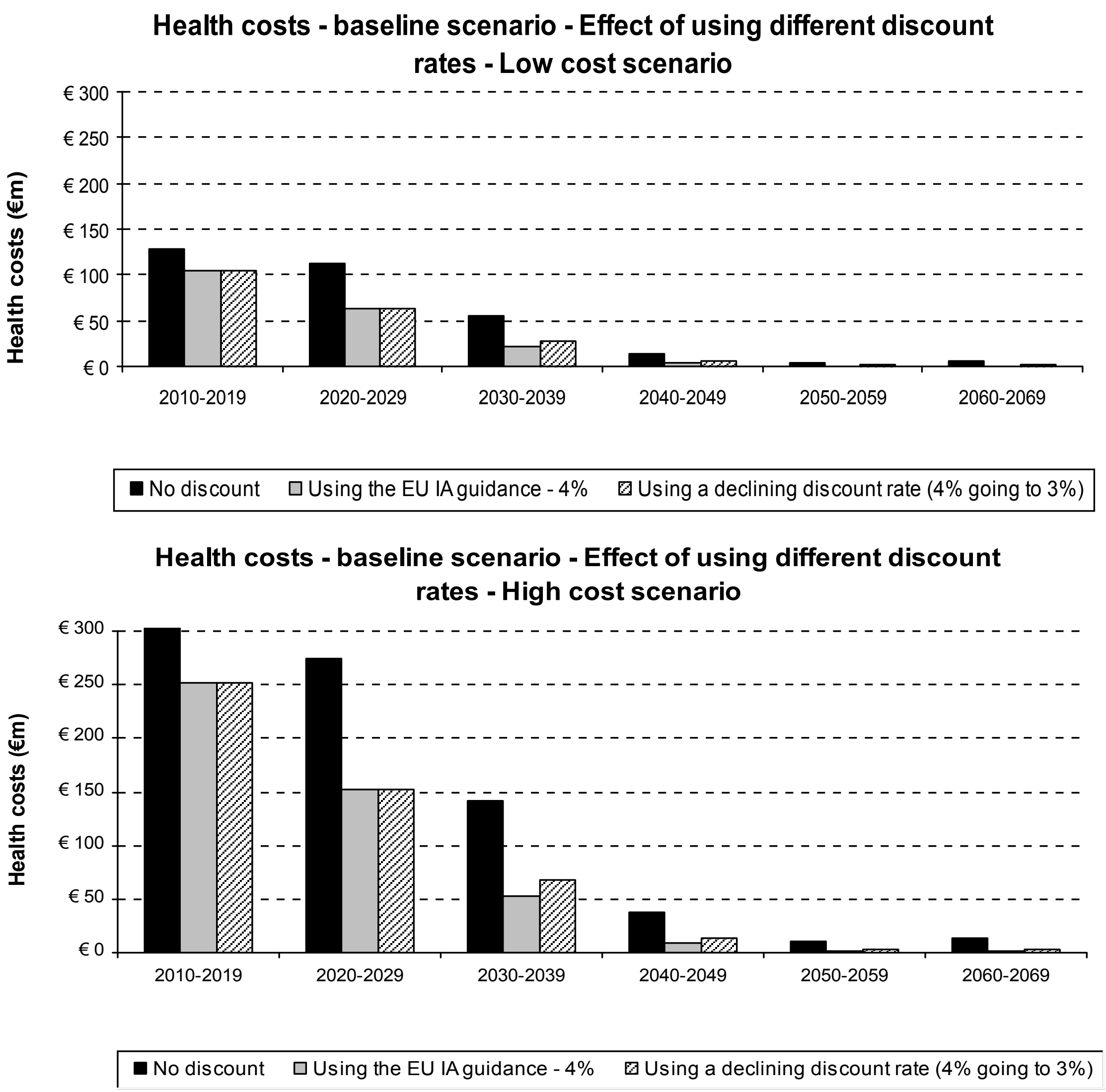


Figure 2.9 Impacts of discounting

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

Existing national OELs in EU Member States are presented in Table 3.1. OELs in countries outside the EU are also presented for information. The current OEL at the EU level is set at 3ppm. It is noted that the OEL in France is an obligatory occupational exposure limit.

This report looks at the impact of the potential implementation of an EU-wide OEL at 1 ppm or 2 ppm.

Examples of control measures to reduce exposure to VCM are summarised in Table 3.2.

Consultation with the ECVM has revealed that exposures during maintenance activities and during shutdowns are where the highest exposure levels that could be reduced by introducing stricter use and enforcement of personal protection equipment and greater ventilation or longer purging time for specific processes.

It was suggested that the implementation of improved equipment and increased ventilation and purging times can reduce occupational exposure levels to below 1ppm.

Table 3.1 Occupational Exposure Limits (time-weighted average (TWA)) in various Member States and selected countries outside the EU

Country	OEL (ppm)
Austria	2
Belgium	3
Denmark	1
France	1
Germany	3
Italy	3
The Netherlands	3
Poland	5 mg/m^{-3} (~2 ppm)
Spain	3
Sweden	1
United Kingdom	3
Canada – Quebec	1
Japan	2
Switzerland	2
USA - OSHA	1

Source: Institute for Occupational Safety and Health of the German Social Accident Insurancehttp://www.dguv.de/bgia/en/gestis/limit_values/index.jsp

Table 3.2 General measures to reduce exposure to VCM

Organisational measures	Personnel measures	Technical measures
Improvement of storage facilities to reduce fugitive emissions e.g. tank vents to be passed to the thermal / catalytic oxidiser; remote shut off valves.	Good "house keeping" procedures	Implement a formal LDAR (Leak Detection and Repair) programme
Install suitable loading/ unloading equipment to reduce fugitive emissions.	Use of personal protective equipment (PPE)	Repair pipe and equipment leaks
Implement a 'closed loop concept' production process	Use of respiratory protective equipment (RPE)	Adequate local exhaust ventilation (LEV)
Continuous monitoring of ambient air		Use of rupture disk before any pressure relief valve to ensure no leak from the valve
Purge pipes and tanks before maintenance activities		

Source: Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Large Volume Organic Chemical Industry - February 2003

In order for a plant to meet the 1 or 2ppm exposure limit, investments would be required to upgrade: exposure control, production, sampling, decommissioning, loading and unloading equipment. Engineering controls are considered the most effective way of reducing exposure to VCM[16]. Specific control measures used to limit exposure to VCM include:

- Containment/ enclosure operations;
- Rigid LDAR (leak detection and repair) regimes;
- Local exhaust ventilation (LEV);
- Respiratory protective equipment (RPE);
- Personal protective equipment (PPE);
- Closed loop vapour return systems; and
- VCM gas detectors.

In addition to the measures above, the vinyl manufacturing industry has highlighted the following measures for reducing VCM emissions during PVC production:

- Effective removal of VCM from equipment before opening;
- Effective stripping of polymer suspension;
- Improving efficiency of VCM recovery;
- Provisions to prevent accidental emissions;

[16] Inchem Health and Safety Guide on Vinyl Chloride (1999), available at: www.inchem.org/documents/hsg/hsg/hsg109.htm

- Provisions and procedures to control fugitive emissions; and
- Good "House keeping procedures"[17].

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

The exposure data presented in Figure 2.1 to Figure 2.4 indicate that GM exposure in all of the monitored plants are below the EU OEL of 3 ppm (7.67 mg/m^3) and the proposed OELs of 2 ppm (5.11 mg/m^3) and 1 pm (2.56 mg/m^3). In all but two plants, the 90th percentile TWA exposure was below 2 ppm. Eight out of thirty-two of the monitored plants (25%) had 90th percentile exposures above or approaching 1 ppm (2.56 mg/m^3) suggesting that increased exposure control measures are required if an OEL of 1 ppm is introduced. Consultation with the ECVM indicated that plants located in countries that have recently joined the EU would require the most adaptation in order to comply with an OEL of 1 ppm.

3.2.1 Current exposure control systems

Both VCM and PVC manufacturing plants aim to recover as much VCM as possible and to lose as little as possible to fugitive emissions to the inside of the plant and to the greater environment. Reductions in fugitive emissions have been accomplished using containment and LDAR (leak detection and repair) regimes. For example, rupture disks and safety valves are used to prevent leaks from relief vents. The pressure between the rupture disc and the safety valves is monitored to detect leaks. VCM emissions during loading and unloading are minimized by the use of closed-loop vapour return systems. Some loading stations also use VCM gas detectors at potential leakage points which can trigger loading shutdown if VCM emissions exceed a threshold.

Local exhaust ventilation and respiratory protective equipment are also used to reduce exposure. VCM pipes and storage tanks are typically purged prior to maintenance activities.

Medical surveillance is also used to identify workers whose health is affected by VCM exposure.

Figure 2.4 demonstrates that most (but not all) VCM and PVC plants in the EU currently control VCM exposures such that 90% of workers have TWA exposures below 1 ppm. This demonstrates that it is achievable to control exposure to comply with an OEL of 1 ppm. Implementation of improved control and/or process upgrading will be required in about 25% of the plants if they where required to comply with an OEL of 1 ppm.

[17] European Council of Vinyl Manufacturers (2009) 'On the environmental impact of the manufacture of polyvinyl chloride (PVC): A description of Best Available Techniques

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

For VCM, the introduction of two European OELs, 2 ppm (5.11 mg/m^3) and 1 ppm (2.56 mg/m^3) are to be tested. Liver cancer numbers will therefore be estimated given current EU OEL of 3 ppm (7.67 mg/m^3) and full compliance[18] with the new introductory OELs.

We present data for two "intervention" scenarios as described in Table 4.1 below, compared to the baseline trend scenario described in section 2.4.

Table 4.1 Baseline and intervention scenarios

Carcinogen	Vinyl chloride monomer (VCM)
Intervention scenarios[1]	
Baseline scenario (1)	Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m^3)
Intervention scenario (2)	Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance
Intervention scenario (3)	Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance

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

Results for the baseline scenario (1) and two intervention scenarios compared to the baseline scenario are in Figure 4.1 (attributable registrations), Figure 4.2 (for attributable fractions) and Figure 4.3 (DALYs) for men plus women for the total EU (27 countries) for liver cancer. A summary of the results for liver cancer for the total EU is in Table 4.2 below. Due to cancer latency, no effect is seen from interventions in 2010 until 2030.

Figure 4.1 shows the estimated number of registrations for liver cancer attributable to VCM exposure decreasing rapidly in the three scenarios over the next 50 years.

Figure 4.2 shows that in addition to the number of liver cancer registrations, the attributable fraction (AF) decreases over the period up to 2060. All three scenarios decrease at the same rate and by 2060 it is predicted that 0.00% of all liver cancer could be attributed to VCM expsoure, regardless of which scenario is followed.

The estimated DALYs drop from just over 200 years in 2010 to almost zero years in 2060 for all three scenarios (Figure 4.3).

Table 4.2 summarises the data shown in the previous figures. The data for the first two time periods (2010, 2020) are identical for all scenarios, and then the data for the two interventions are shown in the next two groups of four columns (2030-2060). Attributable deaths for liver cancer are predicted to decrease from 14 deaths in 2010 to zero deaths in 2060 for both intervention scenarios (2) and (3).

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

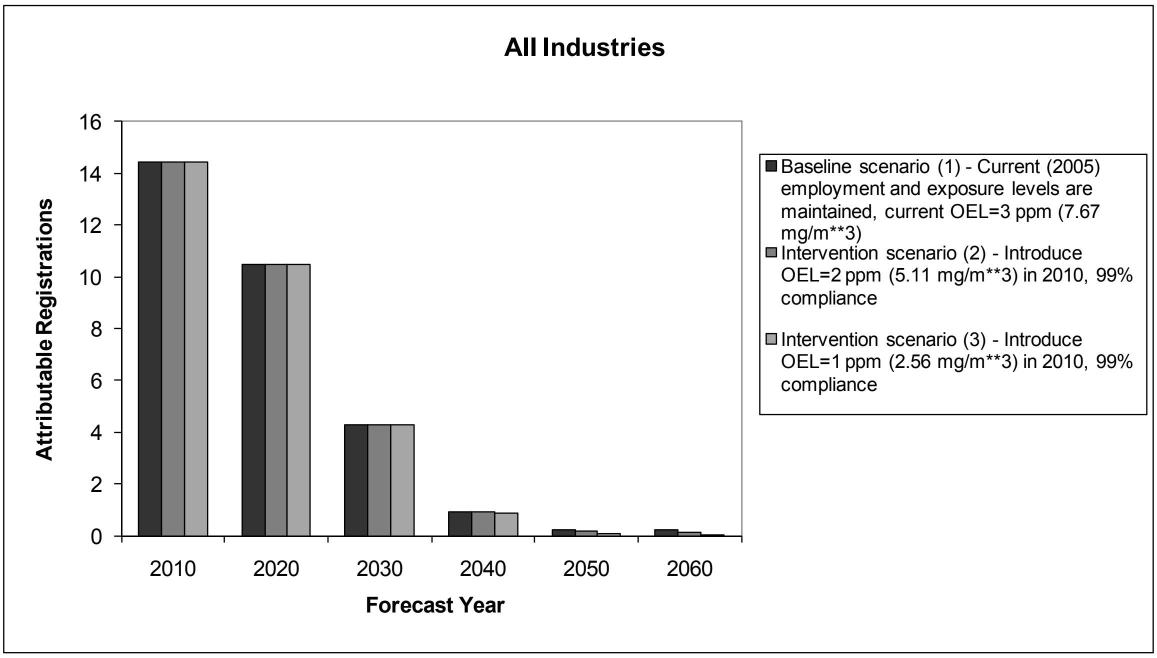


Figure 4.1 Results for baseline (1) and intervention scenarios (2) to (3) compared to the baseline scenario – Occupation Attributable cancer registrations, Liver cancer, men plus women

