WORKING FOR A HEALTHY FUTURE

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

1,3-Butadiene

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SUMMARY

1,3-butadiene is classified as a human carcinogen by IARC (Group 1) and is a Cat 1 carcinogen in the EU. It is associated with an increased risk of lymphohaematopoietic cancer. We have considered the impacts of introducing an OEL of 0.5, 1 or 5 ppm, averaged over an 8-hour working day.

1,3-butadine is a very flammable, colourless gas. Most 1,3-butadiene produced is polymerized at a relatively small number of sites in Europe to form synthetic rubber. It is also used as a chemical intermediate in the production of neoprene, in the production of methylmethacrylate-butadiene-styrene (MBS) polymer and for producing adiponitrile, a nylon precursor. The production capacity in 2006 in the EU was estimated to be 2.9 million tonnes.

We estimated that about 27,600 workers in the EU are potentially exposed to 1,3-butadiene. About 4.3% of workers in the high exposure industries are exposed above 5 ppm, 27.8% above 1 ppm and 45.8% above 0.5 ppm. In the low exposure industries levels are probably below 0.5 ppm. Exposure levels in the industries where 1,3-butadiene is used are judged to be decreasing by 7% per annum over recent years.

We estimate that in 2010 in the EU there will be about one death from lymphohaematopoietic cancer, based on two incident cases, that might be attributable to past exposure to 1,3-butadiene, which corresponds to about 0.0014% of all LH cancer deaths amongst the exposed workers. If no specific actions are taken to reduce exposure to 1,3-butadiene the predicted numbers of liver cancer deaths increases slightly so that in 2060 there would be two attributable LH deaths. DALYs and YLL also increase; from 24 to 32 years and 19 to 25 years, respectively. Total estimated health costs associated with inaction range from €41m to €167m, which mostly fall on Germany, UK, France and Spain.

The introduction of an OEL is predicted to have little impact on risk of LH, regardless of the level it is set at. This is because we assume that exposures will continue to drop steadily so that most workers in the high exposed jobs will by 2030 be in the low exposure category (90% of the high exposed jobs < 0.6 ppm). However, we were unable to identify a level at which there was no risk for LH cancer and the low exposed workers still have associated elevated relative risk of 1.05. There are therefore no net health benefits from setting an OEL.

Potential improvements in handling 1,3-butadiene to ensure compliance with an OEL include, technical measures such as improved equipment for loading/unloading and leak detection, organisational measures, such as regular inspection of equipment, and greater use of personal respiratory protection.

The total compliance costs aggregated over the period 2010 to 2069 range from between €2m to €7m for an OEL of 5 ppm to €27 to €100m for an OEL of 0.5 ppm. In part the range of costs for each option depends on the relative use of engineering controls or personal protective equipment to control exposure to episodic releases. The sectors that experience the highest impact and thus cost are those that would experience the largest benefits from the control of exposure and meeting the OEL (i.e. NACE 25.1 and 23). No plant closures are foreseen as a consequence of introducing and OEL. There is unlikely to be any significant change to macro-economic impacts.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

Exposure to 1,3-butadiene in workplace air is associated with increased risk of lymphohaematopoietic (LH) cancer, mainly lymphosarcoma. 1,3-butadiene 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, 2]. 1,3-butadiene is therefore already regulated as a carcinogen throughout the EU.

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 In this assessment we consider the impacts of introducing an OEL of either 0.5, 1 or 5 ppm.

1.2 OELS/EXPOSURE CONTROL

Existing national occupational exposure limits (OELs) in EU member states are presented in Table 1.1. These are expressed as long-term limits, averaged over an 8-hour working day (OEL 8hr-TWA) or short-term exposure limits (STELs), i.e. 15 minutes. OELs from the OSHA are also presented for comparison.

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

Country	OEL TWA (ppm)	OEL STEL (ppm)	Comments
Austria	15	60	Treatment after polymerization
Austria	5	20	Other uses
Belgium	2		
Czech Republic	4	9	
Denmark	10	20	
Estonia	1	5	
Finland	1		
Latvia	45		
Lithuania	0.5	5	
Netherlands	21		
Poland	4	18	
Slovakia	5		
Slovenia	15	60	
Slovenia	5	20	
Spain	2		
Sweden	0.5	5	
United Kingdom	10		
USA – OSHA	1	15	

Source: http://www.dguv.de/bgia/en/gestis/limit_values/index.jsp and http://osha.europa.eu/en/publications/reports/548OELs/view

The OELs varied largely across the EU member states; the 8-hr OELs ranged from 0.5 ppm (1.14 mg/m^3) in Sweden to in 45 ppm (102 mg/m^3) in Latvia; the STELs ranged from 5 ppm in Sweden, Lithuania and Estonia to 60 ppm in Slovenia and Austria. For

[1] Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf
[2] Available at: http://ecb.jrc.ec.europa.eu/esis/

the purposes of this report OELs of 0.5, 1 and 5 ppm are considered for the intervention.

1.3 DESCRIPTION OF DIFFERENT USES

1,3-butadine is a very flammable, colourless gas. In Europe, 1,3-butadiene is mainly or even exclusively produced by the steam cracking of hydrocarbons (IARC, 2006). The quantity of butadiene produced depends on the hydrocarbon feed; light feeds, such as ethane, give primarily ethylene when cracked, but heavier feeds favour the formation of olefins, butadiene, and aromatic hydrocarbons. 1,3-Butadiene can also be made directly, by (oxidative) dehydrogenation of C4 fraction from the crude distillation, using chromium-alumina as a catalyst. Finally, it can also be produced from ethanol.

Most of the butadiene (which is produced as monomers) is polymerized to produce synthetic rubber. While polybutadiene itself is a very soft, almost liquid material, polymers prepared from mixtures of butadiene with styrene or acrylonitrile (acrylonitrile-butadiene-styrene ABS, and styrene-butadiene latex), are both tough and elastic. It is also used as a chemical intermediate in the production of neoprene for automotive and industrial rubber goods; in the production of methylmethacrylate-butadiene-styrene (MBS) polymer, which is used as a PVC reinforcing agent; and for producing adiponitrile, a nylon precursor.

The most widespread use of 1,3-butadiene is in the manufacture of styrene-butadiene-rubber (SBR) and styrene-butadiene latex, the former being used in the production of synthetic rubber products for automobile tires and the latter in paints, carpet backing and paper coatings. The EU Risk Assessment Report (RAR) for 1,3-butadiene indicates that in 1981 84% of 1,3-butadiene was used in the SBR production industry, with 56% dedicated to the production of styrene-butadiene latex, 22% to polybutadiene rubber and 6% to the production of polychloroprene (EU, 2002).

In the EU there are currently (July 2010) 9 plant sites producing emulsion of SBR, 4 producing solution of SBR, seven producing polybutadiene or butadiene rubber (BR) and 6 producing nitrile butadiene rubber (NBR). Some of the sites produce two or more of these elastomers at the same location (McGraw, 2010).

The main route of occupational exposure to 1,3-butadiene, a gas, is by inhalation. The potential for oral or dermal exposure cannot be entirely excluded, but is considered to represent a very minor potential route of exposure (EU, 2002).

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

Cancers of the lymphohaematopoietic (LH) system includes Hodgkin's disease (HD), non-Hodgkin’s lymphoma (NHL), other lymphomas, multiple myeloma (MM) and leukaemia. As the IARC working group noted, the diagnosis and classification of lymphatic and haematopoietic cancers are very complex and have undergone several changes over time. We have chosen to consider the risk for all of these cancers combined.

Ferlay *et al* (2007) note that in Europe, about 3.2% of all cancers are NHL (7th commonest cancer) and 2.2% are leukaemias (10th commonest cancer). There is a similar incidence of these cancers in men and women. Other forms of LH are less common and for example there are five times fewer cases of HD compared with NHL.

Around 40% of people with leukaemia survive for at least five years after they are diagnosed, although the survival rate differs by leukaemia type. Survival rates for leukaemia have steadily increased over the last thirty years (Verdecchia *et al*, 2007). A slightly higher proportion of NHL patients survive for 5-years (about 50%), but with all LH cancer there is considerable variation in prognosis depending on the type of tumour and the stage of development.

NHL is more common amongst people with a weakened immune system, including those taking immunosuppressive drugs. Infection with some viruses and bacteria can increase the risk of NHL and those with coeliac disease have an increased risk of some types of NHL. There are also genetic risk factors for NHL.

NHL may be caused by occupational exposure to dioxins, tetrachloroethylene, trichloroethylene, non-arsenical pesticides and insecticides and by some hair dyes (risk for hairdressers). MM may also be caused by non-arsenical pesticides (Siemiatycki *et al*, 2004).

Leukaemia may be caused by ionising radiation, although this probably only accounts for a small proportion of cases. Other agents that are accepted risk factors are occupational exposure to ethylene oxide, benzene, work in boot and shoe manufacture and some drugs used in cancer chemotherapy. It also thought that leukaemia may be induced by some viruses, e.g. Epstein-Barr virus and Hepatitis B virus. People who smoke cigarettes are also at increased risk. Siemiatycki *et al* (2004) that there is suggestive evidence that occupational exposure to formaldehyde and nonarsenical insecticides, along with work in petroleum refining and the rubber industry may also cause leukaemia.

1.4.2 Summary of the available epidemiological literature on risk

Epidemiologic research on 1,3-butadiene (BD) has focused primarily on workers in two industries in North America, the styrene-BD rubber (SBR) industry (Delzell *et al*, 1989, Delzell *et al*, 1995, Delzell *et al*, 1996, Delzell *et al*, 2001, Delzell, 2006, Graff *et al*, 2005, Macaluso *et al*, 1996, Sathiakumar *et al*, 1998, Sathiakumar *et al*, 2005) and the BD-monomer industry (Divine, 1990, Divine and Hartman, 1996, Divine and Hartman, 2001, Downs *et al*, 1987).

A cohort mortality study of 2,800 male workers employed at least six months between 1943 and 1996 was carried out at a BD monomer production facility in Texas, USA (Divine and Hartman, 2001). Previous analyses showed a significant increase for deaths from cancer of the lymphohaematopoietic (LH) system that was mainly due to an increase in deaths from lymphosarcoma, but also non-significant excesses of other LH cancers (Hodgkin's disease (HD), leukaemias, and multiple myeloma(MM)). A job-exposure matrix was developed with each job given an exposure class code of 0-5 based on the potential for exposure to BD in terms of frequency and intensity (Divine and Hartman, 1996). The most recent analysis followed the cohort to 1999 (Divine and Hartman, 2001). The study found non-significant excesses of non-Hodgkin's disease (NHL) (SMR=1.48, 95%CI=0.89-2.31), HD (SMR=1.61, 95%CI=0.44-4.11), leukaemia (SMR=1.29, 95%CI=0.77-2.04) and MM (SMR=1.27, 95%CI=0.51-2.61) and a statistically significant excess of LH cancers (SMR=1.41, 95%CI=1.05-1.86), when considered as a whole. The risk of LH cancer decreased with length of employment, and was significantly increased in those first employed before 1950 (SMR=1.54, 95%CI=1.13-2.06), whereas there was a deficit in those first employed after 1950 (SMR=0.71, 95%CI=0.19-1.82). Individuals who had the potential for exposure to BD on a routine basis showed a significantly excess risk of LH cancer (SMR=1.66, 95%CI=1.15-2.32), especially those employed for less than five years (SMR=1.83, 95%CI=1.12-2.83). However, individuals with background exposures were at a non-significant excess risk (SMR=1.74, 95%CI=0.75-3.43), whereas the low-exposure group had a lower than expected risk (SMR=0.79, 95%CI=0.39-1.41). Survival analyses were performed using an estimate of cumulative BD exposure as a time-dependent explanatory variable defined as a combination of job-exposure class, calendar time, and length of time in job, and observed no relationship with exposure but a significant effect with age at hire.