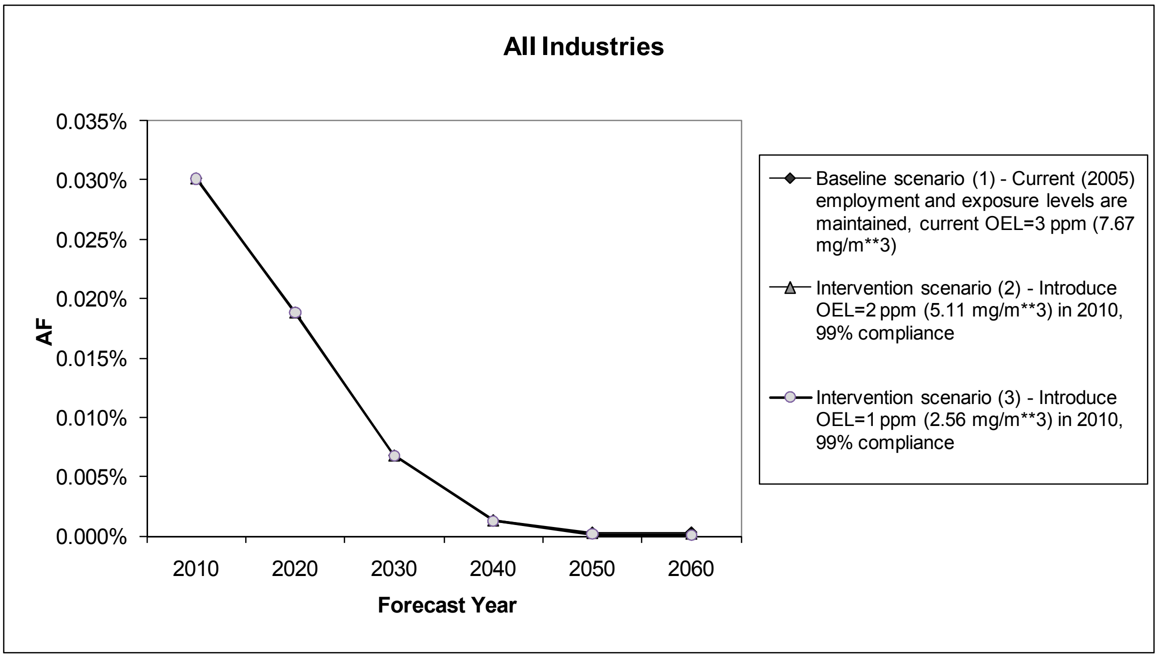


Figure 4.2 Occupation Attributable Fractions, Liver cancer

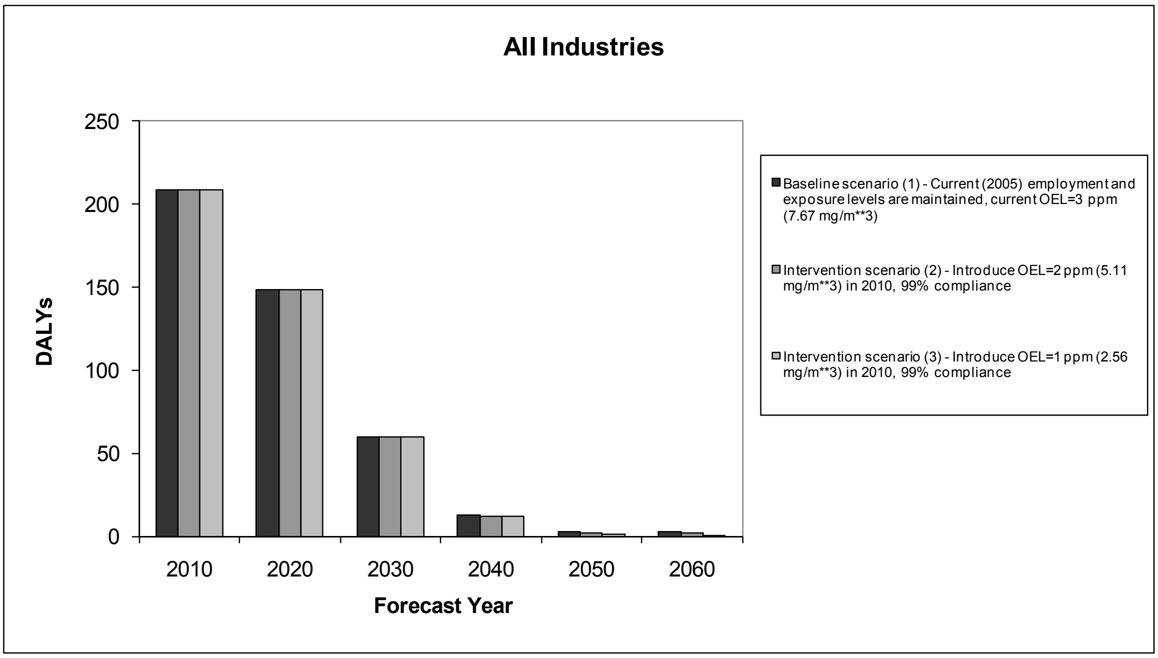


Figure 4.3 Occupation Attributable DALYs, Liver cancer

In Table 8.3.1 in Appendix 8.3 are the estimated proportions exposed above the OELs to be tested, currently and as estimated under the baseline forecast scenario (1). Under the baseline scenario (1) these proportions remain constant from 2011-20 onwards, and under the alternative change scenarios they behave as determined by the scenarios.

Full results are given in Appendix 8.3 for men plus women by country in Table 8.3.3. A breakdown of attributable numbers by industry and exposure level is in Table 8.3.5. Estimates of numbers of cancer registrations ‘avoided’ in each of the forecast target years from 2030 onwards relative to the baseline scenario can be obtained by subtraction. Data for men and women separately, and by industry within country, is in the supplementary spreadsheets (*VCM_Report Tables.xls*), if required.

Table 4.2 Results for the intervention[1] scenarios (2) to (3), total EU (27 countries), men plus women[19]

Scenario	All scenarios		Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m**3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m**3) in 2010, full compliance			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	85,029	88,452	92,092	94,072	94,982	94,982	92,092	94,072	94,982	94,982
Proportion of the population exposed	0.024%	0.023%	0.024%	0.024%	0.024%	0.025%	0.024%	0.024%	0.024%	0.025%
Liver cancer										
Attributable Fraction	0.03%	0.02%	0.007%	0.001%	0.000%	0.000%	0.007%	0.001%	0.000%	0.000%
Attributable deaths	14	11	4	1	0	0	4	1	0	0
Attributable registrations	14	10	4	1	0	0	4	1	0	0
'Avoided' cancers			0	0	0	0	0	0	0	0
YLLs	204	146	59	12	2	2	59	12	1	0
DALYs	208	149	60	12	2	2	60	12	1	0

[1] Compared to baseline scenario (1)

4.1.2 Monetised health benefits

The possible health benefits (i.e. avoided healthcare costs and effects of having cancer and avoided life years lost) for the introduction of an EU-wide OEL at 2ppm and 1ppm are shown in Table 4.3.

The change in cancer impacts over the first 30 years (2010-2040) are predominately the result of impacts from past exposure that are predicted to continue to occur in the future (these are relatively small).

The benefits of introducing an OEL in 2010 are more noticeable from 2040 onwards. Table 4.3 shows that the most stringent OEL (1ppm) assessed results in the greatest health benefits. The impacts of introducing an OEL at 2ppm are estimated to have limited benefits as there is already estimated to be a reduction towards 1ppm and below, under the baseline scenario. This means benefits from compliance with the OEL are realised slightly earlier then what would have occurred under the baseline scenario. The results are also illustrated in Figure 4.5.

[19] Deaths and registrations are rounded to the nearest whole number. Where YLLs/YLDs/DALYs appear in association with zero deaths/registrations, this is due to rounding the deaths/registrations down to zero.

Table 4.3 Health benefits of intervention over time (Present Value – 2010 €m prices)

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	Totals
Intervention scenario (2) Introduce OEL= 2ppm (5.11mg/m^3) in 2010, full compliance							
Female	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
Male	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1
Total	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1
Intervention scenario (3) Introduce OEL= 1ppm (2.56 mg/m^3) in 2010, full compliance							
Female	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
Male	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1	1 to 2
Total	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1	1 to 3

Notes:

- All costs are presented in present value using a discount rate of 4%
- Totals may not match to sums of females and male costs due to underlying small differences in raw data and rounding to nearest million

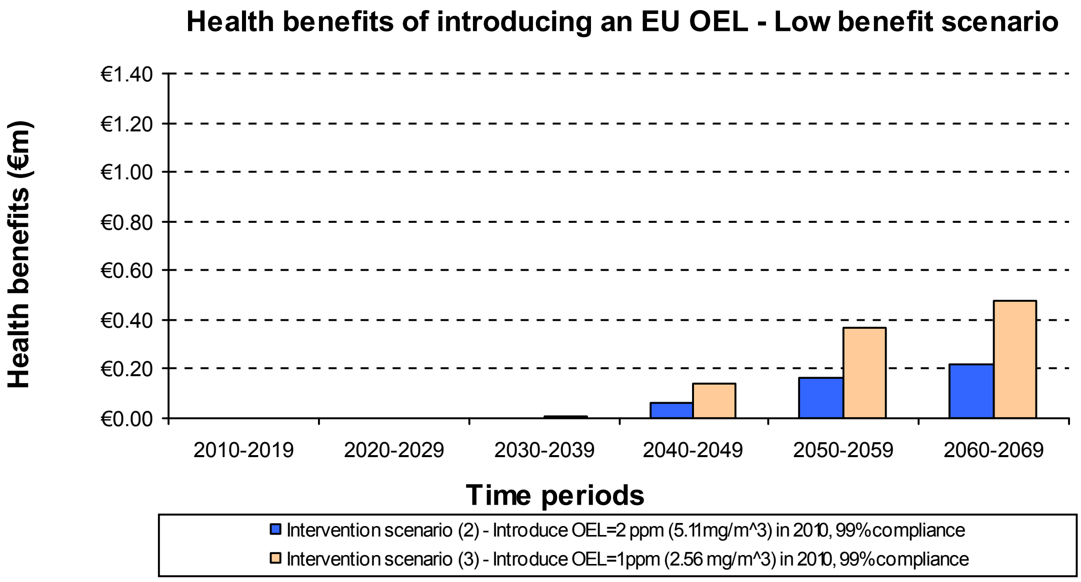


Figure 4.4 Health benefits over time of introducing an EU wide OEL (Present Value – 2010 €m prices)

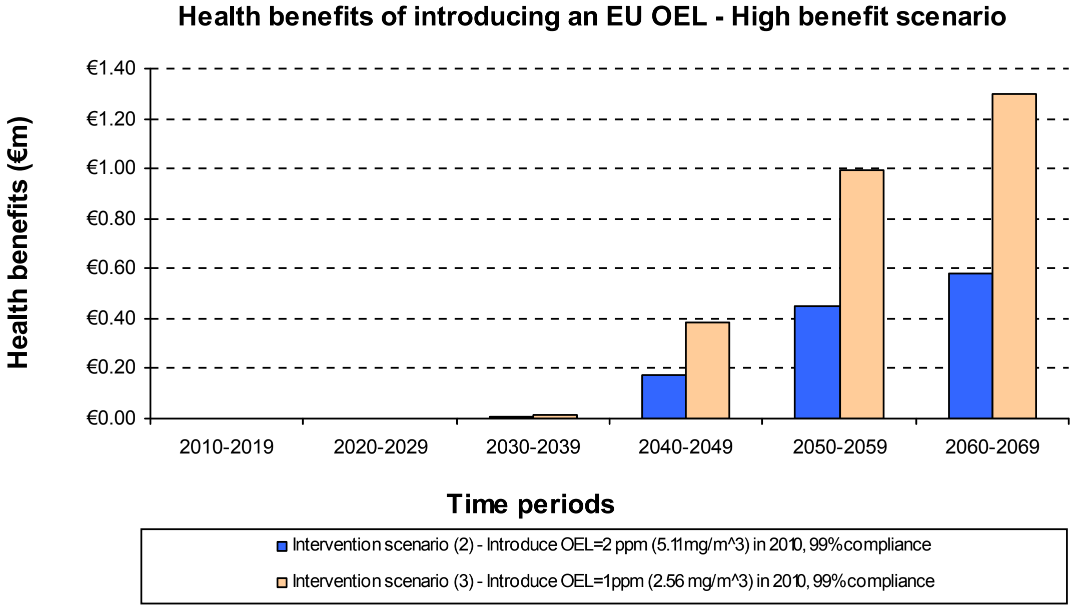


Figure 4.5 Health benefits over time of introducing an EU wide OEL (Present Value – 2010 €m prices)

These health benefits will affect Member States differently depending upon the overall number of workers within affected industry groups, existing risk management measures (RMMs) and the proportion of males and females within these groups. The total benefits by Member State are shown in Figure 4.6 (low scenario) and Figure 4.7 (high scenario), where France, Germany and Italy are predicted to particularly benefit from the OEL assuming full compliance[20]. There seems to be a general correlation between Member States that would incur health costs and those that would benefit from the introduction of an EU-wide OEL. For instance, Figure 2.7 shows that Italy is predicted to have the highest health costs without further intervention and Figure 4.6 indicates that Italy is expected to benefit the most from the introduction of an EU-wide OEL (scenarios 2 and 3).

The monetised benefits of a proposed OEL for VCM are likely to affect men more than women given PVC and VCM manufacturers employ more males than females. This is shown in Figure 4.8. The Member State and industry groups that are predicted to benefit most from a revised OEL also vary at a gender level. This analysis is presented in Appendix 8.4.

[20] The assumption of full compliance is a standard assumption used in EU Impact Assessments.

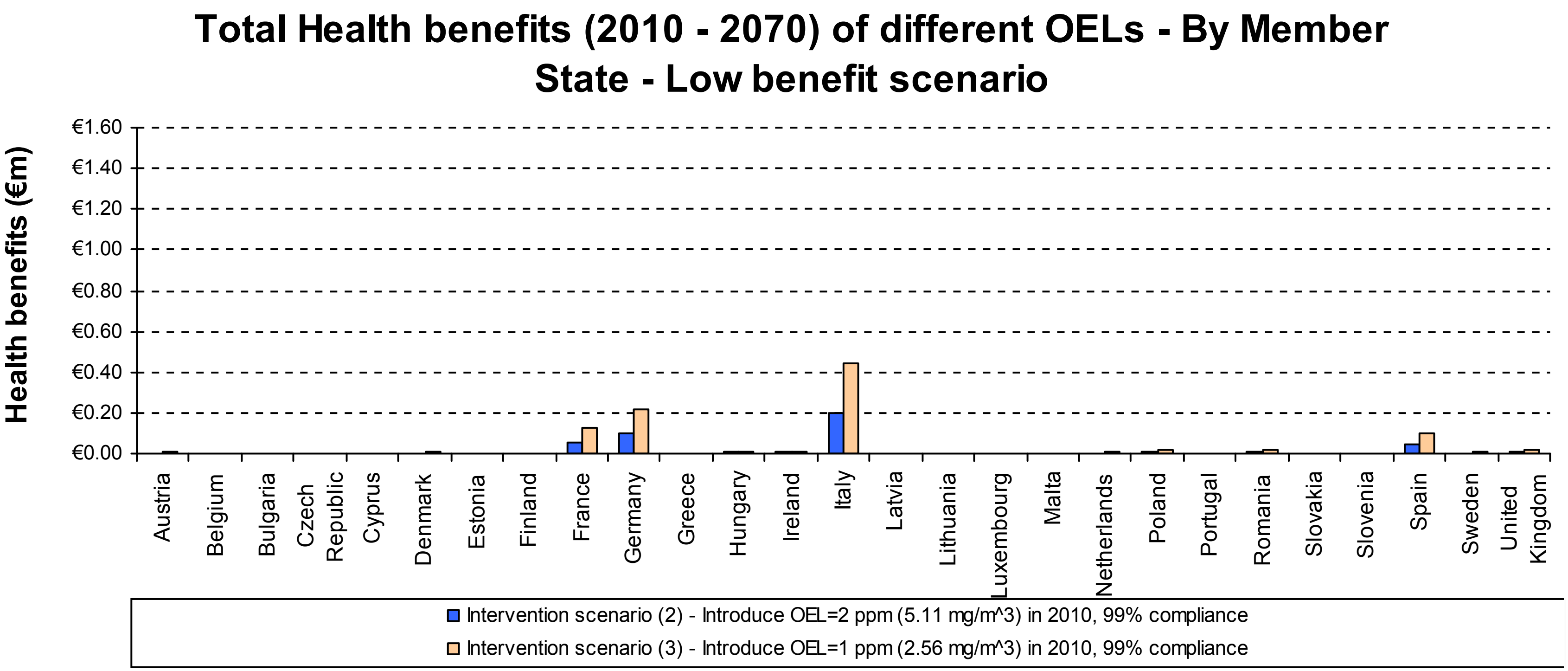


Figure 4.6 Total health benefits of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

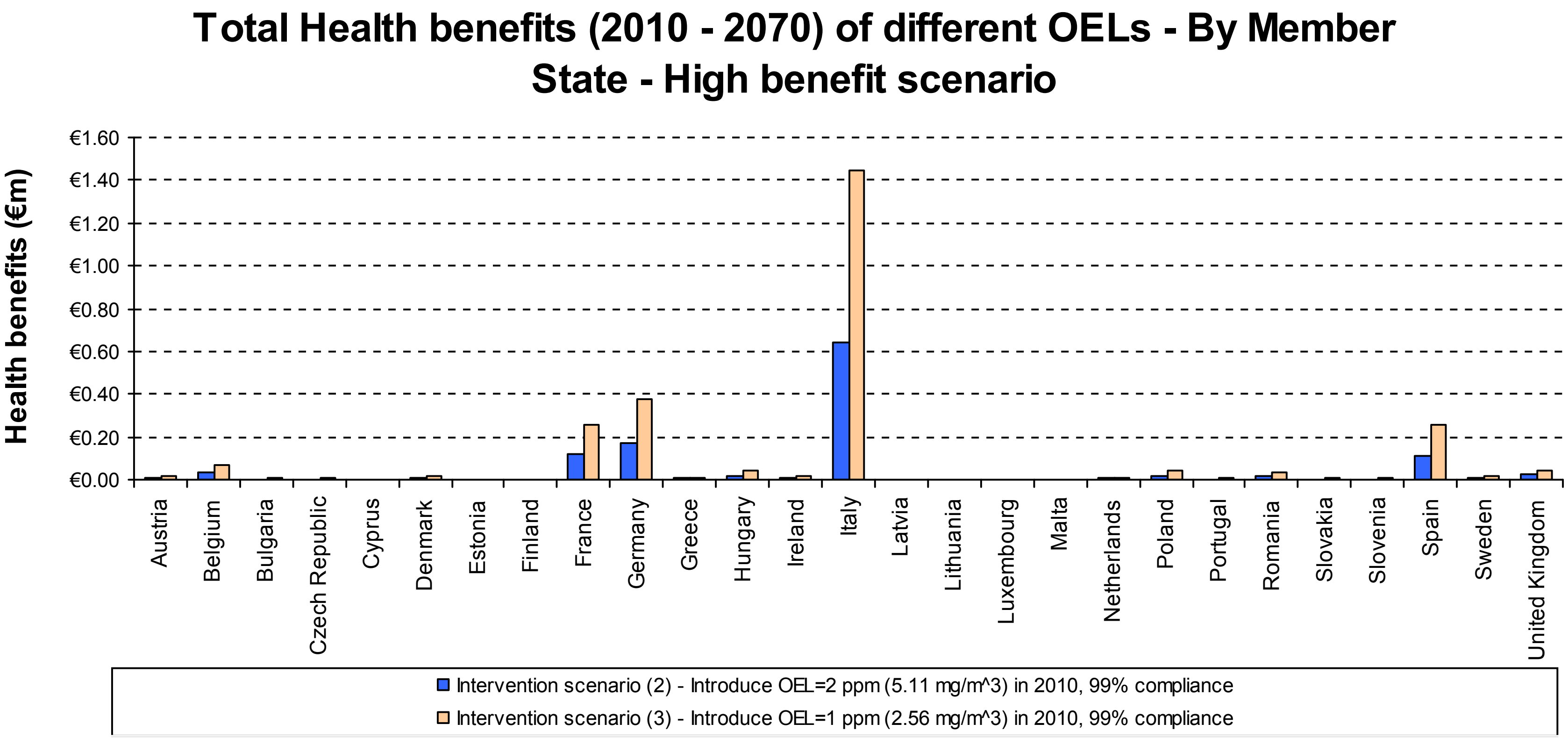
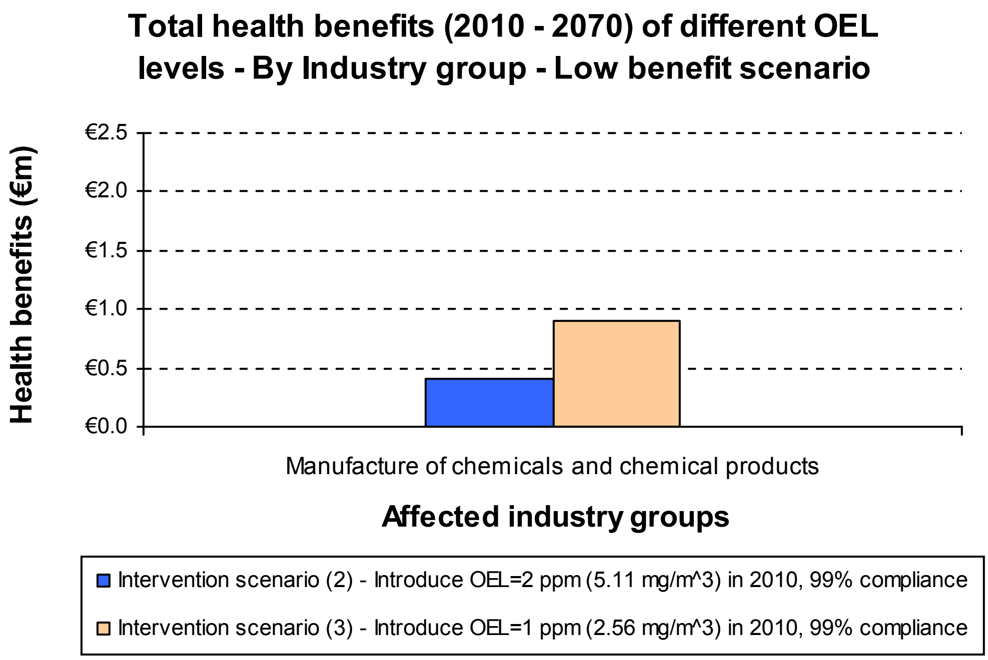


Figure 4.7 Total health benefits of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)



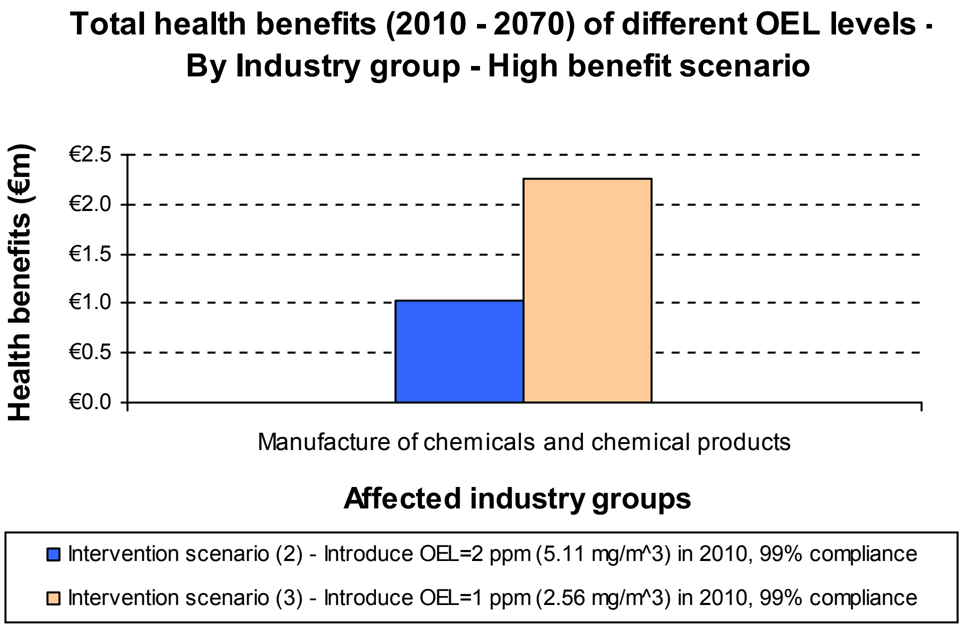


Figure 4.8 Total health benefits of introducing an EU wide OEL – By Industry Group

As with the baseline scenario, in order to present all costs and benefits consistently in present value terms, it is necessary to discount all future costs and benefits. This was done using the IA guidelines recommended 4% discount rate. Since most health impacts occur over a long period of time relative to costs, the impacts of discounting are significant. As a means of sensitivity testing, different discount rates are also used. The overall impact of discounting can be seen in:

- Figure 4.9 for introducing an OEL of 2ppm (scenario 2)
- Figure 4.10 for introducing an OEL of 1ppm (scenario 3)

Detailed tables are included in Appendix 8.5, with results presented using different discount rates.

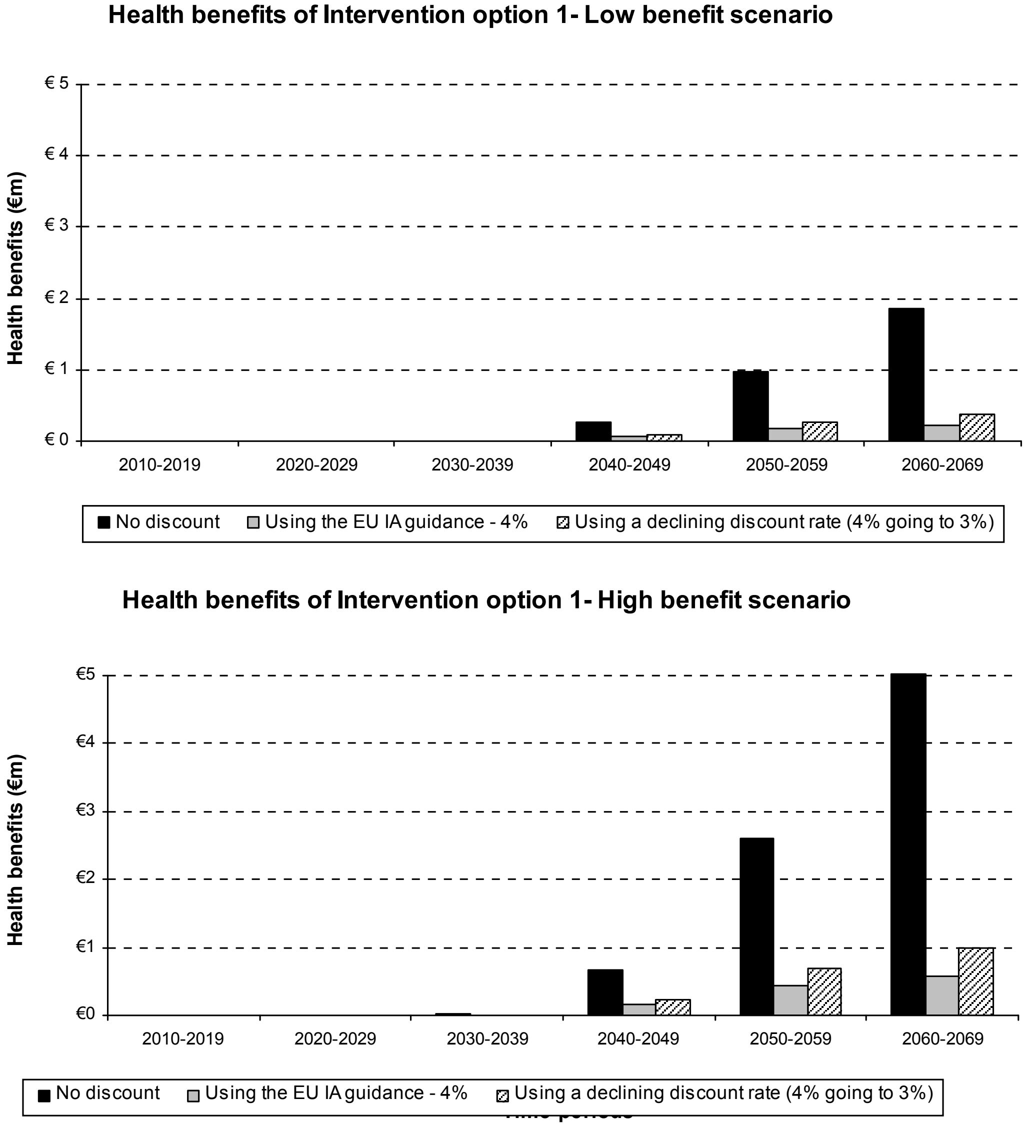
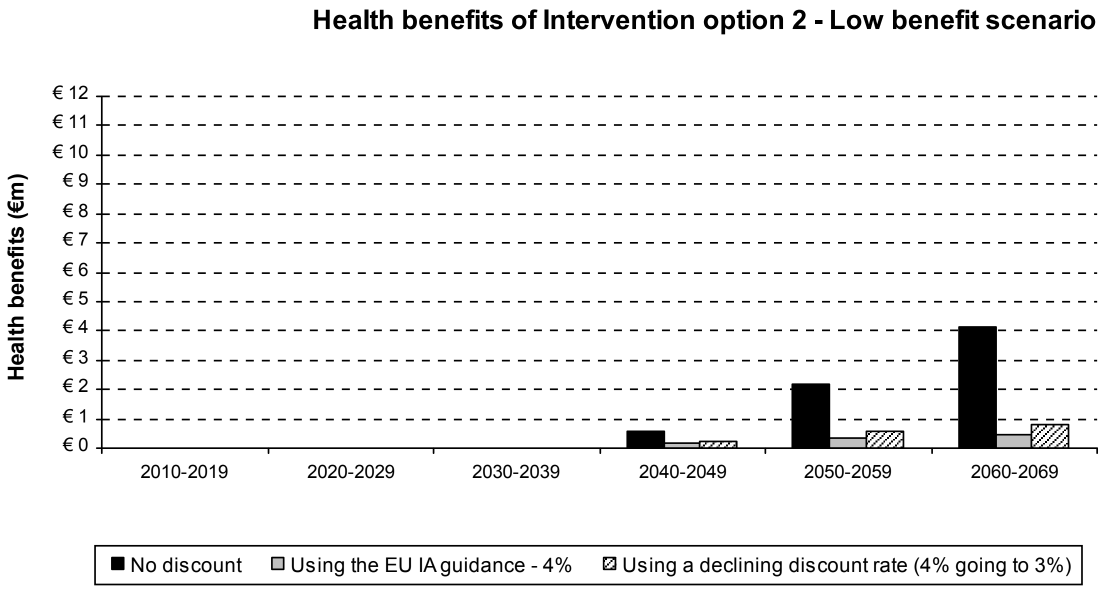


Figure 4.9 Impacts of discounting – Introducing an OEL of 2ppm



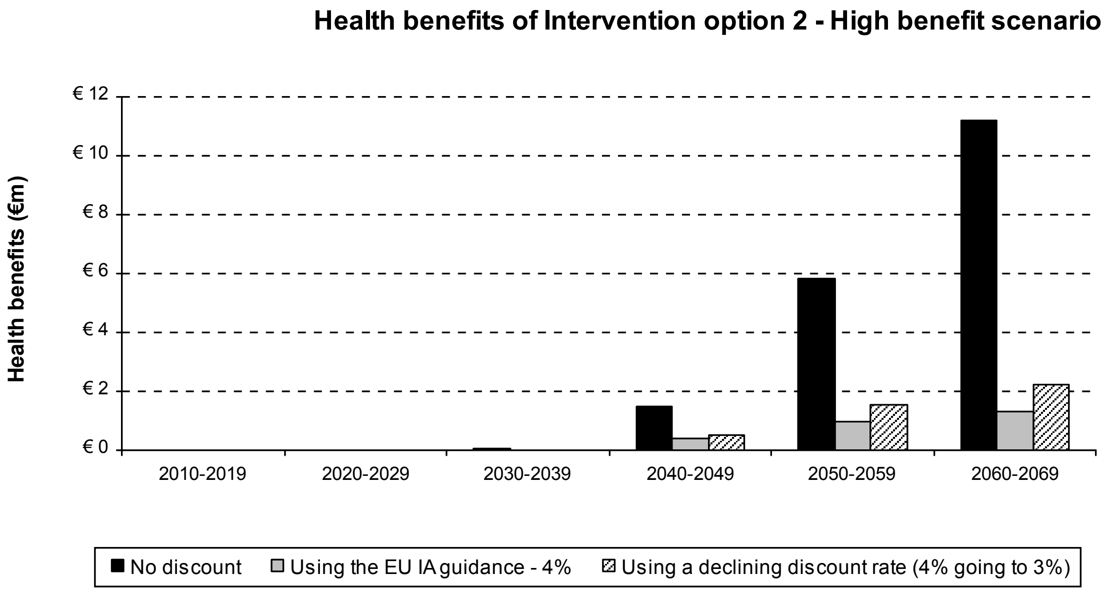


Figure 4.10 Impacts of discounting – Introducing an OEL of 1ppm

Since the benefits of introducing an EU-wide OEL are mostly realised from 2040, the level of discounting has a significant impact on the overall size of health benefits. A limitation is that the benefits of any risk reduction measures undertaken post 2040 will not be included in this study, since the benefits of these measures to reduce occupational exposure in 2040-2070 are unlikely to be realised until after 2070 (due to the lag period in the development of cancer), a period which is not estimated in this study.