In the most informative study mortality was examined in a cohort of 17924 men employed in the North American SBR industry (Delzell *et al*, 1989, Delzell *et al*, 1995, Delzell *et al*, 1996, Delzell *et al*, 2001, Delzell, 2006, Graff *et al*, 2005, Macaluso *et al*, 1996, Sathiakumar *et al*, 1998, Sathiakumar *et al*, 2005). All subjects were men who had worked for at least one year between 1943 and 1991. Work histories were used to classify subjects according to employment in five major work areas and combined with exposure concentrations to develop a job-exposure matrix. Early analyses showed significantly reduced deaths from all causes and all cancers, and non-malignant causes of death (Sathiakumar *et al*, 1998). The workers were also shown to have an increased risk of leukaemia that was concentrated among hourly paid men with 20 or more years since hire and ten or more years of employment in the industry (Delzell *et al*, 1996, Delzell *et al*, 2001, Macaluso *et al*, 1996, Sathiakumar *et al*, 1998). The risk was greater in subjects employed in polymerisation, maintenance labour and laboratories, three areas in styrene-BD operations and the polymerisation short-stopping agent dimethydithiocarbamate (DMDTC). In the most recent analysis a total of 162 deaths from LH cancers were observed (Delzell, 2006, Sathiakumar *et al*, 2005), resulting in an SMR of 1.06 (95%CI=0.90-1.23). No difference was seen between the follow-up periods of 1944-91 (SMR=1.06) and 1992-98 (SMR=1.04). For the individual cancers making up LH cancer non-significant excesses were observed for leukaemia (SMR=1.16, 95%CI=0.91-1.47) and HD (SMR=1.11, 95%CI=0.58-1.95), with an expected risk for NHL (SMR=1.00, 95%CI=0.75-1.30) and lower than expected risk for myeloma (SMR=0.95, 95%CI=0.62-1.40). In this analysis no significant excess was seen among “ever hourly” workers (SMR=1.09, 95%CI=0.91-1.28) but the excess remained in those with 20 or more years since hire and ten or more years of employment (SMR=1.30, 95%CI=1.04-1.60). A statistically significant risk was still seen in maintenance labour and laboratory workers. In addition, a significant dose-response relationship was observed, with a statistically significant excess in the highest exposed group (Table 1.2) (Delzell, 2006).

Table 1.2 Relationship between risk of lymphohaematopoietic cancers and exposure to 1,3-butadiene

Butadiene exposure (ppm-years)	Observed/Expected	SMR[1]	95%CI
0	18/27.7	0.65	0.39-1.03
>0 to <33.7	34/32.5	1.05	0.72-1.46
33.7 to <184.7	33/39.7	0.83	0.57-1.17
184.7 to <425.0	25/16.8	1.49	0.96-2.20
425.0+	28/13.8	2.03	1.35-2.93

[1] SMR adjusted for age, race and calendar year

In a similar study of 12160 workers employed one or more years in styrene-BD polymer manufacturing plants in North America followed-up to 1982 no excess of LH cancers was observed (SMR=0.97, 95%CI=0.73-1.26) (Matanoski *et al*, 1990). In a nested case-control study of the LH cases (N=59), a non-significant OR of 2.09 (95%CI=0.85-5.17) was observed using an unmatched analysis (Santos-Burgoa *et al*, 1992). However, using a matched analysis resulted in a significant relationship (OR=2.30, 95%CI=1.13-4.71). Conditional logistic regression modelling was used to examine the association between LH cancers and chemicals and resulted in an OR of 2.42 (95%CI=1.12-5.23) for BD.

A small cohort study of 614 workers at a Texas petrochemical facility between 1948 and 1989, with a minimum of five years employment and potential for exposure to BD monomer were followed-up through 1998 (Tsai *et al*, 2001). All-cause and all-cancer mortality were significantly lower than expected. Only three deaths from LH cancers were observed (SMR=1.06, 95%CI=0.22-3.11).

A cohort mortality study among 364 men (part of large cohort of chemical workers) who were assigned to any of three BD production units located within several chemical plants were followed-up through 1990 (Ward *et al*, 1995, Ward *et al*, 1996). A total of 7 LH cancer deaths were observed (SMR=1.75, 95%CI=0.70-3.61), the majority of which (N=4) were from lymphosarcoma and reticulosarcoma (SMR=5.77, 95%CI=1.57=14.8).

1.4.3 Choice of risk estimates to assess health impact

Epidemiological studies of BD have focussed on workers in the North American styrene-BD rubber (SBR) and BD-monomer (BDM) industries. The SBR industry study only showed a 6% excess of LH neoplasms and a dose-response relationship; whereas the BDM industry studies showed a 40% excess but no dose-response relationship, although the risk was significantly raised in the highest group.

The risk estimate from the SBR industry study will be used in the AF calculation because the study is the largest, has the longer follow-up, covers the relevant exposure period and has adjusted the risk estimate (Delzell, 2006). The highest adjusted risk estimate from the study (SMR=2.03, 95%CI=1.35-2.93) has been selected for the health impact calculation for the highly exposed using a precautionary approach (Table 1.2). The risk estimate of 1.05 (95%CI=0.72-1.46) for the lowest exposed group from the study by Delzell (2006) has been selected for the low exposure group.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

Butadiene was first produced in the late nineteenth century by pyrolysis of various organic materials. It is thought that the commercial butadiene industry developed in the years preceding World War II. Many nations realised that in the event of war, they could be cut off from rubber plantations controlled by Britain and sought to reduce their dependence on natural rubber. Production and use of the substance subsequently increased dramatically during the war (Melnick *et al*, 1993).

Data searches were carried out to determine manufacturing sites currently producing 1,3-butadiene. The European chemical Substances Information System (ESIS) (date unknown) website lists 34 producers/ importers of 1,3-butadiene in Europe (Table 2.1).

Table 2.1 List of producers/ importers according to ESIS website

Company	Country
Alusuisse	Italy
Atochem	France
Basf Ag	Germany
Basf Antwerpen N. V.	Belgium
Borealis Polymers Oy	Finland
Borealis Produtos Quimicos	Portugal
Bp Chemicals Ltd.	UK
Bre - Building Research Establishment	UK
Dow Benelux N. V.	Netherlands
Dow Chemical Iberica S.A.	Spain
Dsm Hydrocarbons B.V.	Netherlands
Ec Erdùlchemie Gmbh	Germany
Enichem Elastomeri	Italy
Enichem S.P.A.	Italy
Exxon Chemical France	France
Exxon Chemical, Limited	Uk
Huels Ag	Germany
ICI Chemicals & Polymers Limited	UK
Institute For Terrestial Ecology	UK
Marghera Butadiene S.P.A.	Italy
Mg Chemiehandel Gmbh	Germany
Neste Chemicals N.V.	Belgium
Neste Produtos Quimicos S.A.	Portugal
Oexno Olefinchemie Gmbh	Germany
Oxeno Olefinchemie Gmbh	Germany
Repsol Petroleo, S.A.	Spain
Repsol Quimica, S.A.	Spain
Rheinische Olefinwerke Gmbh	Germany
Rhodia Austria Gmbh	Austria
Ruetgerswerke Ag	Germany
Shell France	France
Shell Nederland Chemie B.V.	Netherlands
Shell Nederland Chemie B.V.	Netherlands
Sýchsische OLEFINWERKE GMBH	Germany

It is unclear which of these are producers and which are importers. It is likely that this information is out of date and so other sources of information were consulted. There are 22 EU producers of 1,3-butadiene reported in the International Uniform Chemical

Information Database (IUCLID). Only two companies are reported as importers. The amounts imported are thought to be small compared with the quantities produced in the EU.

An estimated 9.3 million tonnes of butadiene were produced worldwide in 2005 (CMAI, 2006). It is estimated that world capacity grew by 3.5% per year between 1997 and 2002, with most of the increase occurring in Asia, South America and the Middle East (IARC, 2006). According to the EU RAR (2002) the total production capacity of 1,3-butadiene is estimated to be between 1,202,000 and 4,960,000 tonnes/year. Production in Western Europe was reported at 1,892,000 tonnes in 1994 by ECN (1995). The production capacity in 2006 in the Western and Eastern EU was estimated to be 2,232,000 tonnes/ year and 736,000 tonnes/year, respectively (IARC, 2006). Asia is now the largest producer of butadiene and accounts for one-third of the world capacity (Walther, 2003).

2.2 PREVALENCE OF 1,3-BUTADIENE EXPOSURE IN THE EU

The prevalence of exposure to 1,3-butadiene was estimated from the Finnish CAREX estimate of 2007, the Spanish CAREX estimate of 2004 and the Italian CAREX estimate of 2000 – 2001 (Mirabelli and Kauppinen, 2005). The proportion of exposed workers in each industry was taken from each of these three CAREX estimates and the average proportion exposed across all three countries was found for each industry. The 2007 proportion estimate for NACE 25 (Manufacture of rubber and plastic products) was not available for Finland and the 2000 proportion was substituted. The average proportion of exposed workers was applied to information on the number of employees in each industry obtained from the Structural Business Statistics and the Labour Force Survey available on the Eurostat database.[3] The average proportion of exposed workers was multiplied by the number of workers employed in each industry in each country in 2006 to estimate the number of exposed workers in each industry and country. For Finland, Spain and Italy the proportion of exposed workers from their respective CAREX updates were used rather than the average proportion. The available data indicates that there are no longer any exposed employees in NACE 26, 60 and 85.

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

The estimated exposure prevalence for the EU member states based on 2006 employment data is shown in Table 2.2. We have estimated that approximately 27,600 workers in the EU were potentially exposed to 1,3-butadiene.

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

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

Table 2.2 Number of workers exposed to beryllium by country and NACE code (NA = Not Available in Eurostat database)

	NACE CODE									
	23	**24**	**251**	**252**	**29**	**63**	**73**	**74**	**80**	**Grand Total**
Austria	NA	242	18	106	8	18	6	15	22	440
Belgium	30	629	18	101	4	16	7	22	37	869
Bulgaria	24	233	20	86	7	13	0	7	21	415
Cyprus	NA	17	0	5	0	2	0	1	2	28
Czech Republic	15	372	114	237	16	14	7	19	28	861
Denmark	NA	268	8	83	6	11	7	13	21	422
Estonia	5	27	3	20	1	4	0	2	6	69
Finland	15	312	23	81	12	9	1	15	7	474
France	139	2471	354	706	31	88	46	126	176	4140
Germany	105	4114	389	1313	106	164	103	172	206	6712
Greece	21	163	5	47	2	13	10	15	30	308
Hungary	32	288	53	133	7	10	7	17	31	582
Ireland	NA	223	4	40	1	6	3	7	13	299
Italy	172	0	0	0	0	0	58	0	152	382
Latvia	0	39	2	19	1	5	1	2	9	79
Lithuania	NA	55	2	39	1	5	1	3	13	122
Luxembourg	0	10	20	10	0	1	NA	2	1	43
Malta	NA	NA	NA	NA	NA	NA	NA	NA	1	1
Netherlands	34	573	17	127	9	29	37	66	53	951
Poland	76	970	171	508	21	25	5	35	112	1936
Portugal	NA	193	28	88	5	13	1	25	31	386
Romania	35	438	67	148	10	22	25	15	41	804
Slovakia	NA	115	34	62	5	4	5	4	16	244
Slovenia	0	126	19	43	3	3	3	3	7	207
Spain	0	1336	246	570	0	128	13	80	105	2503
Sweden	17	391	33	96	12	19	12	19	48	649
United Kingdom	122	1926	148	775	28	122	113	170	251	3690
TOTAL	843	15531	1796	5444	295	744	473	854	1440	27615

Classification of Industries by Exposure Level

Industries in which 1,3-butadiene exposure may occur have been classified as high (H),or low (L) historic exposure based on an evaluation of the peer-reviewed literature, information from industry and expert judgement. The exposure classification by industry is presented in Table 2.3. The industries, grouped by NACE code, were identified from the CAREX data and data from the available published literature.

Table 2.3 Classification of industries by (historic) exposure level

Industry	NACE (rev 1)	Classification
Manufacture of coke, refined petroleum products and nuclear fuel	23	H
Manufacture of chemicals and chemical products	24	L
Manufacture of rubber products	251	H
Manufacture of plastic products	252	L
Manufacture of other non-metallic mineral products	26	L
Manufacture of machinery and equipment n.e.c.	29	L
Land transport; transport via pipelines	60	L
Supporting and auxiliary transport activities; activities of travel agencies	63	L
Research and development	73	L
Other business activities	74	L
Education	80	L
Health and social work	85	L

2.3 LEVEL OF EXPOSURE TO 1,3-BUTADIENE

2.3.1 Estimation of exposure levels

There are very few recent (after 2000) peer-reviewed studies on exposure to 1,3-butadiene in the EU. A literature search in the database PubMed using the terms occupational exposure and 1,3-butadiene provided only 2 studies with exposure data (Albertini *et al* 2007 and Antinnen-Klemett *et al* 2006), both cited in the IARC Monograph (IARC, 2006).

Exposure estimates in the manufacture of refined petroleum products (NACE code 23).

Occupational exposure data reported in the EU Risk Assessment Report (RAR), which were collated from the HSE National Exposure Database (NEDB), industry and published review articles, showed that from 5,000 personal 8-hr TWA exposures, 90% were less than 5 ppm with the majority of these below 1 ppm (2.21 mg/m^3).

Personal exposure levels (8-hr TWA) in butadiene production plants across different sites in the EU ranged from <1 ppm to >25 ppm, with 96.3% of the measurements being below 1 ppm for the crackers (n=1548) and 81.4% below 1 ppm in the extraction units (n=1548) (aggregated data from years 1986-1993) (EU, 2002). Data form 1995 from 15 monomer extraction sites in the EU showed TWA ranging from <0.01 to 5 ppm. Exposure data associated with gasoline production in 1984-1985 in 13 EU countries showed arithmetic means (AM) ranging from below the limit of detection (LOD) to 6.4 ppm (number of measurements is not reported) for the different activities (EU, 2002).

Data from Finland at 33 different sites showed personal concentrations ranging from <0.1 ppm to 477 ppm with a mean of 11.5 ppm and median of <0.1 ppm (IARC, 2006).

Data from the UK in 1984, obtained from the HSE's National Exposure Database (NEDB) from a survey in 7 companies (2 producing butadiene and 5 using this substance as a chemical feed-stock in polymer production) showed 9 out of 10 measurements had concentrations below 1 ppm. The other measurement had a value of 17 ppm.

Information from one manufacturer in the UK reported mean exposure concentrations between 1988 and 1993 of 0.12 ppm (n=43, maximum: 0.72 ppm) and between 1990-1994 of 0.44 ppm (n=225, maximum: 3.9 ppm). A summary of the descriptive statistics on 1,3-butadiene exposure found in the literature review are shown in Appendix 8.2.

Based on the reported geometric mean (GM) we estimated a weighed GM = 0.29 ppm and weighed geometric standard deviation (GSD) = 2 for the manufacture of refined petroleum products industry.

Exposure data by country have not been estimated due to limited availability of results being stratified by country. Although these estimates have been calculated with data from the 1980s and 1990, they are the most representative of exposure concentrations across the EU. We assumed exposure concentrations have decreased 7% per year since 1990. Therefore exposure concentrations in 2006 were estimated to be 0.09 ppm and GSD=2.

Exposure data in the rubber industry (NACE code 251)

The largest dataset of exposure concentration in the rubber industry is reported in the IARC Monograph. Data were obtained from 23 styrene-butadiene rubber plants across the EU 27 collected in 1984-1993. For 65.5% of the measurements concentrations were below 0.5 ppm. Concentrations ranged from <0.5 ppm to >25 ppm.

Individual studies have reported AM exposure concentrations ranging from 0.18 to 0.8 ppm. Concentrations in a styrene-butadiene polymer production plant in the Netherlands collected in 1997 ranged from 0.05-4.48 ppm with an AM of 0.24 ppm (n=14) (EU, 2002). Albertini *et al* (2003) in an exposure study in the Czech Republic in the polymer production industry reported personal 8-hrs TWA concentrations of 0.18 ppm for women with a maximum of 9.8 ppm and 0.8 ppm with a maximum exposure value of 5.7 ppm for exposed men. A Finnish study (Antinnen-Klemet *et al* 2006) reported exposure concentrations collected in 3 styrene-butadiene latex production plants in 1997; 624 samples (70.5 %) were below the limit of quantification (LOQ) of

0.013 ppm; 240 samples (27.1%) were between the LOQ and 1 ppm; and 21 samples (2.45%) exceeded 1 ppm. A summary with the exposure data from the literature review is shown in Appendix 8.3.

Information from the international institute of synthetic rubber producers (McGraw, 2010) indicated that exposure concentrations range from 1 to 5 ppm with an average exposure in the order of 1-2 ppm. Therefore, we assume that currently the AM of exposure to 1,3-butadiene in the rubber industry is 1.5 ppm. The GM and GSD were not reported so the distribution of the exposure data is unknown. We estimated the GM as described in Lavoue *et al* (2007) assuming a GSD=3 which is typical in occupational exposure. The estimated GM was 0.82 ppm.

Weighted exposure concentrations

Overall weighted GM and GSD were estimated across the both industries: manufacture of refined petroleum products and manufacture of rubber where exposure to 1,3-butadiene occurred. Using @Risk 10,000 “measurement” data points were generated using the GM for each industry. The number of “measurements” each industry contributed was weighted according to the estimated number of people exposed in that industry. The prevalence estimates presented in Table 2.2 were used as the number of exposed in each industry.

Since no exposure data were available for each country separately, a single GM and GSD have been calculated for all EU countries using the median prevalence for each NACE codes. The overall weighted GM was 0.43 ppm with a GSD of 4.18. With this weighted exposure concentration 4.3% of workers in high exposure industries are estimated to be exposed above 5 ppm, 27.8% are estimated to be exposed above 1 ppm and 45.8% are estimated to be exposed above 0.5 ppm.

In the low exposure industries levels are probably below 0.5 ppm.

2.3.2 Temporal change in exposure

1,3-Butadiene was first produced in the late nineteenth century by pyrolysis of various organic materials. Commercial production began in the 1930s. Only one study was identified on historical exposure data (Kwekkeboom (1996) and Dubbeld (1998), reported in the IARC, 2006). The study shows formaldehyde concentrations collected in the styrene-butadine polymer production industry in the Netherlands between 1991 and 1996. Data shows similar levels for 1991 and 1996 (Figure 2.1).

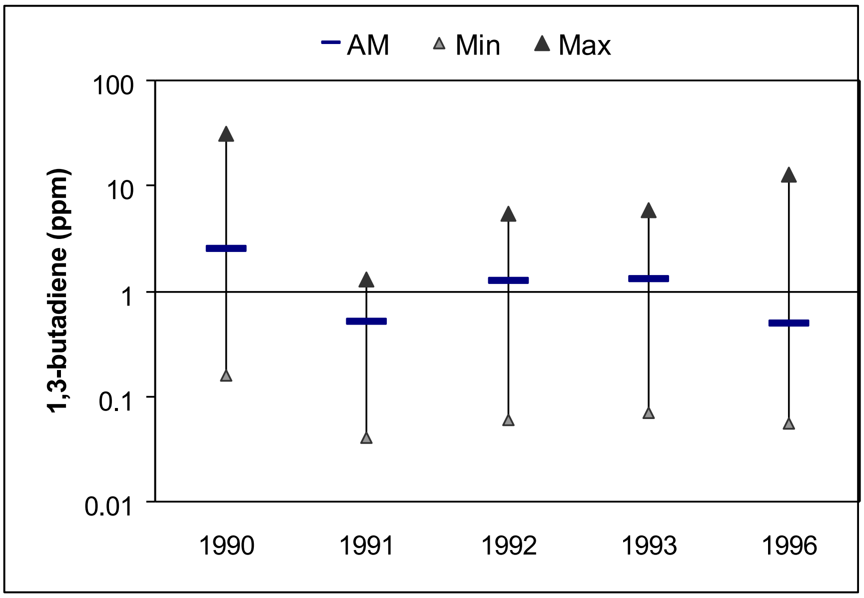


Figure 2.1 Exposure concentration in the styrene-butadiene polymer production industry in the Netherlands (data from IARC, 2006)

Data from a Canadian styrene-butadiene rubber plant indicates a clear decrease in exposure from 1977 to 1991 (Figure 2.2) (Sathiakumar *et al* 2007). The estimated decrease from the linear equation of the log-data was 24% per annum. However it should be noted that this trend might not be representative of EU scenarios. For example, data in Figure 2.1, from the Netherlands, showed similar exposure concentrations in 1991 and 1996.

For the purposes of the health impact assessment we have assumed that exposure has decreased by 7% per annum over recent years in the industries where 1,3-Butadiene is used.

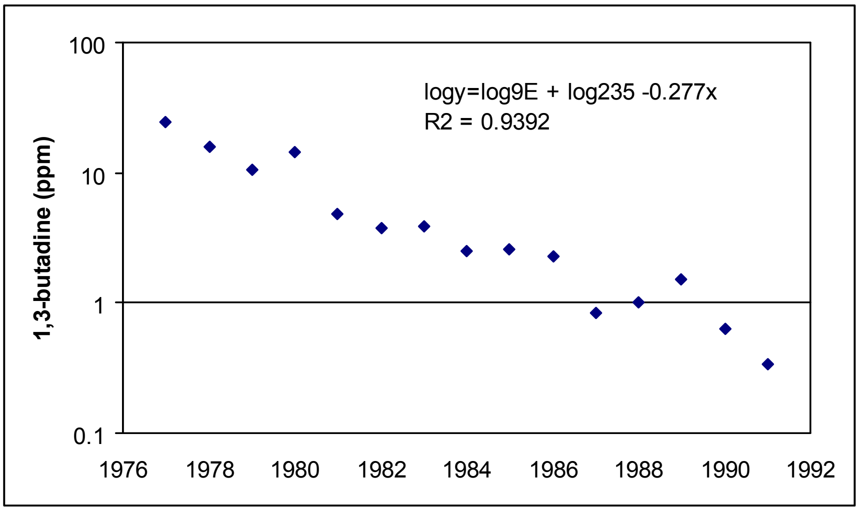


Figure 2.2 Exposure concentrations in the styrene-butadiene rubber production industry in Canada (data from IARC, 2006)

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

2.4.1 Background data

The occupational cancers associated with exposure to 1,3-butadiene are listed in Table 2.4 along with a summary of the information used in the health impact assessment.

Table 2.4 Occupational cancers associated with exposure to 1,3 butadiene

Cancer site	**Lymphohaematopoietic cancers (LH)**	
ICD-10 code	C81-C96	
IARC group for carcinogen	2A	
Strength of evidence for cancer site [(1)]	Suggestive	
Latency assumption	0-20 yrs	
Source of forecast numbers - deaths	Eurostat, 2006, data for LH C81-C96	
Source of forecast numbers - registrations	GLOBOCAN, 2002, data for C81, C82-C85, C90 and C91-C95 summed[4]	
Exposure levels	Relative Risk (RR)	Source of RR
"High"	2.03 (1.35, 2.93)	Delzell (2006)
"Low"	1.05 (0.72, 1.46)	Delzell (2006)

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

2.4.2 Exposed numbers and exposure levels

Industry sectors, their NACE codes and classifications to High/Medium/Low/Background exposure as applicable for the mid 1970s are given in Table 2.3 in the previous section on the exposure. The estimated average exposure level (GM) and measure of variability (GSD) for NACE industries used are 0.43 ppm and 4.18 respectively.

We present data for a "baseline" scenario which for all industries assumes a 7% annual decline in exposure levels and standard change in employed numbers up to the 2001-10 estimation interval and constant levels thereafter.

2.4.3 Forecast cancer numbers

Estimates for total numbers of deaths for Lymphohaematopoietic cancers (ICD10 C81-96) are available from EUROSTAT for the 27 countries of the EU, for 2006, and for registrations for leukaemia (C91-C95), NHL (C82-C85), Hodgkin's lymphoma (C81) and Multiple Myeloma (C96) from GLOBOCAN for 2002. The forecast numbers of deaths and registrations by country used to estimate attributable numbers are in Appendix 8.4.

2.4.4 Results

The cancer deaths and registrations attributed to occupational exposure to 1-3 Butadiene 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.