4.2 ECONOMIC IMPACTS

4.2.1 Operating costs and conduct of business

Compliance costs

According to the ECVM, workers exposed to VCM will be those involved in: VCM manufacture, PVC manufacturing, VCM transport and plant laboratory analyses[21]. ECVM estimates there are 50 – 100 workers typically exposed to VCM at VCM manufacturing and polymerisation sites; the total number of exposed workers in the EU and Norway is in the range 5,000 – 10,000[21].

The exposure data presented in Section 2.3 indicated that:

- 6% of plants had 90th percentile exposure above 2ppm; and
- 25% of plants had 90th percentile exposures above 1ppm.

It is estimated that there are between 30-40 PVC plants in the EU (see Section 2.1). A study conducted in 2004 found that every PVC plant has on average 200 employees employed in PVC production[22]. However, the European Commission (2000) estimates that 90% of PVC plants have less than 100 employees[23]. This information has been used to help determine the number of enterprises that will currently comply with the proposed OELs (see Table 4.4). As set out in the exposure data and health cost modelling, the number of firms with exposure currently exceeding the proposed OELs is expected to fall over time.

Table 4.4 Estimated number of enterprises with exposure currently exceeding the proposed OELs in affected industries

Sector (NACE code)	Option 1 – Assume full compliance for OEL = 2ppm			Option 2 – Assume full compliance for OEL = 1ppm		
	No. of workers affected	No. of enterprises affected	No. of enterprises not affected	No. of workers affected	No. of enterprises affected	No. of enterprises not affected
Manufacture of chemicals and chemical products (24)	400	2	28	1,600-2,000	8-10	20-22
Proportion of total (%)		**6%**	**94%**		**25%**	**75%**

It is estimated that an EU-wide OEL of 2ppm would affect only two PVC plants, whilst an OEL of 1ppm would affect between eight and ten enterprises.

The costs of upgrading equipment to meet the 1ppm exposure limit could be up to €2.5million per VCM/PVC production site; the costs to meet the 2ppm limit would be

[21] Questionnaire response from the European Council of Vinyl Manufacturers on the 2nd November 2009.
[22] PE Europe GmbH (2004) 'Life Cycle Assessment of PVC and of principal competing materials'
[23] European Commission (2000) Green Paper, Environmental issues of PVC, COM(2000) 469 final, Brussels 26th July 2007

approximately 10% of this figure (€0.25m)[24]. Maintenance costs would also increase because additional measures would have to be taken and more preventative maintenance would be required (i.e. small repair of small leakages of valves, pump seals, flanges, and gaskets); these costs could be €50-100 thousand per year per plant. Increasing the ventilation or purging time during maintenance activities or shutdowns would result in several days of production loss per year; these costs could be €250-500 thousand per year per plant.

Based on exposure data and as indicated in Table 4.2, it is reasonable to make the following observations (assumptions):

- Most firms within affected industries would meet the most stringent proposed OEL (1ppm) given that the geometric mean exposure is 0.14 mg/m^3 (0.05 ppm) and the geometric standard deviation is 5.28.
- Currently some firms within affected industries would require further control measures to meet each proposed OEL given that 90^{th} percentile data indicates exposure above 2ppm.

It is estimated that under the baseline scenario, firms are already moving towards complying with the 1ppm OEL. It is estimated that the cost of compliance with an OEL of 2ppm may be in the region of €15m to €30m over the period 2010-69 if there are annual shutdowns. If it is assumed that there are no additional annual production shutdowns for several days for maintenance, the costs could be lower at around €3 to €5m over the period 2010-69.

The impact of introducing an EU wide OEL of 1ppm is that reductions in exposure will be achieved sooner than planned (i.e. investment will be made earlier than planned). It is estimated that the cost of compliance may be in the region of €90m to €185m over the period 2010-69 if there are annual shutdowns. If it is assumed that there are no additional shutdowns, the costs could be lower at around €40 to €65m over the period 2010-69. The costs of compliance are summarised below in tables below (Table 4.5 and Table 4.6).

Table 4.5 Estimated costs of compliance with an OEL of 2ppm

Number of enterprises affected	Type of cost	Annual cost (€m) - 2010 Low	Annual cost (€m) - 2010 High	Cost over period 2010-69 (€m) Low	Cost over period 2010-69 (€m) High
2	Investment	€ 0.0	€ 0.0	€ 0.8	€ 0.8
2	Maintenance	€ 0.1	€ 0.2	€ 2.4	€ 4.7
2	Shutdown - Lost production	€ 0.5	€ 1.0	€ 11.8	€ 23.5
	Total	€ 0.6	€ 1.2	€ 14.9	€ 29.1
	Total (no shutdown)	€ 0.1	€ 0.2	€ 3.2	€ 5.5

Note: Costs over time are discounted using a 4% discount rate. Investment costs were annualised based on a 20 year lifetime for equipment. Costs are based on an indicative estimate of the number of firms affected. In practice, the number of enterprises affected could be higher or lower.

[24] Questionnaire response from the European Council of Vinyl Manufacturers on the 2nd November 2009.

Table 4.6 Estimated costs of compliance with an OEL of 1ppm

Number of enterprises affected			Annual cost (€m) - 2010		Cost over period 2010-69 (€m)	
Low	**High**	**Type of cost**	**Low**	**High**	**Low**	**High**
8	10	Investment	€ 1.5	€ 1.8	€ 33.3	€ 41.6
8	10	Maintenance	€ 0.4	€ 1.0	€ 9.4	€ 23.5
8	10	Shutdown - Lost production	€ 2.0	€ 5.0	€ 47.1	€ 117.6
		Total	€ 3.9	€ 7.8	€ 89.8	€ 182.8
		Total (no shutdown)	€ 1.9	€ 2.8	€ 42.7	€ 65.1

Note: Costs over time are discounted using a 4% discount rate. Investment costs were annualised based on a 20 year lifetime for equipment. Costs are based on an indicative estimate of the number of firms affected. In practice, the number of enterprises affected could be higher or lower.

Consultation with the European Council of Vinyl Manufacturers (ECVM)[24] suggests that for the majority of European VCM/PVC manufacturers the cost of introducing the preventative measures detailed above would not on their own adversely affect capacity investment, drive relocation or impact R&D and employment significantly. However, ECVM note that these additional compliance costs could impact more heavily the VCM and PVC sites in countries that have recently joined the EU (e.g. Czech Republic, Romania, Slovakia, Hungary and Poland). However, it is expected that these investment would occur under the baseline but as suggested, not necessarily as soon as planned.

Conduct of employers

The introduction of an EU-wide OEL below 3ppm may require certain enterprises to reorganise their workplace to ensure that exposure to VCM emissions is minimised. There may also be additional training and authorisation of personnel handling the substance required to ensure that employees minimise their exposure by adhering to good practice in order to reduce exposure (e.g. good personal hygiene, wearing protective clothing, cleaning procedures and safety instructions). However it is expected that these activities would occur under the baseline but as suggested, not necessarily as soon as planned.

Potential for closure of companies

The ECVM suggests there are no substitutes to VCM for VCM production and production is expected to increase in the future[25]. Therefore there is not expected to be any potential closure of companies as a result of introducing the OEL, even if there might be an increase in compliance costs maybe occurred sooner relative to the baseline scenario.

[25] It is noted here that this does not necessarily mean there is not any alternatives to PVC for end products or alternatives to those products that contain PVC. In this instance, an analysis of possible alternatives was not deemed necessary given there are estimated to be minimal economic costs to comply with either OEL of 2 or 1pmm (relative to the baseline scenario costs).

Potential impacts for specific types of companies

Based on consultation with ECVM[26] any potential increase in compliance costs or timing of costs (relative to the baseline) is unlikely to have any significant impacts, since firms may be able to pass through costs (given there may not be any substitutes). However, sites located in Member States which have recently joined the EU could be more affected[26].

Administrative costs to employers and public authorities

The following table (Table 4.7) describes the administrative burden to employers already subject to the Carcinogens Directive but will now incur costs of modifying the OEL already listed in Annex III of the Carcinogens Directive.

Table 4.7 Administrative burdens to employers

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Change in practice to use 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
2. 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	Firms will already have been required to develop/update health and safety and best practice guidance. The guidance and procedures may be required to be updated as control measures may change in light of a more stringent OEL. 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.	Low
3. Additional costs of training new and existing staff in line with requirements of the Directive 4. Additional costs of making information available to employees	11 – Information and training of workers 12 – Information for workers	Firms will already have been required to ensure training and adequate aware of risks and control measures to reduce/minimise exposure.	Low
5. Consultation with employees on compliance with the Directive	13 – Consultation and participation with workers	Largely one-off cost if the revised OEL requires a change in control measures/working practice.	

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.

[26] Questionnaire response from the European Council of Vinyl Manufacturers on the 2nd November 2009.

The following table (Table 4.8) describes the administrative burden to competent authorities already enforcing the Carcinogens Directive but will now incur costs of modifying the OEL already listed in Annex III of the Carcinogens Directive.

Table 4.8 Administrative burdens to Competent Authorities

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Communication with the Commission on provisions in national law to enforce the revised OEL. 2. Time and costs of implementing revised OEL into national law (consultation process)	19 – Notifying the commission 20 – Repeal	Largely one-off cost of transposing the revised OEL into national law	Low - 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.

4.2.2 Impact on innovation and research

Consultation with ECVM[26] suggests that impacts on innovation and research from introducing an EU-wide OEL are estimated to be minimal.

4.2.3 Macroeconomic impact

In 2007, 7.2 million tonnes of VCM was produced in the EU 27 and Norway[26]. The downstream price of PVC has fluctuated between €800 and €1,100/tonne between 2004 and 2007, therefore the European PVC market can be valued at between €5,760 and €7,920 million per annum. The demand for PVC and therefore VCM grew at a rate of 1% per annum during the period 2000-2007; this trend is not expected to continue due to the current economic crisis but growth is expected once the economic situation improves[27].

Short term spending on risk management measures may also be good for the economy as equipment manufacturers (ventilation systems, equipment to support LDAR), installers and others will benefit with money flowing through the economy, if the alternative is that profits are retained (by shareholders or the company and not spent e.g. on R&D, meaning the wider economy would not benefit from increased spending). However, since it is expected that these risk management measures would occur under the baseline, there is not expected to be any macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.

With fewer life years lost and cancer registrations, there might be an economic benefit (for VCM and PVC manufacturers and employees) through avoided loss of output and consumption in the future (post-2040), for example due to greater productivity from fewer sick days as well as greater consumption due to fewer premature deaths and greater taxes raised. However, at a macroeconomic level any benefit would be negligible.

[27] Questionnaire response from the European Council of Vinyl Manufacturers on the 2nd November 2009.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

Based on consultation with ECVM[27], there are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of equipment modifications.

The use of ventilation systems for some enterprises would require behavioural change amongst workers and employees to ensure that, once installed, ventilation systems are being correctly used and maintained. This may require updating health and safety training. In terms of working conditions, the use of mechanical local ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled, and thermal environmental conditions maintained at more acceptable levels. One of the disadvantages of using mechanical ventilation is heat loss, especially in colder regions. If the mechanical ventilation includes a heat exchanger with high efficiency, this might typically reduce the ventilation heat loss by 80-90% and the total heat loss by 30-60%, depending on the insulation level[28].

4.3.2 Changes in end products

99.9% of VCM is used in the production of PVC. This is not expected to change from the introduction of an EU-wide OEL relative to the baseline scenario.

4.4 ENVIRONMENTAL IMPACTS

Information reported in the OECD Screening information data set (SIDS) for vinyl choride[29] reports that vinyl chloride has a vapour pressure of 3330 hPa at 20^{o}C, a water solubility value of 1.1 g/l at 20^{o}C and a log P_{ow} of 1.58 at 22^{o}C. In a soil and water microorganism study, vinyl chloride was biodegraded at 30% after 40 days and 99% after 108 days and has a low bioaccumulation potential. Environmental releases of vinyl chloride are almost exclusively to the air compartment. Fugacity modelling indicated that of the vinyl chloride released >99% will remain in the air compartment. The dominant removal process in the atmosphere is photoxidation with a calculated half-life of 2.2 – 2.7 days. The 96 hour LC_{50} ranges from 210 to > 1000mg/l for fish (from four studies). The estimated (QSAR[30]) value for algae EC_{50} (96hr) is 118 mg/L and the LC_{50} (48 hr) for *Daphnia* is 196 mg/L. Toxic concentrations of vinyl chloride are not expected to be reached in aquatic systems based on low emissions, low bioaccumulation potential and high volatility.

Taking the above information into consideration and the evidence that controls on VCM in the workplace that would be needed to meet the proposed OELs have largely been done, it is not expected that achievement of the OELs would lead to additional environmental impact.

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[28] "Mechanical ventilation with heat recovery in cold climates" - http://web.byv.kth.se/bphys/reykjavik/pdf/art_157.pdf. (Note that this is in relation to housing rather than industrial buildings.)

[29] OECD SIDS vinyl chloride UNEP publications 2001

[30] Quantitative structure activity relationship

5 COMPARISON OF OPTIONS

The main identified impacts of introducing an OEL of 1 or 2ppm are shown in Table 5.1.

Table 5.1 Comparison of options (Present Value – 2010 €m prices)

	Introduce OEL=2ppm		Introduce OEL=1ppm	
Type of impact	**Costs**	**Benefits**	**Costs**	**Benefits**
Health	None - There is expected to be a cost saving from avoided health care and reduced cost of illness due to reductions in cancer registrations. This has been estimated as a benefit.	Health benefits of the proposed OEL have been analysed at the Member State and industrial sector level. The results showed that the benefits of introducing an OEL in 2010 are most apparent from 2040 onwards. It was also found that the monetised benefits are likely to affect men more than women given the VCM and PVC manufacturers employ more men. The monetised benefits were estimated as: ○ Females: < €1m ○ Males: < €1m ○ Totals: < €1m The impacts of introducing an OEL at 2ppm are estimated to have limited benefits as there is already estimated to be a reduction towards 1ppm under the baseline scenario. There is also avoided health costs post-2070, which is not quantified in this study, but again this is expected to be small.	None - There is expected to be a cost saving from avoided health care and reduced cost of illness due to reductions in cancer registrations. This has been estimated as a benefit.	The monetised benefits were estimated as: ○ Females: < €1m ○ Males: €1-2m ○ Totals: €1-3m The impacts of introducing an OEL at 1ppm again are estimated to have limited benefits as there is already estimated to be a reduction towards 1ppm under the baseline scenario. There is also avoided health costs post-2070, which is not quantified in this study, but again this is expected to be small.
Economic	It is estimated that under the baseline scenario, firms are already moving towards complying with the	Having an EU-wide OEL level should remove any EU competitive distortions between EU Member States with different OELs.	The impact of introducing an EU wide OEL of 1ppm is that reductions in exposure will be achieved sooner than planned	Having an EU-wide OEL level should remove any EU competitive distortions between EU Member States with different

Type of impact	Introduce OEL=2ppm Costs	Introduce OEL=2ppm Benefits	Introduce OEL=1ppm Costs	Introduce OEL=1ppm Benefits
	1ppm OEL. It is estimated that the cost of compliance with an OEL of 2ppm may be in the region of €15m to €30m over the period 2010-69 if there are annual shutdowns. If it is assumed that there are no additional shutdowns, the costs could be lower at around €3 to €5m over the period 2010-69.		(i.e. investment will be made earlier than planned). It is estimated that the cost of compliance may be in the region of €90m to €185m over the period 2010-69 if there are annual shutdowns. If it is assumed that there are no additional shutdowns, the costs could be lower at around €40 to €65m over the period 2010-69.	OELs.
Social	Based on consultation with ECVM, there are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of equipment modifications for both proposed OEL scenarios.			
Marco-economic	Since investment in risk management measures would occur under the baseline, there is not expected to be any macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL. With fewer life years lost and cancer registrations, there might be an economic benefit (for VCM and PVC manufacturers and employees) through avoided loss of output and consumption in the future (post-2040), for example due to greater productivity from fewer sick days as well as greater consumption due to fewer premature deaths and greater taxes raised. However, at a macroeconomic level any benefit would be negligible for both proposed OEL scenarios.			
Environmental	None – it is expected that the imposition of measures would not cause additional environmental impacts.	It is not expected that the measures for human health would lead to any additional environmental benefit.	None – it is expected that the imposition of measures would not cause additional environmental impacts.	It is not expected that the measures for human health would lead to any additional environmental benefit.