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

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

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

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

Scenario	**All scenarios**		**Baseline (trend) scenario (1) - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.**			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	79,768	80,993	82,366	82,669	82,669	82,669
Proportion of the population exposed	0.020%	0.020%	0.020%	0.021%	0.021%	0.022%
LH						
Attributable Fraction	0.0014%	0.0012%	0.0012%	0.0012%	0.0013%	0.0013%
Attributable deaths	1	1	2	2	2	2
Attributable registrations	2	2	3	3	3	3
'Avoided' cancers						
YLLs	19	19	21	23	25	25
DALYs	24	24	26	28	30	32

The attributable deaths from previous exposure to 1,3-Butadiene exposures in the EU in 2010 were predicted to be very small, with one attributable LH cancer death. The estimated deaths and cancer registrations increase slightly over the following 50 years with two attributable LH cancer deaths predicted to occur in 2060. The corresponding estimated attributable fraction (AF) for LH cancer decreases slightly from 0.0014% in 2010 to 0.0013% in 2060. DALYs are expected to increase in the baseline scenario – from 24 years in 2010 to 32 years in 2060.

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

The health data (cancer registrations and Years of Life Lost - 'YLL') for the baseline in which there are no further modifications to the Carcinogens Directive are shown in section 2.4 of this report. These data show that there are predicted to be a relatively small number of cancer registrations (2-3 per year, equalling to around 160 over the period 2010-2070[5]) and YLLs (19-25 per year equalling around 1,300 over the period 2010-2070[5]) from lymphohaematopoietic cancer (LH) resulting from predicted future exposure to 1,3-butadiene.

There is predicted to be a slight increase in registrations and YLLs over time, despite a reduction in predicted exposure owing to implementation of existing and ongoing risk management measures across the EU. This is perhaps due to a presumed increase in use either recently (with a lag in cancer development) or increase in the level of use in the future.

[5] 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.

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:

- 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, give a total value for COI. (COI is often the main market-based approach in relation to health impact[6]). COI includes the direct and indirect costs of cancer but not the intangible costs (see below).
- Willingness to Pay (WTP) to avoid cancer – WTP in this study 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 (such as disfigurement, functional limitations, pain and fear) and 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)[7].

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[8]. 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. an 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

[6] ECHA (2008) "Applying SEA as part of restriction proposals under REACH" Available at: http://echa.europa.eu/doc/reach/sea_workshop_proceedings_20081021.pdf
[7] This is consistent with some other European Commission studies and is standard practice for air quality under the Clean Air for Europe (CAFE) programme.
[8] European Commission impact Assessment Guidelines (Jan 2009) - http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_en.pdf

'snap-shot' result is multiplied by 10 in order to derive an estimate for the whole assessment time period (for example, 2020 results are multiplied by 10 to give results over the period 2020-2029). This assumes that each snap-shot year is representative of the following 10 years.

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

Results

The health costs under the baseline scenario are presented in Table 2.7. Health-related costs are predicted to decline over time whist, as shown in Section 2.4, the number of cancer registrations and YLLs are estimated to slightly increase over time. This is due to the effects of discounting costs over time using a 4% discount rate.

The introduction of an EU-wide OEL is not expected to have a significant impact in the short term given that most Member States already have a national OEL in place (the stringency varies by Member State from 0.5ppm to 60ppm). Table 2.7 sets out the ranges 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 2.3.

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	3 to 11	2 to 9	2 to 8	2 to 7	2 to 6	1 to 5	13 to 47
Male	7 to 29	5 to 23	5 to 20	4 to 18	4 to 16	3 to 13	29 to 120
Total	10 to 40	8 to 32	7 to 29	6 to 25	6 to 22	5 to 19	41 to 167

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

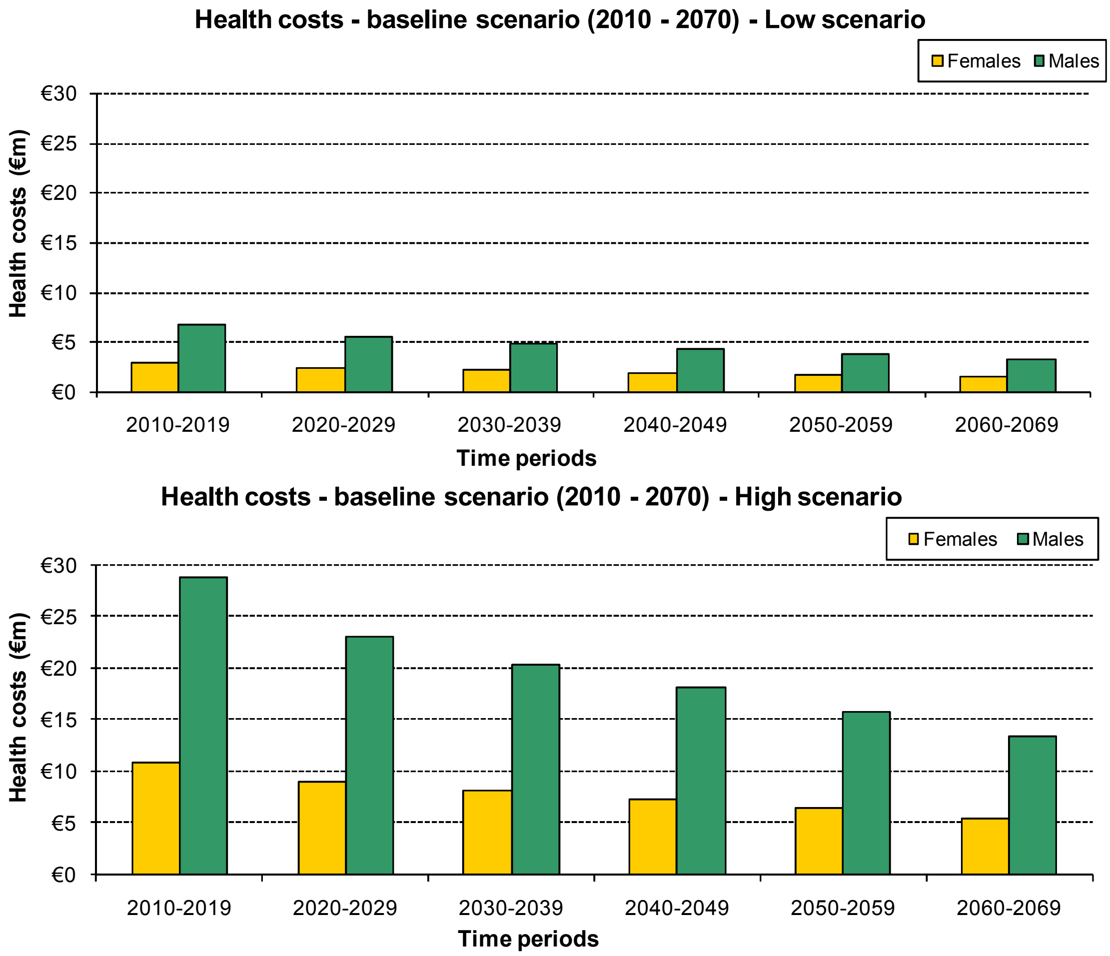
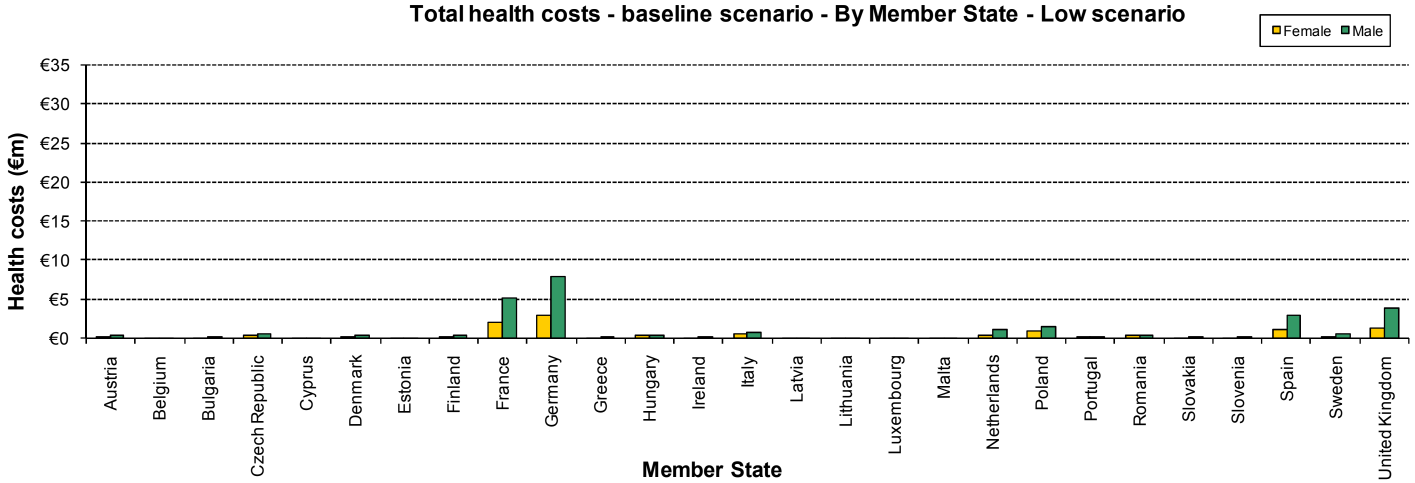


Figure 2.3 Health costs - baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

These costs will affect Member States differently depending upon the overall number of workers within affected industry groups, existing RMMs and the proportion of males and females within these groups. Figure 2.4 shows that France and Germany are predicted to have the highest health costs, followed by Spain and the UK. The industrial sector estimated to be most affected under the baseline is the manufacture of chemicals and chemical products. There are also notable impacts in the manufacture of plastics and plastic products. This is shown in Figure 2.5.

Detailed tables are included in Appendix 8.5.



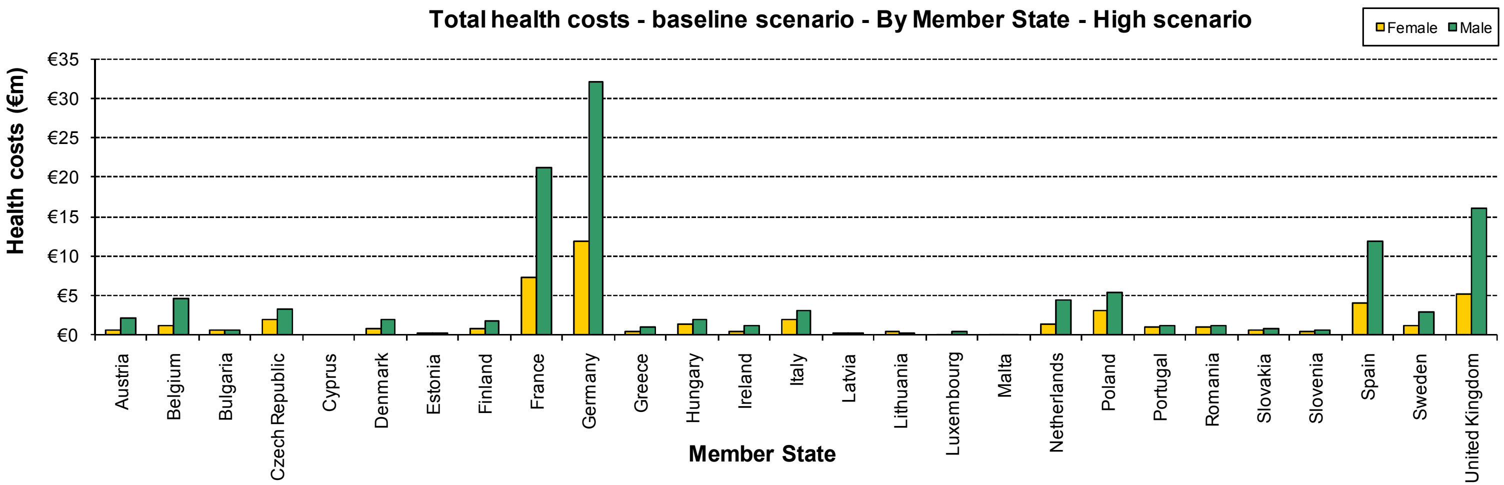


Figure 2.4 Total health costs- baseline scenario – By Member State (Present Value – 2010 €m prices)

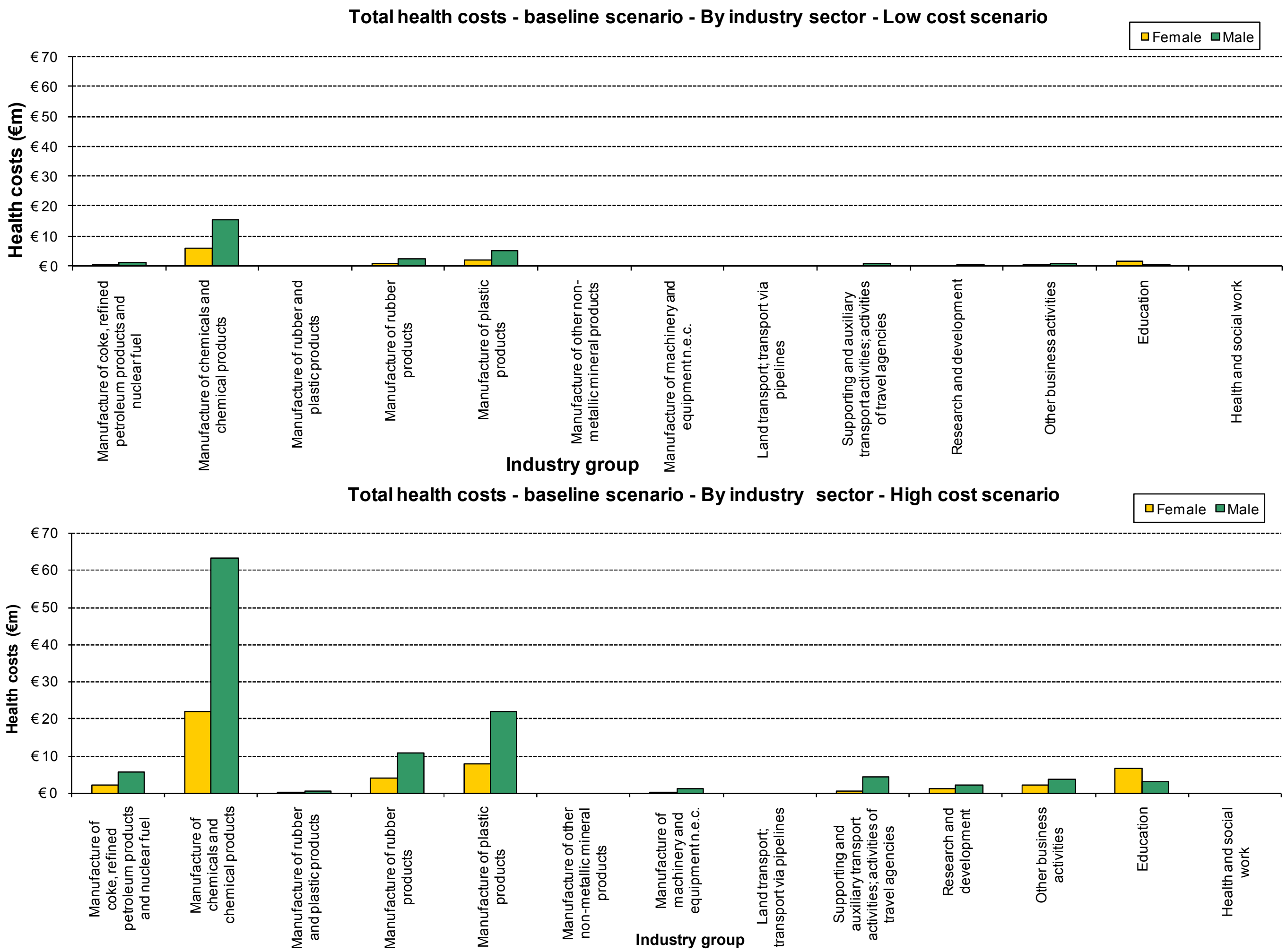
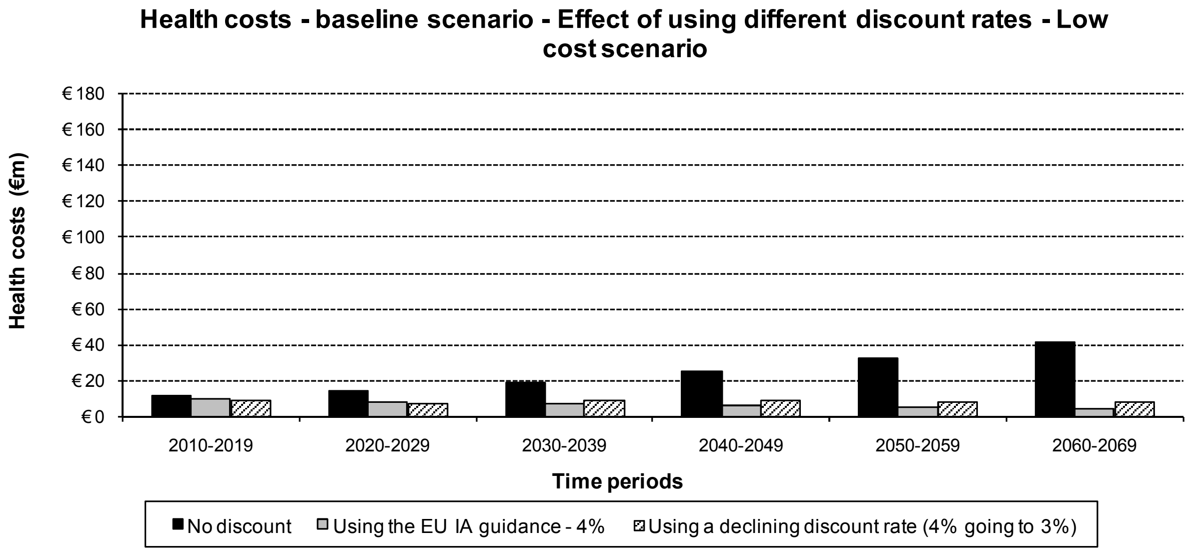


Figure 2.5 Total health costs - baseline scenario - by industry group (Present Value – 2010 €m prices) [9]

[9] 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 2.6, the effects of different discount rates on the overall results are shown, indicating that the impacts of discounting become more pronounced the further in the future that the impact occurs. As the number of registrations and YLLs increase over time, the difference between using discounting and not using discounting becomes more evident.



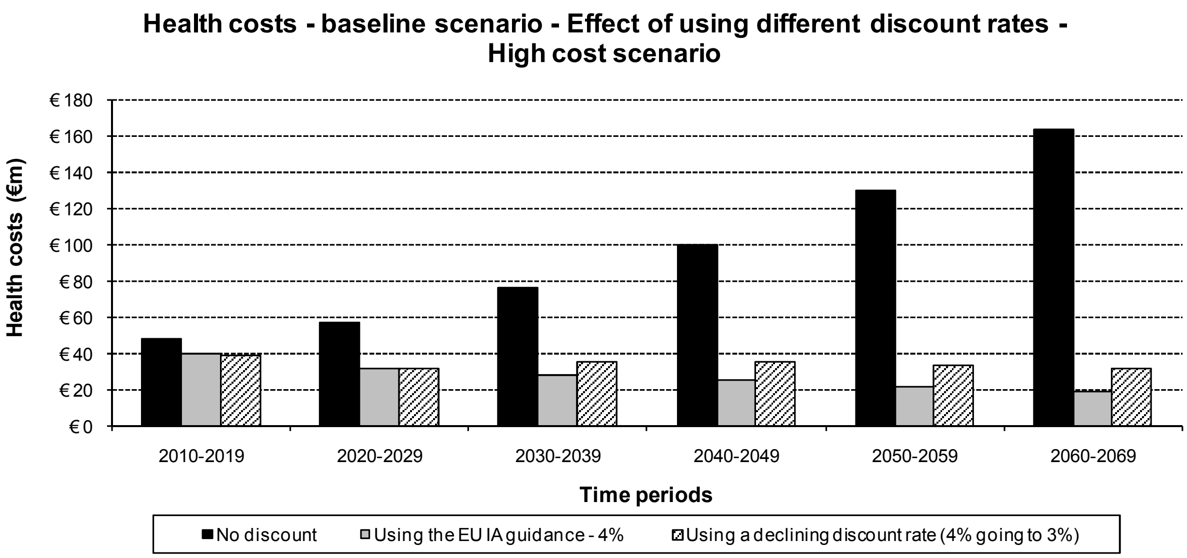


Figure 2.6 Impacts of discounting

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

Occupational exposure to butadiene may occur via inhalation during:

- catalytic steam cracking of petroleum streams and subsequent extraction of butadiene;
- the production of butadiene polymers;
- the use of the polymers;
- during the production and handling of motor fuels (EU, 2002).

Workers who are particularly at risk of occupational exposure are those involved with its manufacture and those working in polymer production plants. In these sectors, potential exposure may occur when the substance is released during the following:

- Material sampling - the butadiene monomer manufacturing industry is understood to use “sample bombs” which is a closed-loop sampling technique. Improperly purged sampling lines are a source of exposure when the cylinder is disconnected because the sampling line is under positive pressure with respect to the work environment. The effectiveness of the closed-loop system depends on the proper fitting of the cylinder. Worn fittings will result in leaks during sampling and voiding procedures.
- Transportation of 1,3-butadiene to and from polymer production facilities may be accomplished through: pipelines, rail tank cars, tank trucks and marine vessels. Of these, only pipe transfer (which is a totally enclosed system) represents a situation, if properly maintained, where no exposure to or release of the substance occurs (Fajen *et al*, 1990). Leaks may occur during loading and unloading of road or rail tankers and marine vessels.
- Periodic and unplanned maintenance - during maintenance the potential for exposure exists for the duration of the time taken to carry out the work. The significance of exposure will depend on steps taken to ensure the system is uncontaminated prior to breaching.
- Fugitive emissions - in addition to the above tasks, exposure may also arise from process leaks, which will depend on the integrity of the equipment and again the industry’s approach to monitoring and controlling such leaks.

Examples of control measures to reduce exposure to 1,3-butadiene are summarised in Table 3.1. It is not known how widespread these measures are amongst manufacturers and uses of 1,3-butadiene, although it is considered likely that most are in common use.

Table 3.1 General recommendations to reduce exposure to 1,3-butadiene

Organisational measures	Personnel measures	Technical measures
Improvement of storage facilities to reduce fugitive emissions	Use of personal protective equipment (PPE)	Implement a Leak Detection and Repair (LDAR) programme
Regular inspection of loading/ unloading equipment and upon any evidence of damage, immediate testing and/ or replacement is recommended.	Use of respiratory protective equipment (RPE) particularly during maintenance activities	Plants should consider retrofitting pumps having single mechanical seals with more effective dual mechanical seals.
	Exposure monitoring of personnel	Improve loading/ unloading equipment to reduce fugitive emissions (e.g. use magnetic gauges or dry-break coupling systems)
		Implement closed or ventilated sampling points
		Local exhaust ventilation (LEV)

Source: Adapted from Fajen *et al*, (1990) and Butadiene Product Stewardship Task Group (2010)

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

OELs in the EU are quite variable ranging from 0.5 to 45 ppm for 8-TWA levels and 1 to 60 ppm for short-term exposure levels. Typical values for 8-hrs TWA are considered 0.5, 1 or 5ppm. From the data shown in Section 2.3.2 it is likely that most of the manufacturing sites have exposure concentrations below 1 ppm.

The manufacture of butadiene monomer and polymer are carried out in closed systems. Therefore exposure occurs predominantly during tasks where the system is breached. These tasks, which may give rise to relatively high short-term exposures, include sampling, coupling of delivery lines, and planned and unplanned maintenance. The significance of these exposures depends on how these tasks are carried out and what measures are taken to reduce the exposure. For example, the use of closed loop/enclosed sampling points and dry break coupling systems will reduce exposure. The extent of the use of such systems was not established. It is therefore the extent to which these short-term exposures are controlled that will dictate the significance of the 8-hour time weighted average exposure (EU, 2002).