6 CONCLUSIONS

We estimate that in 2006 about 18,987 workers in the EU were exposed to VCM with most exposed workers being involved in chemicals manufacture and a smaller proportion of exposed workers being involved in the production of plastic and rubber goods. The estimated geometric mean of current exposure levels is 0.14 mg/m^3 (0.05 ppm) and it is believed that exposures have fallen substantially since the 1970s when reported concentrations frequently exceeded 50 mg/m^3 (20 ppm).

We estimate that in 2010 in the EU there will be about 14 deaths from liver cancer and a similar number of registrations that might be attributable to past exposure to VCM, which corresponds to about 0.03% of all liver cancer deaths amongst the exposed workers. If no specific actions are taken to reduce exposure to VCM, based on the assumption that current employment and exposure levels are maintained, the predicted numbers of liver cancer deaths in 2060 attributable to VCM would be 0 with a predicted 3 years loss of life expectancy (YLLs/DALYs). The introduction of an OEL of I or 2 ppm would lead to reductions in the YLLs/DALYs to 0 or 2 respectively. The total net health benefits from setting an OEL at 2 ppm are estimated to be €0m and the benefits associated with an OEL of I ppm are estimated between €1m and €3m.

There is already an EU-wide OEL in place for VCM of 3 ppm and a number of Member States have set national OELs at 1 or 2 ppm. The 90th percentile of exposure in most plants is already below 2ppm, whereas the 90th percentile of exposure is only below 1 ppm in about a quarter of plants for which data are available. Consultation with the industry association (ECVM) indicated that plants located in countries that have recently joined the EU would require the most adaptation in order to comply with an OEL of 1 ppm. The main additional risk management measures required are upgrades to manufacturing equipment and increased maintenance in order to reduce leaks. The main costs associated with these measures arise from lost production time.

It is considered that under the baseline scenario, firms are already moving towards complying with the 1ppm OEL. It is estimated that the cost of compliance with an OEL of 2ppm may be in the region of €15m to €30m over the period 2010-69 if there are annual shutdowns. If it is assumed that there are no additional shutdowns in production, the costs could be lower (from the avoided loss of production) at around €3 to €5m over the period 2010-69.

It is assumed that the impact of introducing an EU wide OEL of 1ppm is that reductions in exposure would be achieved sooner than would otherwise have occurred (i.e. investment would be made earlier than planned). It is estimated that the cost of compliance may be in the region of €90m to €185m over the period 2010-69 if there are annual shutdowns. If it is assumed at there are no additional shutdowns in production, the costs could be lower at around €40 to €65m over the period 2010-69.

There is a ready market for VCM and no plant closures are expected to result from the implementation of a more stringent OEL.

There are no significant environmental impacts foreseen.

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8 APPENDIX

8.1 ESTIMATED DEATHS AND REGISTRATIONS IN THE EU FROM VINYL CHLORIDE MONOMER

Table 8.1.1 Forecast number of liver cancers in ages 25+ (ages 15+ for registrations), based on projected EU country populations

Liver Cancer Deaths	*Men*						*Women*					
FTY	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Austria	586	724	875	986	1,071	1,075	301	340	402	467	507	505
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	580	599	644	683	704	704	369	395	417	435	447	443
Cyprus	26	37	51	65	80	99	18	24	32	40	47	56
Czech Republic	605	727	882	998	1,081	1,144	348	401	478	519	551	595
Denmark	222	267	306	323	332	340	108	130	155	174	184	184
Estonia	41	44	50	55	60	66	42	46	48	52	55	54
Finland	272	349	421	442	446	465	189	222	267	291	291	290
France	5,892	7,093	8,343	9,202	9,655	10,044	2,057	2,352	2,784	3,204	3,382	3,415
Germany (including ex-GDR from 1991)	4,762	5,692	6,488	7,184	7,229	6,924	2,478	2,802	3,058	3,411	3,547	3,333
Greece	1,032	1,203	1,381	1,623	1,826	1,906	578	714	792	925	1,055	1,113
Hungary	443	496	560	617	676	705	304	334	375	402	417	446
Ireland	111	152	202	259	323	375	91	118	157	201	246	288
Italy	6,827	8,006	9,310	10,725	11,575	11,460	3,642	4,161	4,694	5,375	5,940	5,925
Latvia	87	93	104	118	127	133	56	56	58	61	60	59
Lithuania	91	99	117	134	145	154	68	73	81	93	97	99
Luxembourg	23	32	41	52	62	67	12	14	18	23	28	31
Malta	12	16	18	20	21	22	5	7	9	10	11	11
Netherlands	374	478	587	656	677	664	222	267	329	378	393	380
Poland	1,127	1,363	1,690	1,932	2,106	2,287	1,028	1,213	1,454	1,676	1,737	1,854
Portugal	523	610	713	817	905	951	215	253	290	331	368	388

Liver Cancer Deaths	Men						Women					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Romania	1,656	1,828	2,104	2,378	2,570	2,593	909	1,003	1,134	1,268	1,378	1,425
Slovakia	232	301	364	424	476	486	166	197	243	297	321	354
Slovenia	108	138	164	181	187	181	67	79	91	106	111	112
Spain	3,203	3,905	4,837	5,929	6,818	7,022	1,632	1,914	2,298	2,832	3,336	3,529
Sweden	390	470	541	587	627	663	274	310	360	392	417	438
United Kingdom	2,023	2,404	2,800	3,166	3,447	3,726	1,238	1,383	1,616	1,842	2,032	2,151
European Union (27 countries)	31,134	37,187	43,707	49,614	53,264	54,636	16,461	18,866	21,831	24,929	26,918	27,464

Liver cancer registrations	Men						Women					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Austria	594	713	846	936	966	977	290	324	382	427	440	441
Belgium	392	464	538	584	607	627	254	289	332	363	376	384
Bulgaria	299	309	328	347	356	346	204	214	222	228	229	221
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	620	758	863	963	1,036	1,033	319	380	418	450	482	488
Denmark	213	259	290	305	305	315	130	152	169	180	181	184
Estonia	39	43	48	53	58	60	32	33	35	36	36	35
Finland	167	213	235	240	244	250	95	116	128	131	130	131
France	5,537	6,574	7,413	7,947	8,223	8,526	1,420	1,653	1,858	2,006	2,041	2,058
Germany (including ex-GDR from 1991)	3,360	3,859	4,319	4,504	4,413	4,233	1,527	1,651	1,824	1,907	1,867	1,785
Greece	1,406	1,600	1,833	2,076	2,193	2,144	673	761	847	941	985	955
Hungary	712	795	876	975	1,067	1,095	463	506	533	559	585	589
Ireland	68	90	116	146	168	179	17	22	28	34	39	43
Italy	9,489	10,982	12,619	13,993	14,327	14,057	4,130	4,635	5,216	5,816	5,973	5,784
Latvia	59	63	70	78	84	85	52	52	54	56	56	56

Liver cancer registrations	Men						Women					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Lithuania	76	83	95	106	114	117	69	73	80	85	86	85
Luxembourg	17	23	29	33	36	38	7	8	10	12	13	14
Malta	12	17	20	22	24	26	2	3	3	3	3	3
Netherlands	243	303	346	365	360	363	94	111	125	134	133	131
Poland	972	1,175	1,350	1,492	1,613	1,630	991	1,173	1,331	1,427	1,501	1,500
Portugal	477	550	638	719	770	780	201	228	258	285	302	301
Romania	1,602	1,758	1,994	2,257	2,396	2,370	815	888	977	1,081	1,135	1,120
Slovakia	239	297	356	407	443	445	145	175	206	230	248	249
Slovenia	89	111	131	143	146	140	36	41	46	49	50	48
Spain	3,516	4,319	5,344	6,326	6,817	6,667	1,514	1,800	2,173	2,571	2,815	2,769
Sweden	336	397	440	473	496	528	205	232	256	275	285	301
United Kingdom	1,773	2,076	2,358	2,590	2,764	2,997	1,105	1,252	1,437	1,603	1,701	1,826
European Union (27 countries)	32,249	37,934	43,519	47,801	49,852	50,251	14,686	16,729	18,933	20,700	21,438	21,415

8.2 SUPPLEMENTARY TABLES - COSTS UNDER THE BASELINE SCENARIO

Table 8.2.1 Health costs – baseline scenario – Member State breakdown - Based on a 4% discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0	€ 2	€ 2	Austria	€ 1	€ 5	€ 6
Belgium	€ 0	€ 0	€ 0	Belgium	€ 2	€ 7	€ 9
Bulgaria	€ 1	€ 1	€ 2	Bulgaria	€ 1	€ 2	€ 3
Czech Republic	€ 1	€ 2	€ 3	Czech Republic	€ 2	€ 4	€ 6
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 0	€ 1	€ 2	Denmark	€ 1	€ 3	€ 4
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 0	€ 0
Finland	€ 0	€ 0	€ 0	Finland	€ 0	€ 0	€ 0
France	€ 6	€ 38	€ 44	France	€ 9	€ 79	€ 88
Germany	€ 6	€ 28	€ 34	Germany	€ 9	€ 48	€ 57
Greece	€ 0	€ 1	€ 2	Greece	€ 1	€ 5	€ 6
Hungary	€ 1	€ 1	€ 2	Hungary	€ 3	€ 5	€ 7
Ireland	€ 0	€ 1	€ 1	Ireland	€ 0	€ 1	€ 1
Italy	€ 13	€ 51	€ 64	Italy	€ 36	€ 168	€ 203
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 0	€ 0
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 0	€ 0
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 0	€ 0
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 2	€ 2	Netherlands	€ 0	€ 3	€ 3
Poland	€ 2	€ 3	€ 5	Poland	€ 4	€ 6	€ 10
Portugal	€ 0	€ 1	€ 1	Portugal	€ 1	€ 2	€ 2
Romania	€ 2	€ 3	€ 4	Romania	€ 4	€ 6	€ 10
Slovakia	€ 0	€ 0	€ 1	Slovakia	€ 1	€ 1	€ 2
Slovenia	€ 0	€ 1	€ 1	Slovenia	€ 0	€ 1	€ 2
Spain	€ 1	€ 5	€ 6	Spain	€ 2	€ 13	€ 15
Sweden	€ 1	€ 2	€ 2	Sweden	€ 1	€ 4	€ 5
United Kingdom	€ 3	€ 12	€ 15	United Kingdom	€ 5	€ 24	€ 30
TOTAL	€ 38	€ 156	€ 194	**TOTAL**	€ 84	€ 387	€ 471

Table 8.2.2 Health costs – baseline scenario – Industry group breakdown - Based on a 4% discount rate

Low	Female	Male	Total
Manufacture of chemicals and chemical products	€ 36	€ 146	€ 183
TOTAL	€ 36	€ 146	€ 183

High	Female	Male	Total
Manufacture of chemicals and chemical products	€ 77	€ 357	€ 434
TOTAL	€ 77	€ 357	€ 434

Note: Industry breakdown results may not equate exactly to Member State breakdown due to differences in underlying health data.

Table 8.2.3 Health costs – baseline scenario – Member State breakdown - Based on a declining discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0	€ 2	€ 3	Austria	€ 1	€ 5	€ 6
Belgium	€ 0	€ 0	€ 0	Belgium	€ 2	€ 8	€ 9
Bulgaria	€ 1	€ 1	€ 2	Bulgaria	€ 1	€ 2	€ 3
Czech Republic	€ 1	€ 2	€ 3	Czech Republic	€ 2	€ 4	€ 6
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 0	€ 1	€ 2	Denmark	€ 1	€ 3	€ 4
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 0	€ 0
Finland	€ 0	€ 0	€ 0	Finland	€ 0	€ 0	€ 0
France	€ 6	€ 40	€ 46	France	€ 9	€ 82	€ 91
Germany	€ 6	€ 30	€ 36	Germany	€ 10	€ 50	€ 60
Greece	€ 0	€ 1	€ 2	Greece	€ 1	€ 5	€ 6
Hungary	€ 1	€ 1	€ 2	Hungary	€ 3	€ 5	€ 8
Ireland	€ 0	€ 1	€ 1	Ireland	€ 0	€ 1	€ 1
Italy	€ 14	€ 53	€ 67	Italy	€ 37	€ 176	€ 213

Low	Female	Male	Total	High	Female	Male	Total
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 0	€ 0
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 0	€ 0
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 0	€ 0
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 2	€ 2	Netherlands	€ 0	€ 3	€ 3
Poland	€ 2	€ 3	€ 5	Poland	€ 5	€ 6	€ 11
Portugal	€ 0	€ 1	€ 1	Portugal	€ 1	€ 2	€ 2
Romania	€ 2	€ 3	€ 5	Romania	€ 4	€ 6	€ 11
Slovakia	€ 0	€ 0	€ 1	Slovakia	€ 1	€ 1	€ 2
Slovenia	€ 0	€ 1	€ 1	Slovenia	€ 0	€ 1	€ 2
Spain	€ 1	€ 6	€ 7	Spain	€ 3	€ 14	€ 16
Sweden	€ 1	€ 2	€ 2	Sweden	€ 1	€ 4	€ 5
United Kingdom	€ 3	€ 12	€ 15	United Kingdom	€ 6	€ 25	€ 31
TOTAL	€ 40	€ 162	€ 202	**TOTAL**	€ 87	€ 404	€ 491

Table 8.2.4 Health costs – baseline scenario – Industry group breakdown - Based on a declining discount rate

Low	Female	Male	Total
Manufacture of chemicals and chemical products	€ 38	€ 152	€ 190
TOTAL	€ 38	€ 152	€ 190

High	Female	Male	Total
Manufacture of chemicals and chemical products	€ 80	€ 372	€ 452
TOTAL	€ 80	€ 372	€ 452

Note: Industry breakdown results may not equate exactly to Member State breakdown due to differences in underlying health data.

Table 8.2.5 Summary

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	21 to 45	12 to 27	5 to 12	1 to 2	0 to 1	0 to 0
Male	85 to 207	50 to 126	22 to 56	4 to 11	1 to 2	1 to 2
Total	106 to 252	63 to 153	27 to 68	5 to 14	1 to 3	1 to 3

Table 8.2.6 Health costs – baseline scenario – Member State breakdown - Based on a no discounting

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 1	€ 3	€ 4	Austria	€ 1	€ 8	€ 9
Belgium	€ 0	€ 0	€ 0	Belgium	€ 3	€ 13	€ 16
Bulgaria	€ 2	€ 2	€ 3	Bulgaria	€ 2	€ 2	€ 5
Czech Republic	€ 1	€ 3	€ 4	Czech Republic	€ 3	€ 7	€ 9
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 1	€ 2	€ 3	Denmark	€ 2	€ 5	€ 6
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 0	€ 0
Finland	€ 0	€ 0	€ 0	Finland	€ 0	€ 0	€ 0
France	€ 9	€ 61	€ 70	France	€ 14	€ 126	€ 140
Germany	€ 10	€ 48	€ 58	Germany	€ 15	€ 81	€ 97
Greece	€ 0	€ 2	€ 3	Greece	€ 2	€ 7	€ 9
Hungary	€ 1	€ 2	€ 3	Hungary	€ 4	€ 8	€ 13
Ireland	€ 1	€ 1	€ 2	Ireland	€ 0	€ 2	€ 2
Italy	€ 22	€ 87	€ 109	Italy	€ 61	€ 287	€ 348
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 0	€ 1
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 0	€ 1
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 0	€ 0
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 1	€ 3	€ 3	Netherlands	€ 1	€ 4	€ 5
Poland	€ 3	€ 5	€ 8	Poland	€ 7	€ 10	€ 17
Portugal	€ 1	€ 1	€ 2	Portugal	€ 1	€ 3	€ 4

Low	Female	Male	Total	High	Female	Male	Total
Romania	€ 3	€ 4	€ 7	Romania	€ 6	€ 10	€ 17
Slovakia	€ 0	€ 1	€ 1	Slovakia	€ 1	€ 2	€ 3
Slovenia	€ 0	€ 1	€ 2	Slovenia	€ 1	€ 2	€ 3
Spain	€ 2	€ 10	€ 12	Spain	€ 4	€ 24	€ 29
Sweden	€ 1	€ 3	€ 4	Sweden	€ 2	€ 6	€ 8
United Kingdom	€ 4	€ 18	€ 22	United Kingdom	€ 8	€ 38	€ 46
TOTAL	€ 63	€ 258	€ 321	**TOTAL**	€ 139	€ 647	€ 786

Table 8.2.7 Health costs – baseline scenario – Industry group breakdown - Based on a declining discount rate

Low	Female	Male	Total
Manufacture of chemicals and chemical products	€ 60	€ 241	€ 301
TOTAL	€ 60	€ 241	€ 301

High	Female	Male	Total
Manufacture of chemicals and chemical products	€ 127	€ 592	€ 719
TOTAL	€ 127	€ 592	€ 719

Note: Industry breakdown results may not equate exactly to Member State breakdown due to differences in underlying health data.

Table 8.2.8 Summary

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	26 to 55	22 to 48	11 to 25	3 to 7	1 to 2	1 to 2
Male	103 to 251	91 to 226	45 to 117	12 to 32	3 to 9	4 to 11
Total	128 to 306	113 to 275	56 to 142	15 to 38	4 to 11	5 to 14

8.3 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

Table 8.3.1 Proportions exposed above the exposure limits being tested by country, forecast scenario

Forecast Scenario OEL	1971-80 *7.67 mg/m^3 (3 ppm)*	1981-90	1991-00	2001-10	2011-20	2021-30	1971-80 *5.11 mg/m^3(2 ppm)*	1981-90	1991-00	2001-10	2011-20	2021-30	1971-80 *2.56 mg/m^3 (1 ppm)*	1981-90	1991-00	2001-10	2011-20	2021-30
Austria	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Belgium	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Bulgaria	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Cyprus	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Czech Republic	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Denmark	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Estonia	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Finland	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
France	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Germany	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Greece	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Hungary	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Ireland	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Italy	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Latvia	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Lithuania	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Luxembourg	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Malta	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Netherlands	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04

Forecast Scenario OEL	1971-80	1981-90	1991-00	2001-10	2011-20	2021-30	1971-80	1981-90	1991-00	2001-10	2011-20	2021-30	1971-80	1981-90	1991-00	2001-10	2011-20	2021-30
	7.67 mg/m³ (3 ppm)						*5.11 mg/m³(2 ppm)*						*2.56 mg/m³ (1 ppm)*					
Poland	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Portugal	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Romania	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Slovakia	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Slovenia	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Spain	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
Sweden	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
United Kingdom	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04
TOTAL	0.75	0.36	0.08	0.01	0.01	0.01	0.82	0.46	0.13	0.02	0.02	0.02	0.91	0.62	0.24	0.04	0.04	0.04

Table 8.3.2 Numbers and proportions of the population ever exposed for baseline and intervention[(1)] scenarios (2) to (3), by country, men plus women

Scenario[(1)]	All Scenarios		Baseline scenario (1) [(2)] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m³)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m³) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m³) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Number ever exposed in the REP													
Austria	1,057	1,121	1,190	1,226	1,246	1,246	1,190	1,226	1,246	1,246	1,190	1,226	1,246	1,246
Belgium	2,302	2,416	2,540	2,594	2,624	2,624	2,540	2,594	2,624	2,624	2,540	2,594	2,624	2,624
Bulgaria	1,460	1,534	1,615	1,651	1,670	1,670	1,615	1,651	1,670	1,670	1,615	1,651	1,670	1,670
Cyprus	205	220	235	245	250	250	235	245	250	250	235	245	250	250
Czech Republic	3,307	3,432	3,572	3,614	3,636	3,636	3,572	3,614	3,636	3,636	3,572	3,614	3,636	3,636

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Number ever exposed in the REP													
Denmark	1,147	1,228	1,312	1,361	1,387	1,387	1,312	1,361	1,387	1,387	1,312	1,361	1,387	1,387
Estonia	202	218	234	245	250	250	234	245	250	250	234	245	250	250
Finland	114	127	141	151	156	156	141	151	156	156	141	151	156	156
France	12,779	12,651	12,488	12,543	12,426	12,426	12,488	12,543	12,426	12,426	12,488	12,543	12,426	12,426
Germany	15,904	16,724	17,611	18,018	18,236	18,236	17,611	18,018	18,236	18,236	17,611	18,018	18,236	18,236
Greece	880	970	1,063	1,127	1,162	1,162	1,063	1,127	1,162	1,162	1,063	1,127	1,162	1,162
Hungary	1,214	1,292	1,375	1,421	1,445	1,445	1,375	1,421	1,445	1,445	1,375	1,421	1,445	1,445
Ireland	816	856	900	919	929	929	900	919	929	929	900	919	929	929
Italy	14,537	15,378	16,276	16,731	16,974	16,974	16,276	16,731	16,974	16,974	16,276	16,731	16,974	16,974
Latvia	247	268	290	305	312	312	290	305	312	312	290	305	312	312
Lithuania	523	558	594	614	625	625	594	614	625	625	594	614	625	625
Luxembourg	41	44	47	50	51	51	47	50	51	51	47	50	51	51
Malta	159	164	170	172	172	172	170	172	172	172	170	172	172	172
Netherlands	2,342	2,494	2,656	2,745	2,793	2,793	2,656	2,745	2,793	2,793	2,656	2,745	2,793	2,793
Poland	4,706	4,977	5,267	5,415	5,494	5,494	5,267	5,415	5,494	5,494	5,267	5,415	5,494	5,494
Portugal	1,035	1,107	1,183	1,228	1,252	1,252	1,183	1,228	1,252	1,252	1,183	1,228	1,252	1,252
Romania	2,174	2,306	2,447	2,521	2,560	2,560	2,447	2,521	2,560	2,560	2,447	2,521	2,560	2,560
Slovakia	584	624	667	691	704	704	667	691	704	704	667	691	704	704
Slovenia	576	602	631	643	649	649	631	643	649	649	631	643	649	649
Spain	2,625	3,274	3,945	4,421	4,679	4,679	3,945	4,421	4,679	4,679	3,945	4,421	4,679	4,679
Sweden	1,798	1,928	2,066	2,148	2,192	2,192	2,066	2,148	2,192	2,192	2,066	2,148	2,192	2,192
United Kingdom	12,295	11,938	11,577	11,275	11,109	11,109	11,577	11,275	11,109	11,109	11,577	11,275	11,109	11,109
TOTAL	85,029	88,452	92,092	94,072	94,982	94,982	92,092	94,072	94,982	94,982	92,092	94,072	94,982	94,982

Scenario[1] / Country	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Proportion of the population exposed													
Austria	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Belgium	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Bulgaria	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04
Cyprus	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Czech Republic	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.05
Denmark	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Estonia	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Finland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
France	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02
Germany	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Greece	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Hungary	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ireland	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Italy	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.03	0.03	0.04	0.04
Latvia	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Lithuania	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Luxembourg	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Malta	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Netherlands	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Poland	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Portugal	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Romania	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Slovakia	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Slovenia	0.04	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05
Spain	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m³)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m³) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m³) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Proportion of the population exposed													
Sweden	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
United Kingdom	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TOTAL	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Table 8.3.3 Results for baseline and intervention(1) scenarios for liver cancer, by country, men plus women

Scenario(1) / Country	All Scenarios		Baseline scenario (1) (2) - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Fraction													
Austria	0.021	0.013	0.004	0.001	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.044	0.029	0.012	0.003	0.001	0.001	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Bulgaria	0.021	0.013	0.004	0.001	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyprus	0.015	0.006	0.001	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Czech Republic	0.024	0.013	0.003	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Denmark	0.037	0.023	0.008	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Estonia	0.014	0.008	0.002	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Finland	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
France	0.043	0.025	0.008	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Germany	0.036	0.025	0.010	0.002	0.001	0.001	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Greece	0.010	0.006	0.002	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hungary	0.021	0.014	0.005	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Ireland	0.037	0.023	0.009	0.002	0.001	0.001	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Italy	0.046	0.031	0.013	0.003	0.001	0.001	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Latvia	0.012	0.007	0.002	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	0.012	0.006	0.001	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Luxembourg	0.015	0.009	0.003	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.026	0.016	0.006	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Poland	0.018	0.011	0.004	0.001	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Portugal	0.012	0.007	0.002	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Romania	0.015	0.009	0.003	0.001	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slovakia	0.016	0.009	0.003	0.000	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m³)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m³) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m³) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Fraction													
Slovenia	0.043	0.027	0.010	0.002	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Spain	0.008	0.006	0.003	0.001	0.000	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sweden	0.030	0.018	0.006	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
United Kingdom	0.038	0.021	0.006	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
TOTAL	0.030	0.019	0.007	0.001	0.000	0.000	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m³)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m³) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m³) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Deaths													
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Germany	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Deaths													
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	5	4	2	0	0	0	2	0	0	0	2	0	0	0
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	11	4	1	0	0	4	1	0	0	4	1	0	0

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Registrations													
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Germany	2	1	1	0	0	0	1	0	0	0	1	0	0	0
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	6	5	2	1	0	0	2	1	0	0	2	1	0	0
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[(1)]	All Scenarios		Baseline scenario (1) [(2)] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Registrations													
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	10	4	1	0	0	4	1	0	0	4	1	0	0

Scenario[(1)]	All Scenarios		Baseline scenario (1) [(2)] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lost (YLLs)													
Austria	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	3	2	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	52	36	12	2	0	0	12	2	0	0	12	2	0	0
Germany	38	28	13	3	1	1	13	3	1	0	13	3	0	0
Greece	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	2	2	1	0	0	0	1	0	0	0	1	0	0	0
Ireland	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Italy	67	50	23	5	1	1	23	5	1	1	23	5	1	0

Scenario[1]	**All Scenarios**		**Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)**				**Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance**				**Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance**			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Attributable Years of Life Lost (YLLs)													
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	2	2	1	0	0	0	1	0	0	0	1	0	0	0
Poland	5	4	1	0	0	0	1	0	0	0	1	0	0	0
Portugal	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Romania	5	4	1	0	0	0	1	0	0	0	1	0	0	0
Slovakia	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Spain	6	5	3	1	0	0	3	1	0	0	3	1	0	0
Sweden	3	2	1	0	0	0	1	0	0	0	1	0	0	0
United Kingdom	18	11	3	0	0	0	3	0	0	0	3	0	0	0
TOTAL	204	146	59	12	3	3	59	12	2	2	59	12	1	0

Scenario[1]	All Scenarios		Baseline scenario (1) - [2] Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/ m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/ m^3) in 2010, full compliance			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lived with Disability (DALYs)													
Austria	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	3	2	1	0	0	0	1	0	0	0	1	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	3	2	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	53	36	12	2	0	0	12	2	0	0	12	2	0	0
Germany	38	29	13	3	1	1	13	3	1	0	13	3	0	0
Greece	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	2	2	1	0	0	0	1	0	0	0	1	0	0	0
Ireland	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Italy	68	52	24	6	1	1	24	6	1	1	24	5	1	0
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	2	2	1	0	0	0	1	0	0	0	1	0	0	0
Poland	6	4	1	0	0	0	1	0	0	0	1	0	0	0
Portugal	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Romania	5	4	1	0	0	0	1	0	0	0	1	0	0	0
Slovakia	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	1	1	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1] Country	All Scenarios		Baseline scenario (1) - [2] Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/ m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/ m^3) in 2010, full compliance			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lived with Disability (DALYs)													
Spain	6	5	3	1	0	0	3	1	0	0	3	1	0	0
Sweden	3	2	1	0	0	0	1	0	0	0	1	0	0	0
United Kingdom	18	12	3	0	0	0	3	0	0	0	3	0	0	0
TOTAL	208	149	60	12	3	3	60	12	2	2	60	12	1	0

(1) Intervention scenarios have been estimated assuming baseline exposure and employment levels
(2) Change from 2010 in baseline scenario is due to trends in ‘historic’ (pre 2005) part of REP

Note: numbers and proportions ever exposed remain constant across the baseline and intervention scenarios

Table 8.3.4 Numbers and proportions of the EU population ever exposed, by industry, men plus women

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Number ever exposed in the REP													
Publishing, printing and reproduction of recorded media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	60,653	61,048	61,612	61,163	60,801	60,801	61,612	61,163	60,801	60,801	61,612	61,163	60,801	60,801
Manufacture of rubber and plastic products	9,220	9,159	9,116	8,975	8,871	8,871	9,116	8,975	8,871	8,871	9,116	8,975	8,871	8,871
Water transport	1,529	1,842	2,155	2,412	2,548	2,548	2,155	2,412	2,548	2,548	2,155	2,412	2,548	2,548
Supporting and auxiliary transport activities; activities of travel agencies	2,640	3,181	3,723	4,165	4,401	4,401	3,723	4,165	4,401	4,401	3,723	4,165	4,401	4,401
Research and Development	1,356	1,633	1,912	2,141	2,263	2,263	1,912	2,141	2,263	2,263	1,912	2,141	2,263	2,263
Other business activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	9,630	11,588	13,574	15,215	16,097	16,097	13,574	15,215	16,097	16,097	13,574	15,215	16,097	16,097

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
Industry sector	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Proportion of the population exposed													
Publishing, printing and reproduction of recorded media	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Manufacture of coke, refined petroleum products and nuclear fuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Manufacture of chemicals and chemical products	0.017	0.016	0.016	0.015	0.015	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016
Manufacture of rubber and plastic products	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Water transport	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Supporting and auxiliary transport activities; activities of travel agencies	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Research and Development	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Other business activities	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	0.003	0.003	0.004	0.004	0.005	0.005	0.003	0.004	0.004	0.004	0.003	0.004	0.004	0.004

Table 8.3.5 Occupational attributable fractions, registrations, YLLs and DALYs for lung cancer by industry, men plus women

Scenario[1]	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/ m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/ m^3) in 2010, full compliance			
Industry sector	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Fraction													
Publishing, printing and reproduction of recorded media	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of coke, refined petroleum products and nuclear fuel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacture of chemicals and chemical products	0.03	0.02	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Manufacture of rubber and plastic products	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Supporting and auxiliary transport activities; activities of travel agencies	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Research and Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other business activities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Scenario[1] Industry sector	All Scenarios 2010	2020	Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3) 2030	2040	2050	2060	Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance 2030	2040	2050	2060	Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance 2030	2040	2050	2060
	Attributable Deaths													
Publishing, printing and reproduction of recorded media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	14	11	4	1	0	0	4	1	0	0	4	1	0	0
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research and Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other business activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[(1)] Industry sector	All Scenarios		Baseline scenario (1) [(2)] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/m**3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Registrations													
Publishing, printing and reproduction of recorded media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	14	10	4	1	0	0	4	1	0	0	4	1	0	0
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research and Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other business activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1] / Industry sector	All Scenarios		Baseline scenario (1) [2] - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m^3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/m^3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/m^3) in 2010, full compliance			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lost (YLLs)													
Publishing, printing and reproduction of recorded media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	204	146	59	12	3	3	59	12	2	2	59	12	1	0
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research and Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other business activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained, current OEL=3 ppm (7.67 mg/ m3)				Intervention scenario (2) - Introduce OEL=2 ppm (5.11 mg/ m3) in 2010, full compliance				Intervention scenario (3) - Introduce OEL=1 ppm (2.56 mg/ m3) in 2010, full compliance			
Industry sector	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lived with Disability (DALYs)													
Publishing, printing and reproduction of recorded media	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	208	149	60	12	3	3	60	12	2	2	60	12	1	0
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research and Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other business activities	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(1) Intervention scenarios have been estimated assuming baseline exposure and employment levels
(2) Change from 2010 in baseline scenario is due to trends in ‘historic’ (pre 2005) part of REP