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

For 1,3-butadiene, OELs of 0.5, 1 and 5 ppm are to be tested. Lymphohaematopoietic cancer numbers will therefore be estimated given current (baseline) and full compliance[10] to the OELs. Baseline for all industries assumes a 7% annual decline in exposure levels and standard change in employed numbers up to the 2021-30 estimation interval and constant levels thereafter.

The three scenarios to be tested are described in Table 4.1 below.

Table 4.1 Baseline and intervention scenarios

Carcinogen **Intervention scenarios**[(1)]	**1,3-butadiene**
Baseline (trend) scenario (1)	Linear employment and exposure level trends assumed to 2021-30, constant thereafter.
Intervention scenario (2)	Full compliance for OEL = 0.5 ppm
Intervention scenario (3)	Full compliance for OEL = 1 ppm
Intervention scenario (4)	Full compliance for OEL = 5 ppm

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

Results for the baseline scenario (1) and intervention scenarios compared to the baseline scenario are in Figure 4.1 (attributable registrations), Figure 4.2 (AFs) and Figure 4.3 (DALYs) for men plus women for the total EU (27 countries) for LH cancer. A summary of the results for LH cancer for the total EU is in Table 4.2 below.

Introducing full compliance with any of the proposed OELs in 2010 does not avoid cancers occurring from 2010 onwards. Although some industries (NACE codes 23 and 251) were assumed to be ‘high’ exposed historically (in the 1970s) it is assumed that exposure levels have fallen by 7% a year to 2021-30 so that the assumed distribution of exposure levels around the current mean and estimated means up to 2021-30 under the baseline (trend) scenario place nearly all the exposed in the lowest recognised risk category, with or without intervention using the trial OELs (Figure 4.1). However attributable cancers are not eliminated in this analysis as there is no recognised background exposure level boundary below which it can be assumed that excess risk disappears (RR=1), i.e. we cannot identify a level below which there is no risk.

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

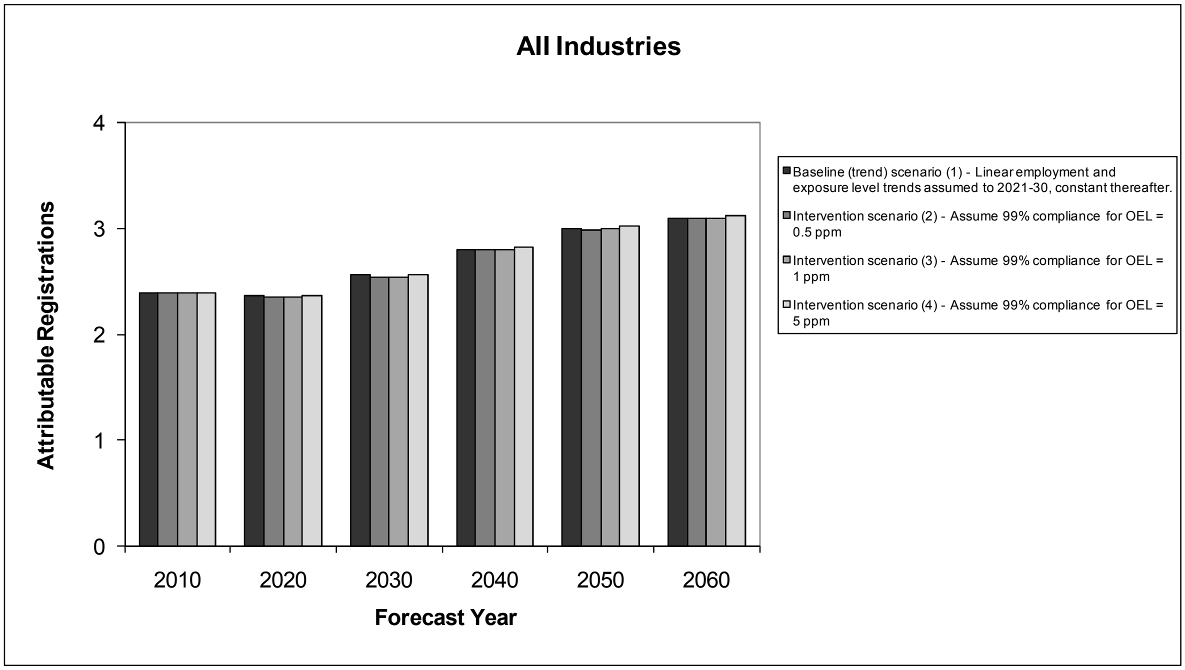


Figure 4.1 Results for intervention scenarios compared to the baseline scenario (1) – Occupation Attributable cancer registrations, LH cancer, men plus women

Figure 4.1 shows that the number of registrations for LH attributable to 1,3-Butadiene exposure increases slightly for the baseline and intervention scenarios over the next 50 years.

Figure 4.2 shows that the attributable fraction decreases until 2030 and then slightly increases over the next 30 years.

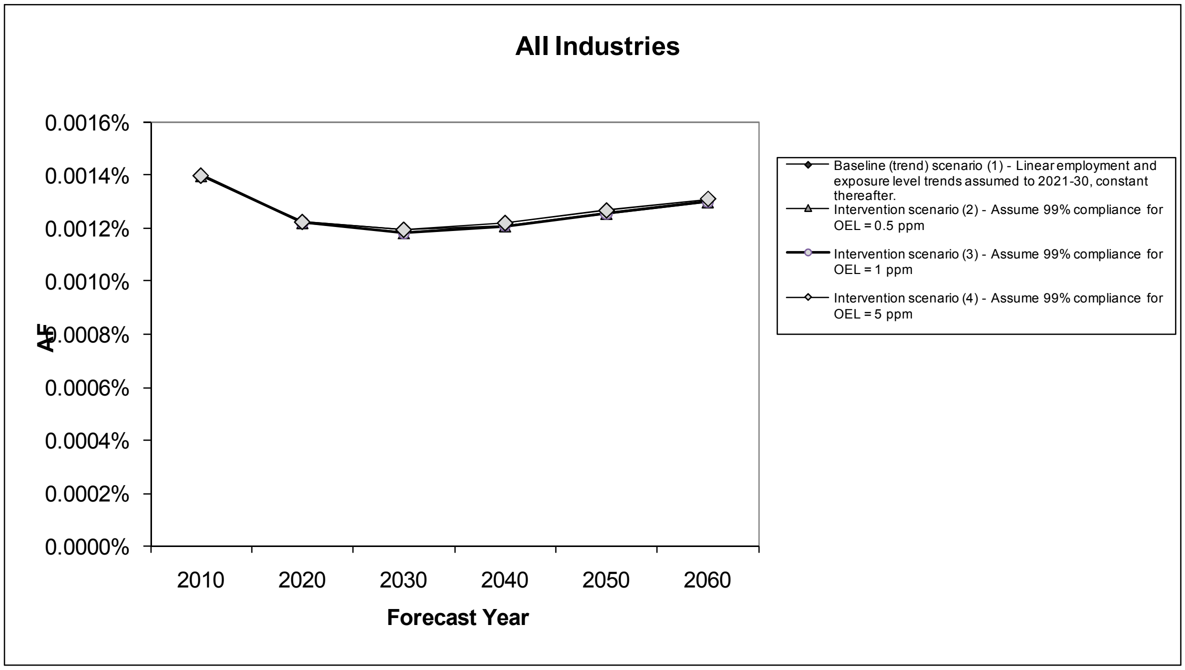


Figure 4.2 Occupation Attributable Fractions, LH cancer

The estimated DALYs increase slightly over the next 50 years for all of the scenarios (baseline and intervention) from just under 25 years in 2010 to just over 30 years in 2060 (Figure 4.3).

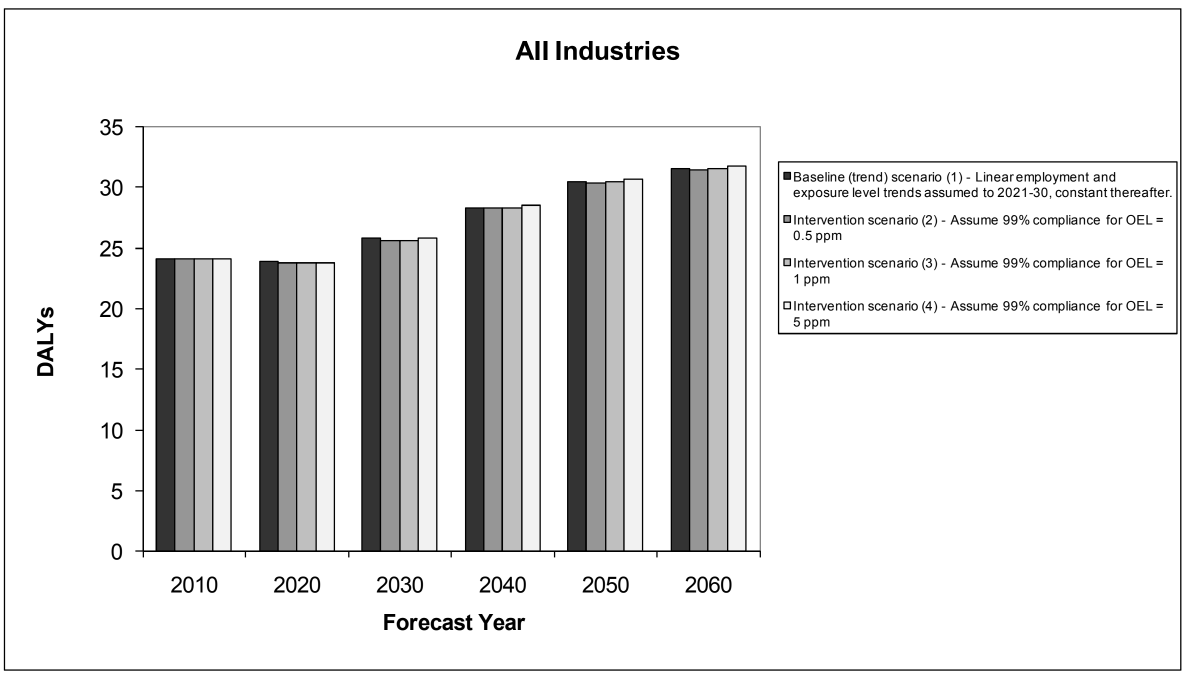


Figure 4.3 Occupation Attributable DALYs, LH cancer

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 intervention scenarios are shown in the three groups of four columns (2030-2060). Attributable LH cancer deaths increase slightly from 1 in 2010 to 2 deaths in 2060 for scenario 2 (99% compliance with OEL of 0.5 ppm), 2 deaths for scenario 3 (99% compliance with OEL of 1ppm) and 2 deaths for scenario 4 (99% compliance with OEL of 5ppm).

In Table 8.6.1 in Appendix 1.18.6 are the estimated proportions exposed above the OEL to be tested, currently and as estimated under the baseline forecast scenario (1). Under the alternative change scenarios they behave as determined by the scenarios.

Full results are given in Appendix 1.18.6 for men plus women by country in Tables 8.6.2 and 8.6.3. A breakdown of attributable numbers by industry is in Tables 8.6.4 and 8.6.5. 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, are available in supplementary spreadsheets (*1,3-Butadiene Report data.xls*), if required.

Table 4.2 Results for the intervention scenarios, total EU (27 countries), men plus women

Scenario	All scenarios		Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	79,768	80,993	82,366	82,669	82,669	82,669	82,366	82,669	82,669	82,669	82,366	82,669	82,669	82,669
Proportion of the population exposed	0.020%	0.020%	0.020%	0.021%	0.021%	0.022%	0.020%	0.021%	0.021%	0.022%	0.020%	0.021%	0.021%	0.022 %
LH														
Attributable Fraction	0.0014 %	0.0012 %	0.0012 %	0.0012 %	0.0013 %	0.0013 %	0.0012 %	0.0012 %	0.0013 %	0.0013 %	0.0012 %	0.0012 %	0.0013 %	0.0013 %
Attributable deaths	1	1	2	2	2	2	2	2	2	2	2	2	2	2
Attributable registrations	2	2	3	3	3	3	3	3	3	3	3	3	3	3
'Avoided' cancers			0	0	0	0	0	0	0	0	0	0	0	0
YLLs	19	19	20	23	24	25	21	23	24	25	21	23	25	26
DALYs	24	24	26	28	30	31	26	28	30	32	26	29	31	32

4.1.2 Monetised health benefits

The possible health benefits (i.e. avoided healthcare costs and effects of having cancer) for the introduction of an EU wide OEL at 5 ppm, 1 ppm and 0.5 ppm are shown in Table 4.3. The changes in cancer impacts over the first 30 years (2010-2040) are predominately the result of chronic impacts from past exposure as well as short term acute impacts that are predicted to continue to occur in the future (these are relatively small).