Note: numbers and proportions ever exposed remain constant across the baseline and intervention scenarios

8.4 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

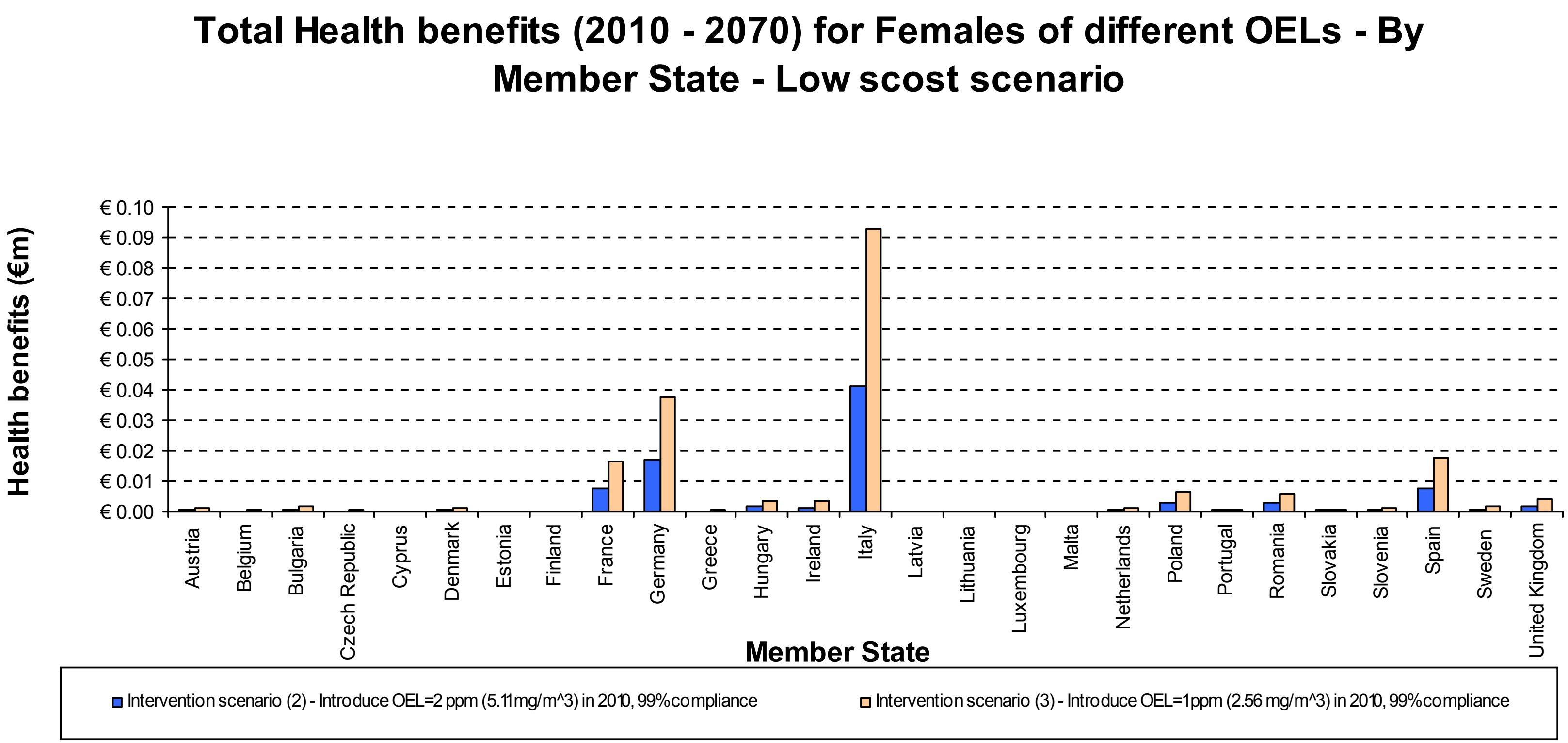

Figure 8.4.1 Total health benefits to females of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

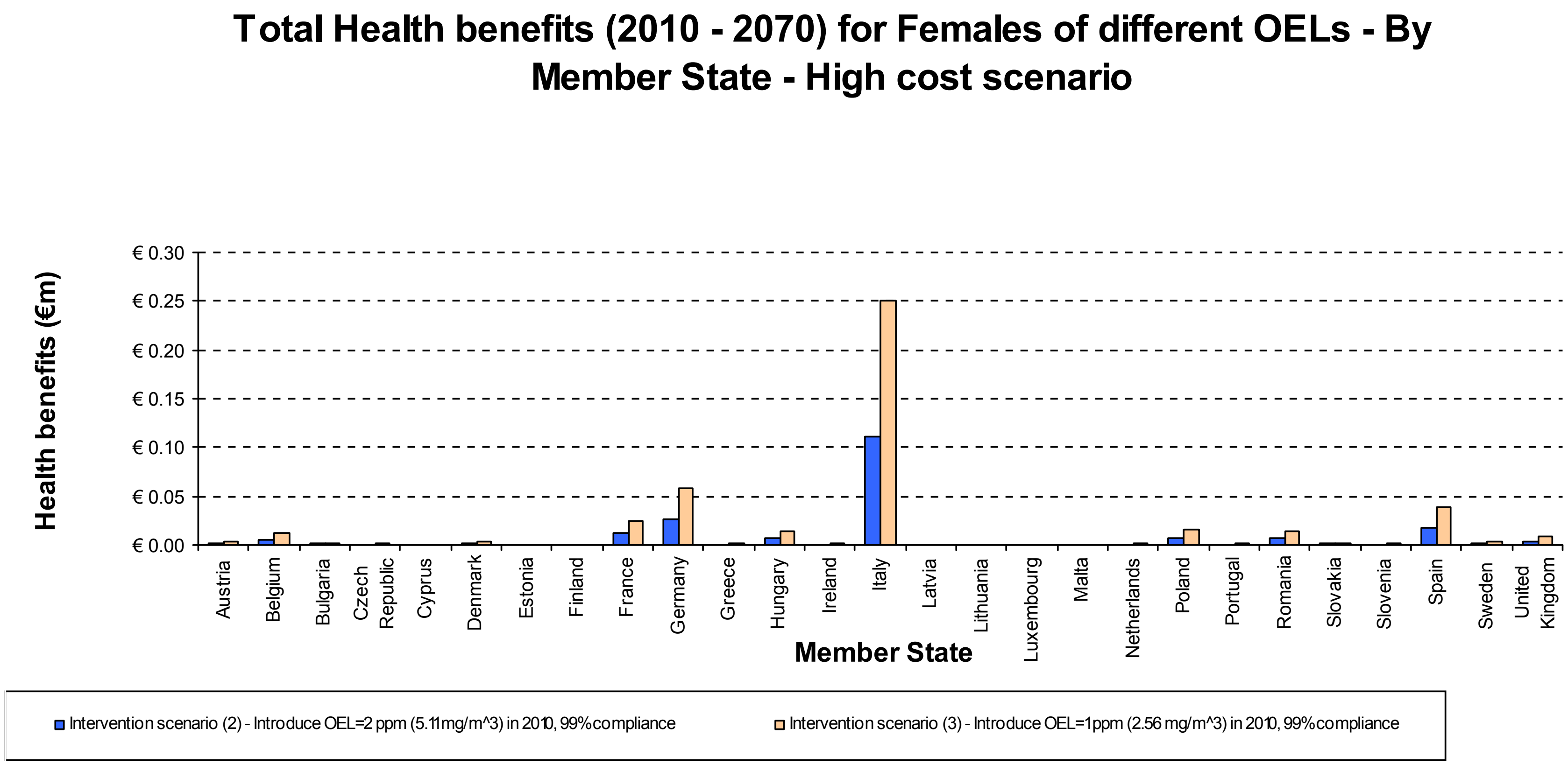

Figure 8.4.2 Total health benefits for females of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

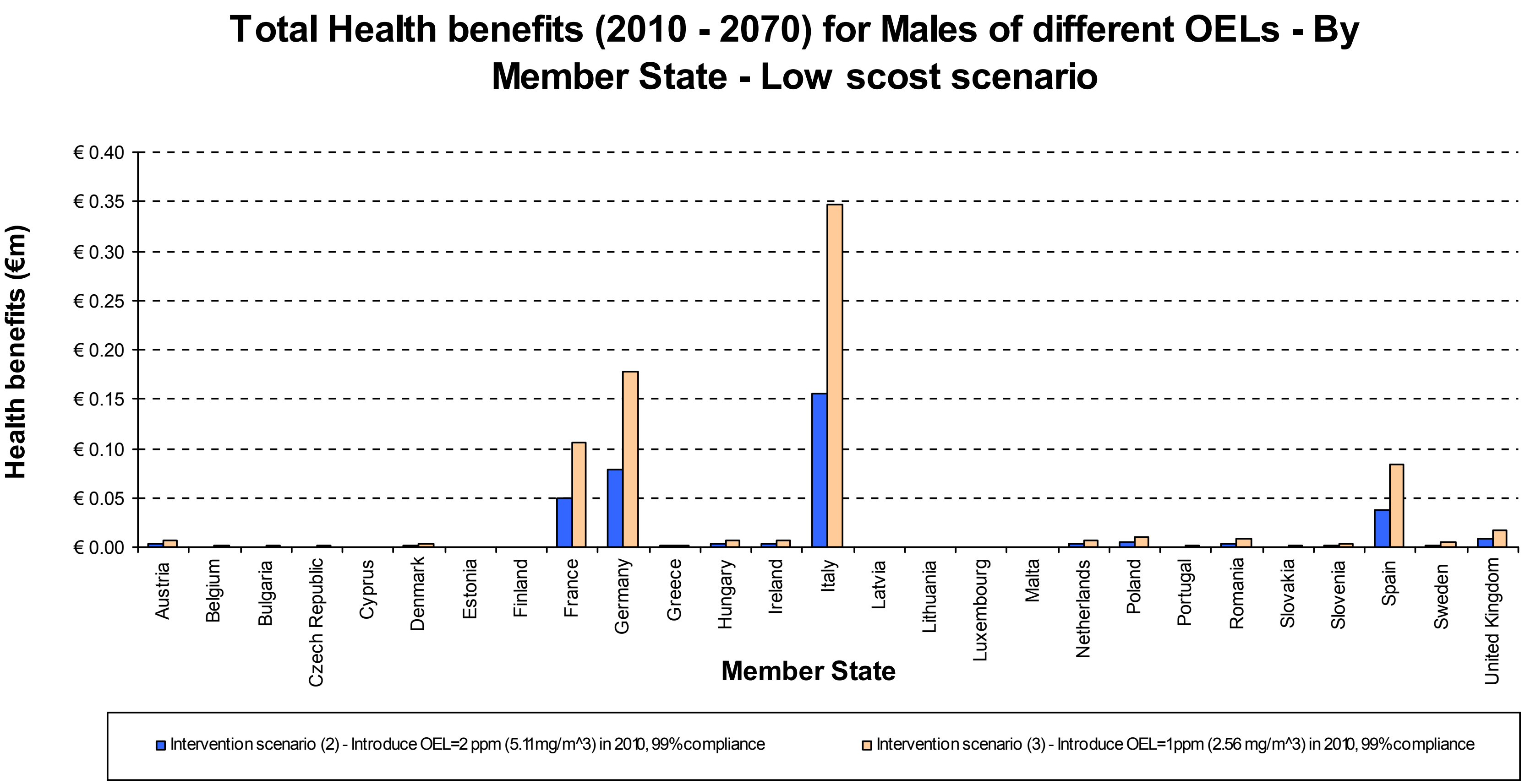

Figure 8.4.3 Total health benefits to males of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

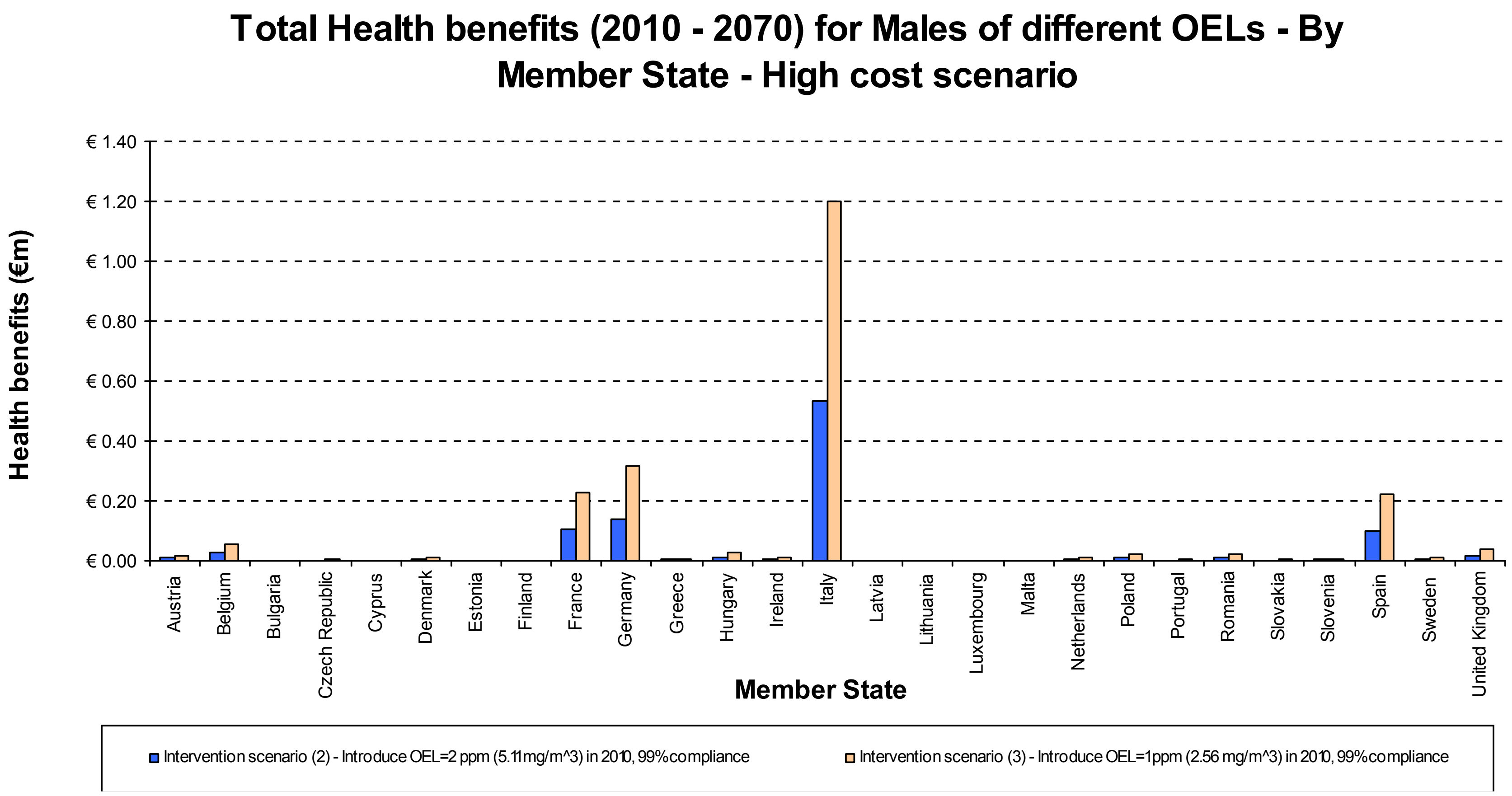

Figure 8.4.4 Total health benefits for males of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