The benefits of introducing an OEL in 2010 are therefore most apparent from 2030-2039. There is estimated to be a small benefit to introducing a more stringent OEL with benefits being greatest with an OEL set at 0.5 ppm. The impacts of introducing an OEL at 5 ppm are estimated to have limited benefits as there is already estimated to be a reduction towards 5 ppm and below under the baseline scenario. The results are also illustrated in Figure 4.4.

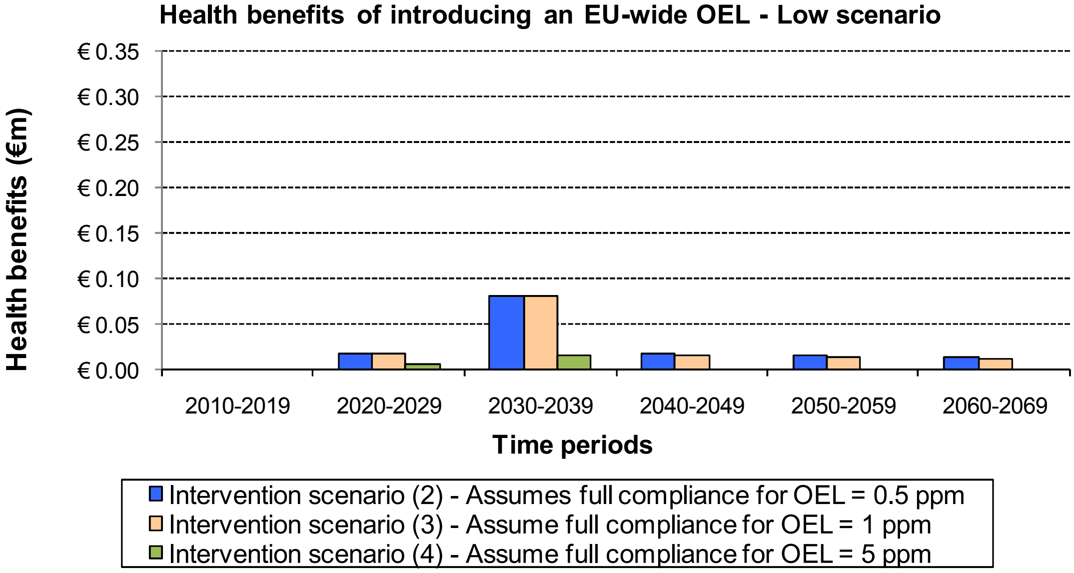
Table 4.3 Health benefits of intervention over time (Present Value – 2010 €m prices)

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	Totals
Intervention scenario (2) - Assumes full compliance for OEL = 0.5 ppm							
Female	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0	0 to 0.1
Male	0 to 0	0 to 0	0.1 to 0.2	0 to 0	0 to 0	0 to 0	0.1 to 0.4
Total	0 to 0	0 to 0.1	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0	0.1 to 0.6
Intervention scenario (3) - Assume full compliance for OEL = 1 ppm							
Female	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0	0 to 0.1
Male	0 to 0	0 to 0	0.1 to 0.2	0 to 0	0 to 0	0 to 0	0.1 to 0.4
Total	0 to 0	0 to 0.1	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0	0.1 to 0.5
Intervention scenario (4) - Assume full compliance for OEL = 5 ppm							
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 0.1
Total	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0	0 to 0.1

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



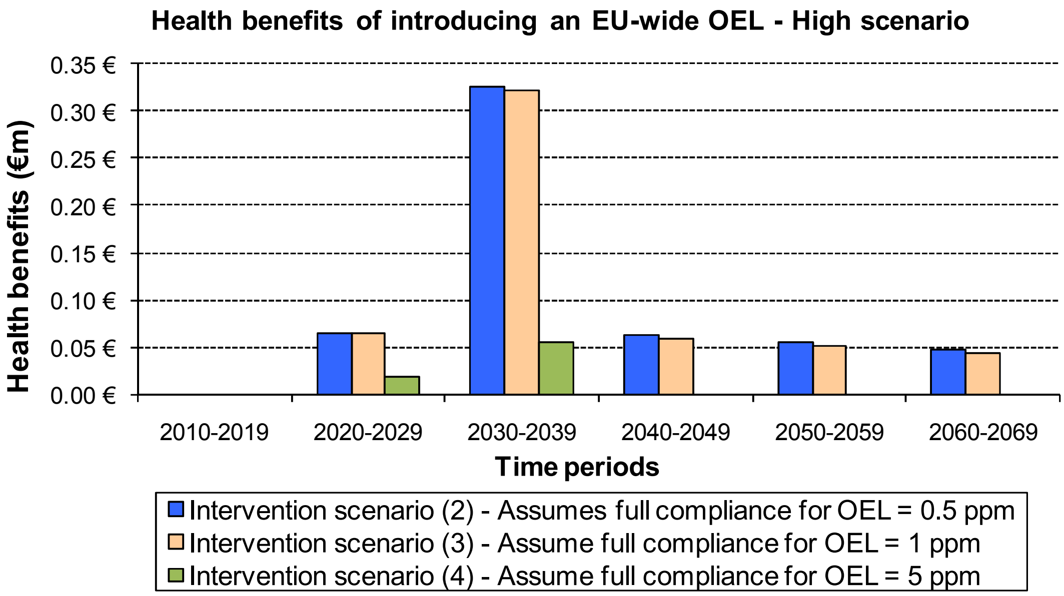


Figure 4.4 Health benefits over time of introducing an EU wide OEL (Present Value – 2010 €m prices)

These 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 4.5 (low scenario) and Figure 4.6 (high scenario), where Italy and France are predicted to particularly benefit from the OEL assuming full compliance[11], followed by Germany. Since these none of these three countries has an existing OEL in place this may explain why these three Member States would benefit most.

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

The monetised benefits of a revised OEL for 1,3-butadiene are likely to affect men more than women given the industrial sectors most exposed to 1,3-butadiene employee a higher proportion of men. The industrial sectors estimated to benefit most from a revised OEL (and full compliance) are the manufacture of rubber products and the manufacture of coke, refined petroleum products and nuclear fuel. This is shown in Figure 4.7 (low scenario) and Figure 4.8 (high scenario).

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 8.7.

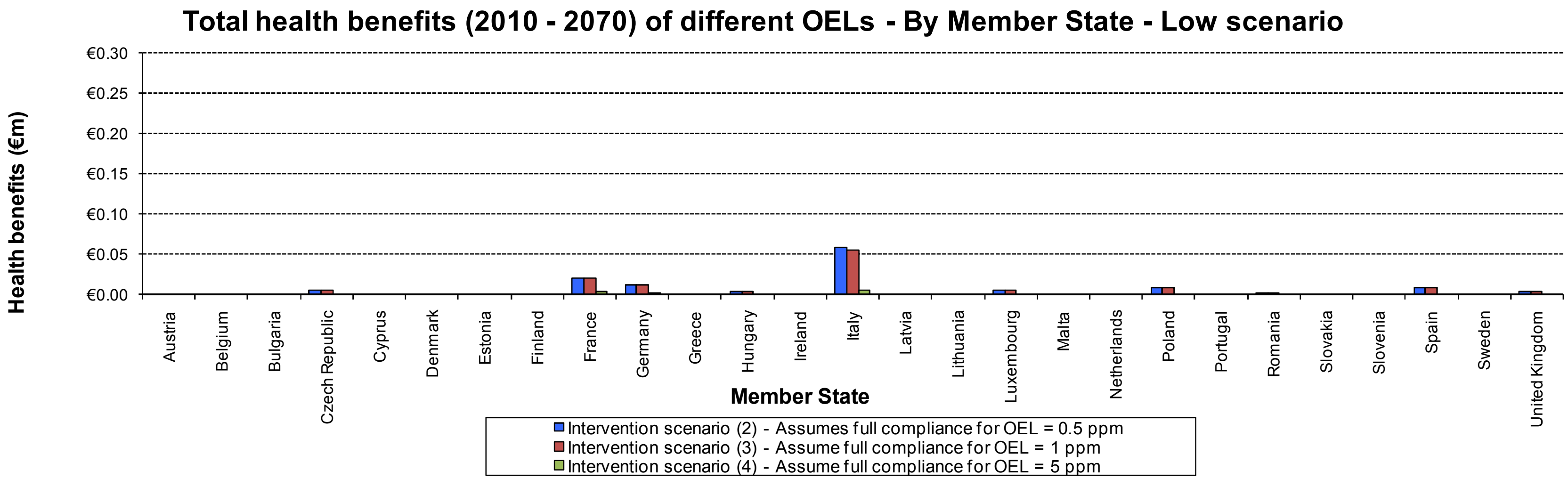


Figure 4.5 Total health benefits of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

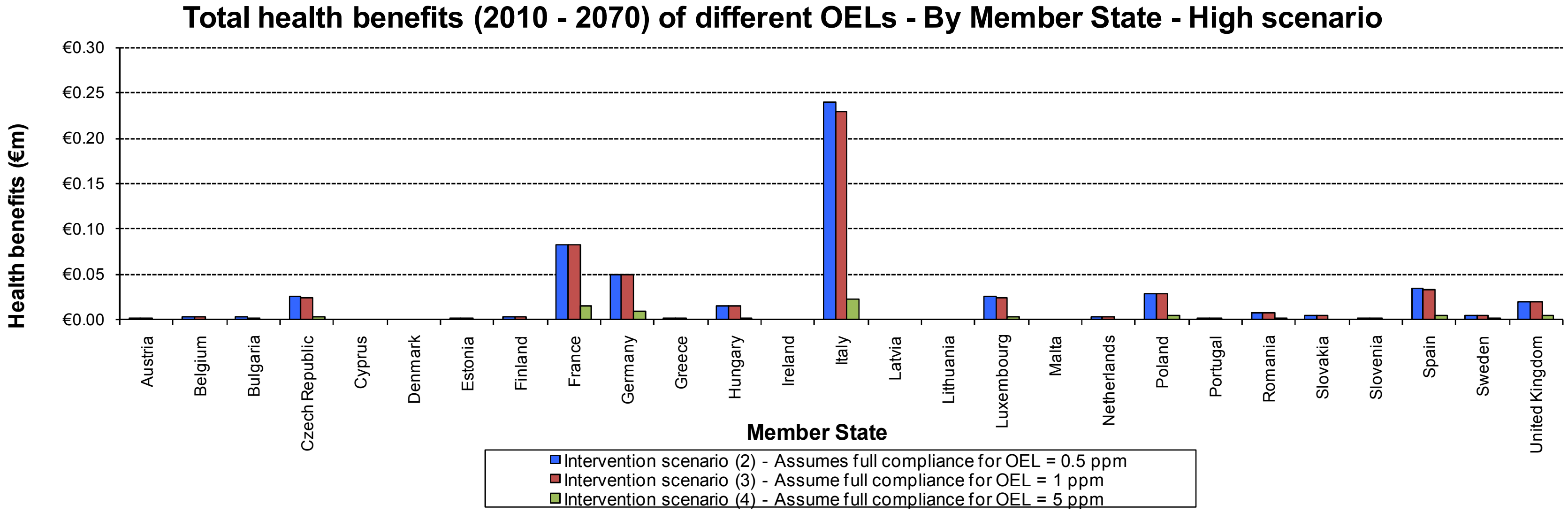


Figure 4.6 Total health benefits of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