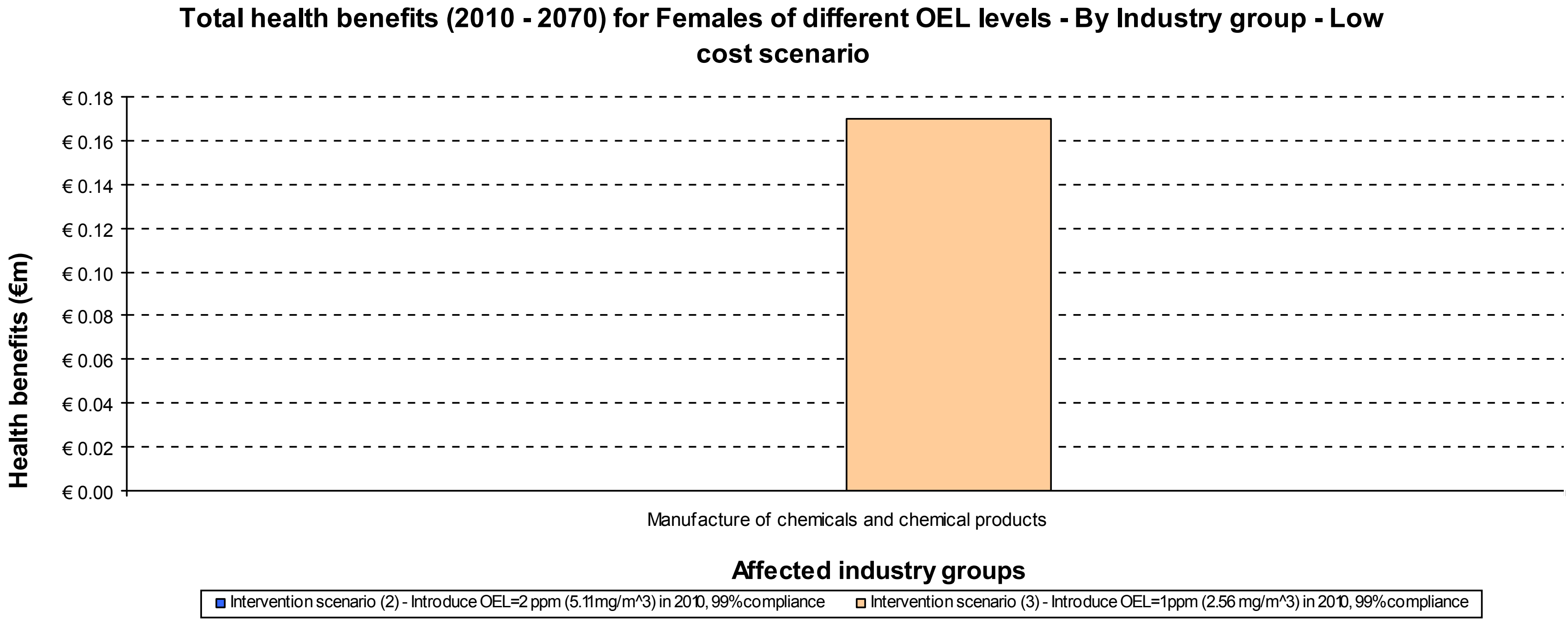

Figure 8.4.5 Total health benefits to females of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

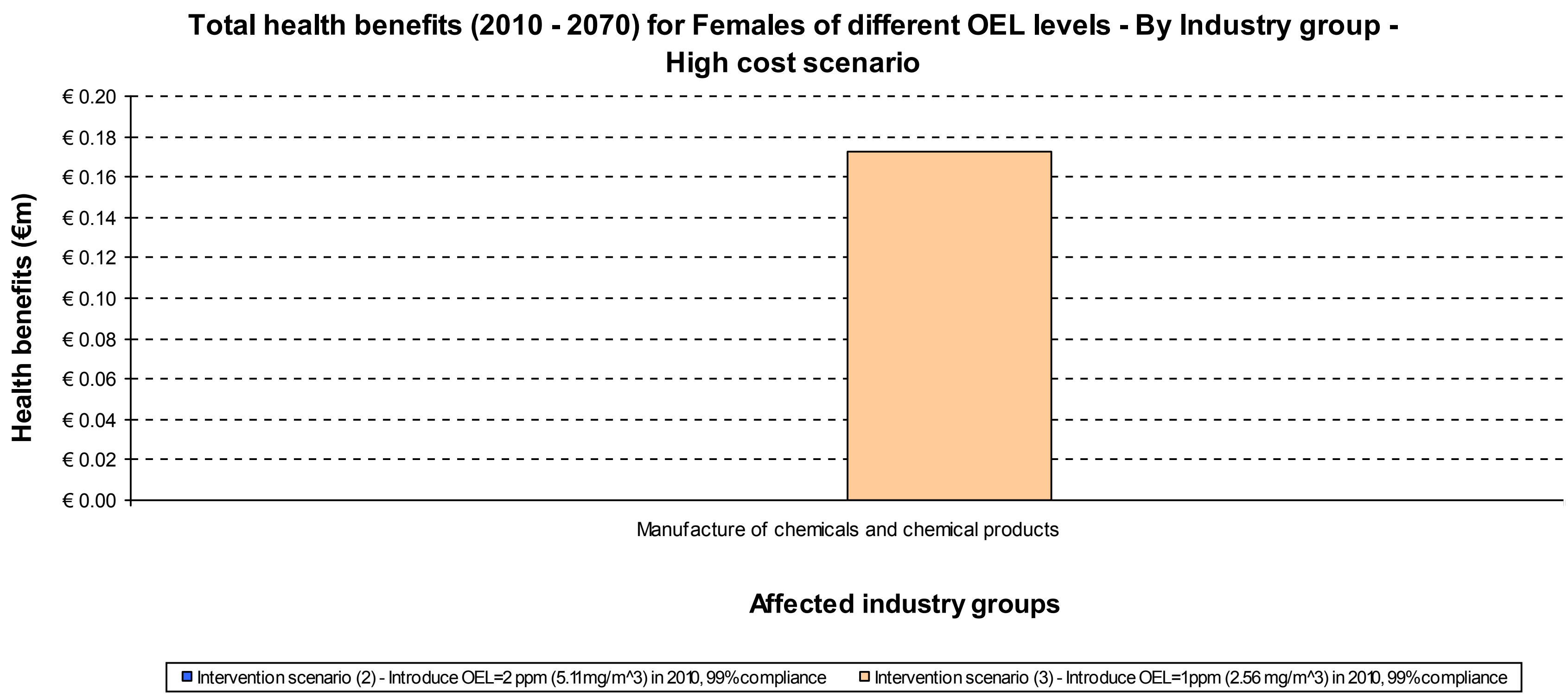

Figure 8.4.6 Total health benefits for females of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

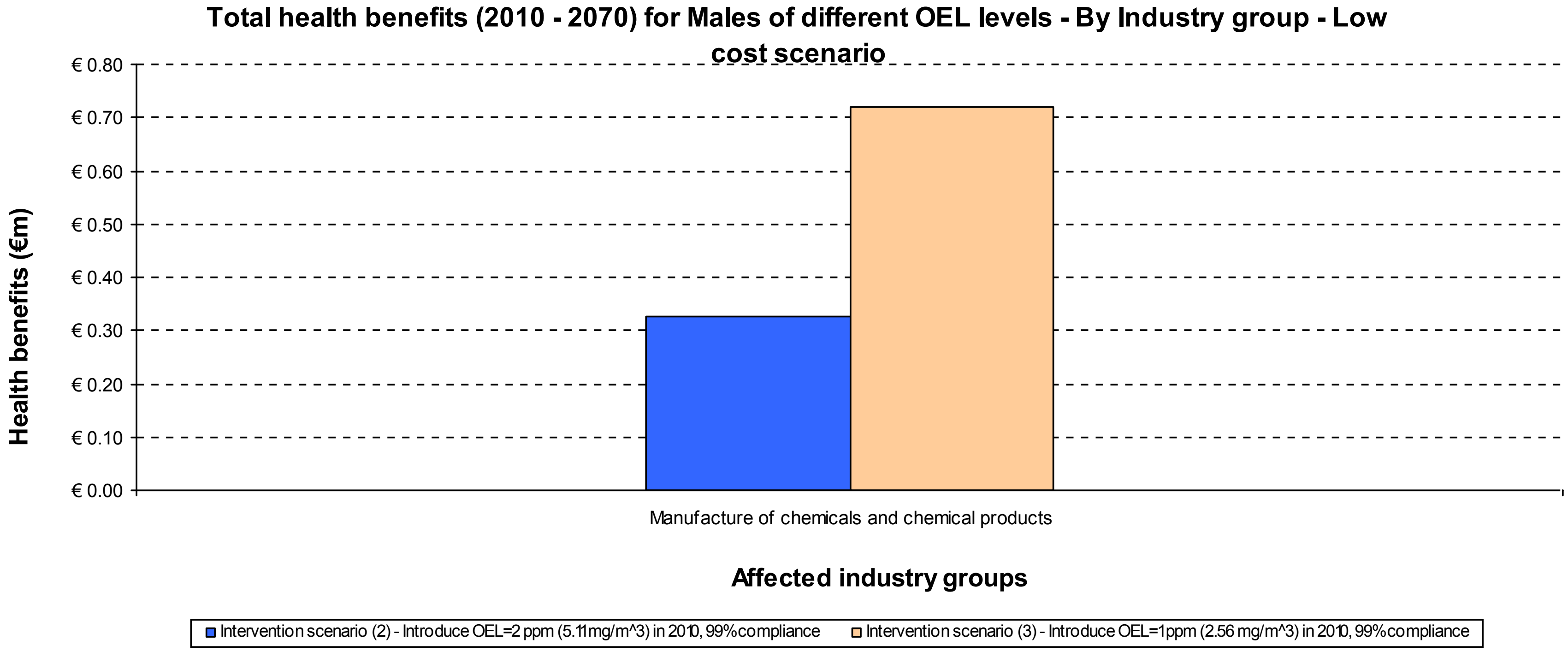

Figure 8.4.7 Total health benefits to males of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

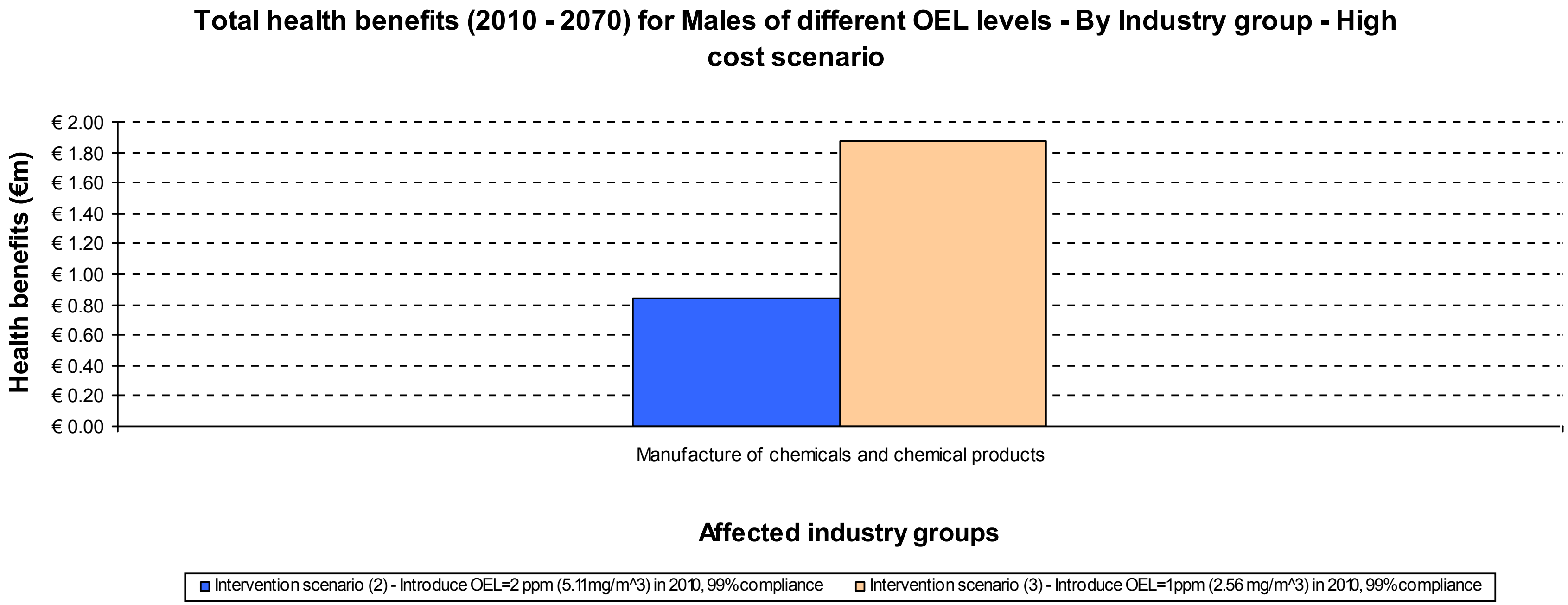

Figure 8.4.8 Total health benefits for males of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

8.5 HEALTH BENEFITS USING DIFFERENT DISCOUNT RATES

COLOUR KEY
No discount
Using the EU IA guidance - 4%
Using a declining discount rate (4% going to 3%)

Table 8.5.1 Introducing an OEL of 2ppm

Hardwood dust		Option 1 - Assume full compliance for OEL = 2ppm					
Range of costs (€m)	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1
	Males	0 to 0	0 to 0	0 to 0	0 to 1	1 to 2	1 to 4
	Totals	0 to 0	0 to 0	0 to 0	0 to 1	1 to 3	2 to 5
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Belgium	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Bulgaria	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Czech Republic	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Cyprus	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Denmark	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Estonia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Finland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
France	€ 0	€ 1	€ 0	€ 0	€ 0	€ 0
Germany	€ 1	€ 1	€ 0	€ 0	€ 0	€ 0
Greece	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Hungary	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Ireland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Italy	€ 1	€ 2	€ 0	€ 1	€ 0	€ 1

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Latvia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Lithuania	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Luxembourg	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Malta	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Poland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Portugal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Romania	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Slovakia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Slovenia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Spain	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Sweden	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
United Kingdom	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of chemicals and chemical products	€ 3	€ 7	€ 0	€ 1	€ 1	€ 2

Table 8.5.2 Introducing an OEL of 1ppm

Hardwood dust	Option 2 - Assume full compliance for OEL = 1ppm						
Range of costs (€m)	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	1 to 2
	Males	0 to 0	0 to 0	0 to 0	0 to 1	2 to 5	3 to 9
	Totals	0 to 0	0 to 0	0 to 0	1 to 2	2 to 6	4 to 11
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	0 to 1
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 1	1 to 2
	Totals	0 to 0	0 to 0	0 to 0	0 to 1	1 to 2	1 to 2

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Belgium	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Bulgaria	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Czech Republic	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Cyprus	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Denmark	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Estonia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Finland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
France	€ 1	€ 1	€ 0	€ 0	€ 0	€ 0
Germany	€ 1	€ 1	€ 0	€ 0	€ 0	€ 1
Greece	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Hungary	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Ireland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Italy	€ 3	€ 2	€ 0	€ 1	€ 1	€ 2
Latvia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Lithuania	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Luxembourg	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Malta	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Poland	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Portugal	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Romania	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Slovakia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Slovenia	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Spain	€ 1	€ 0	€ 0	€ 0	€ 0	€ 0
Sweden	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
United Kingdom	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of chemicals and chemical products	€ 6	€ 16	€ 1	€ 2	€ 1	€ 4

HEAD OFFICE:

Research Avenue North,
Riccarton,
Edinburgh, EH14 4AP,
United Kingdom
Telephone: +44 (0)131 449 8000
Facsimile: +44 (0)131 449 8084

Tapton Park Innovation Centre,
Brimington Road, Tapton,
Chesterfield, Derbyshire, S41 0TZ,
United Kingdom
Telephone: +44 (0)1246 557866
Facsimile: +44 (0)1246 551212

Research House Business Centre,
Fraser Road,
Perivale, Middlesex, UB6 7AQ,
United Kingdom
Telephone: +44 (0)208 537 3491/2
Facsimile: +44 (0)208 537 3493

Brookside Business Park,
Cold Meece,
Stone, Staffs, ST15 0RZ,
United Kingdom
Telephone: +44 (0)1785 764810
Facsimile: +44 (0)1785 764811

Email: iom@iom-world.org