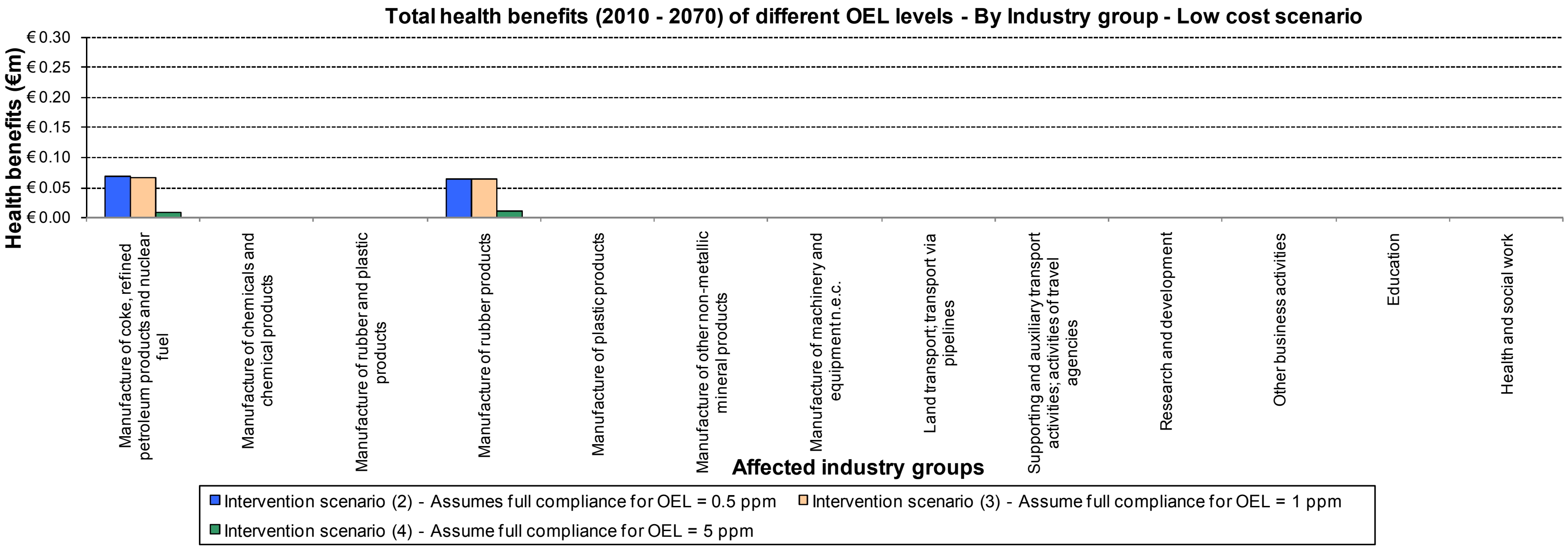


Figure 4.7 Total health benefits of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

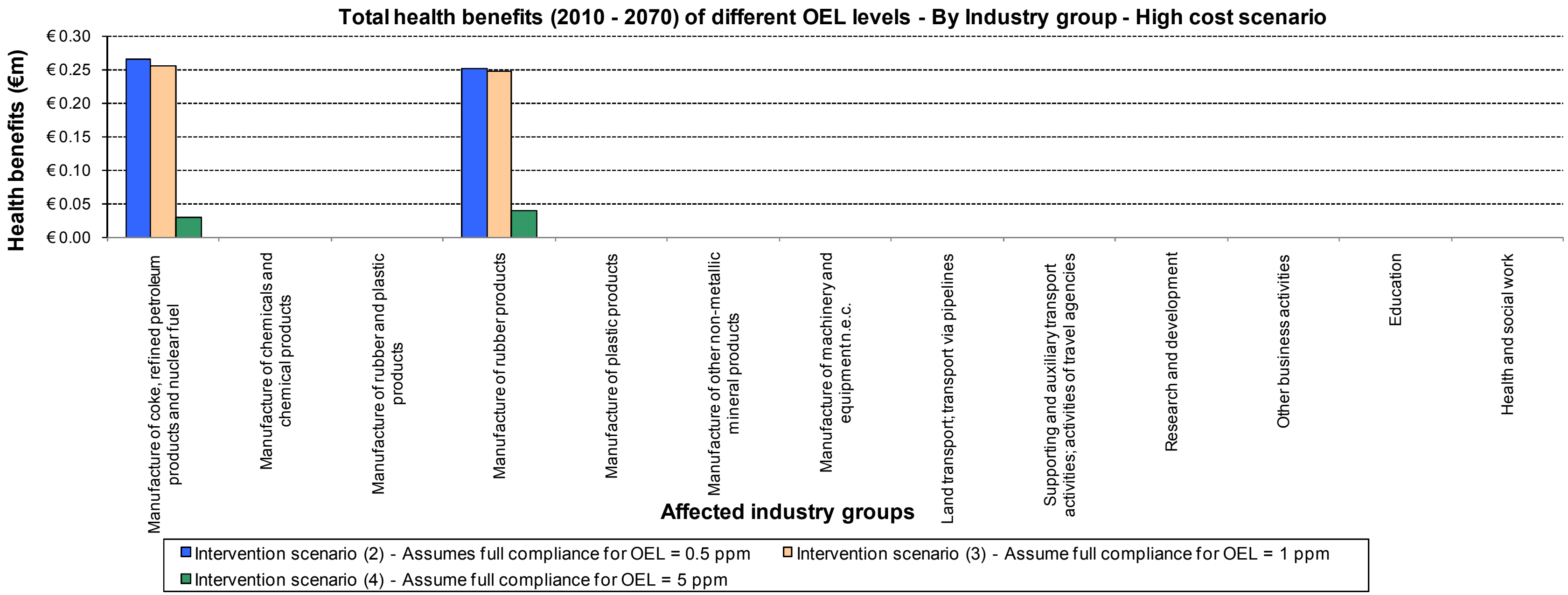


Figure 4.8 Total health benefits of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

As with the baseline scenario, in order to present all costs and benefits consistently in present value, 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 (in relative terms, at least). 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 0.5 ppm
- Figure 4.10 for introducing an OEL of 1 ppm
- Figure 4.11 for introducing an OEL of 5 ppm

Detailed tables are included in Appendix 8.8, with results presented using different discount rates.

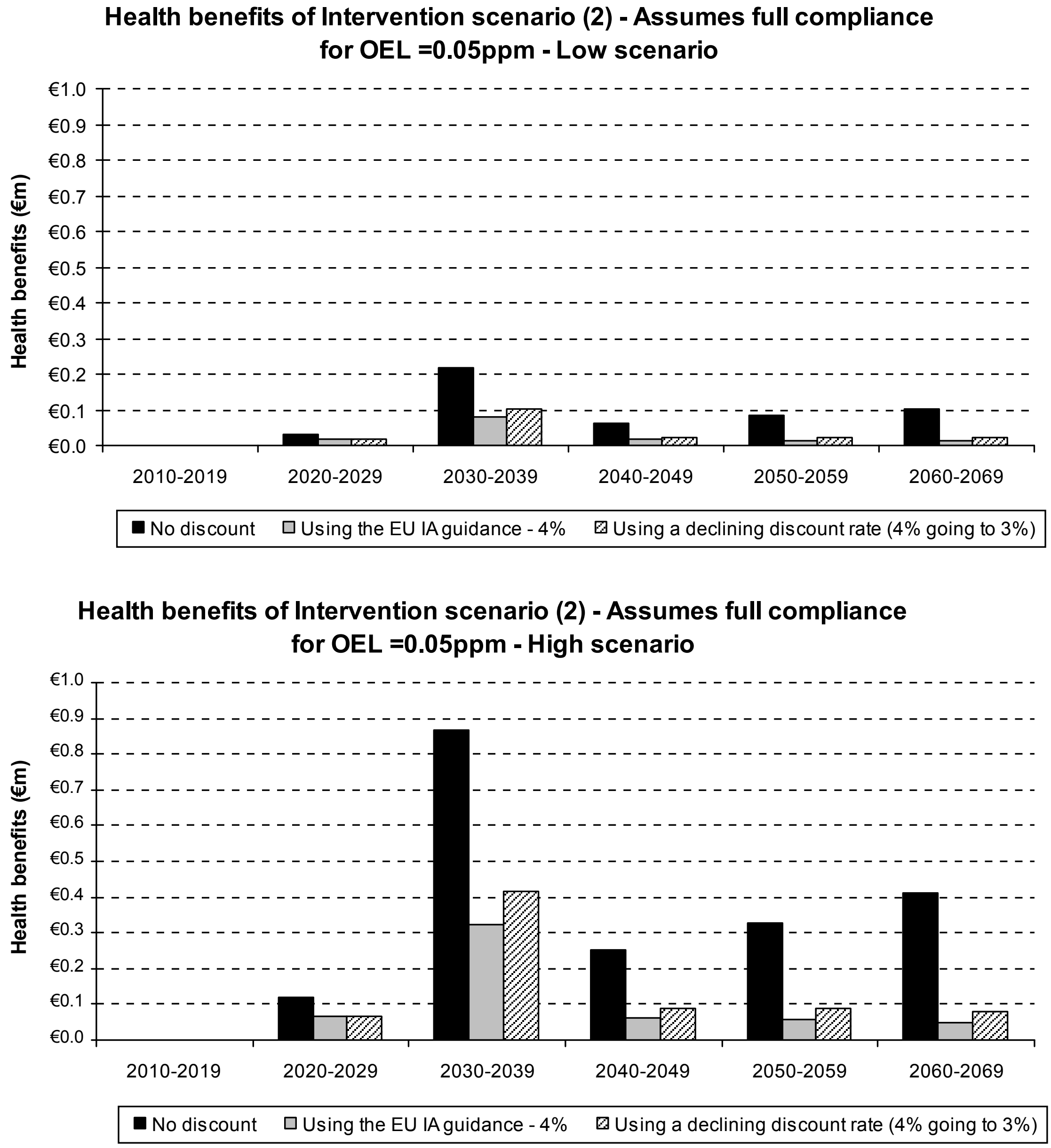
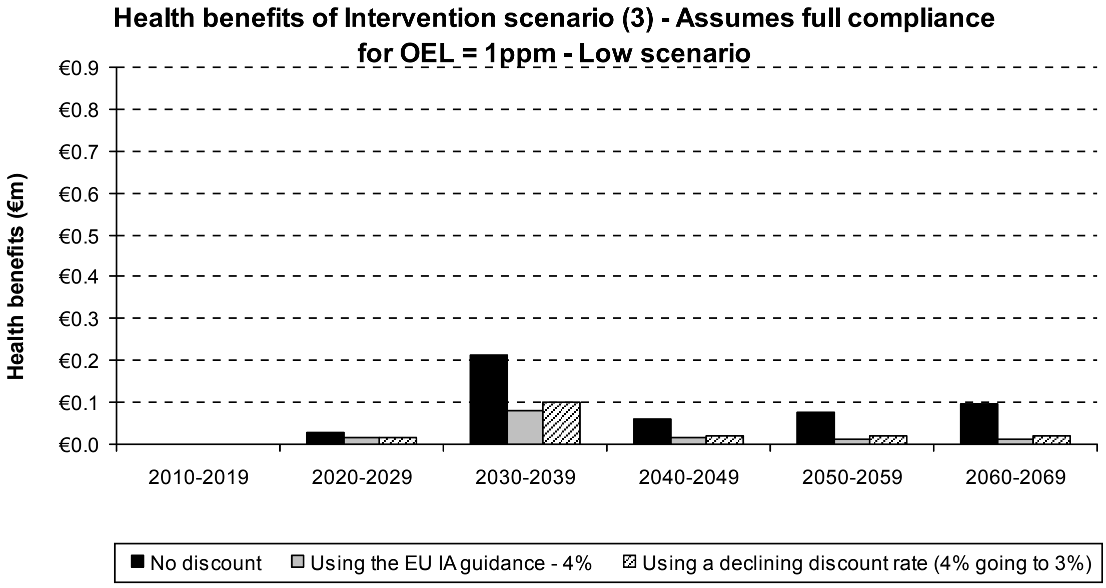


Figure 4.9 Impacts of discounting – Introducing an OEL of 0.5 ppm



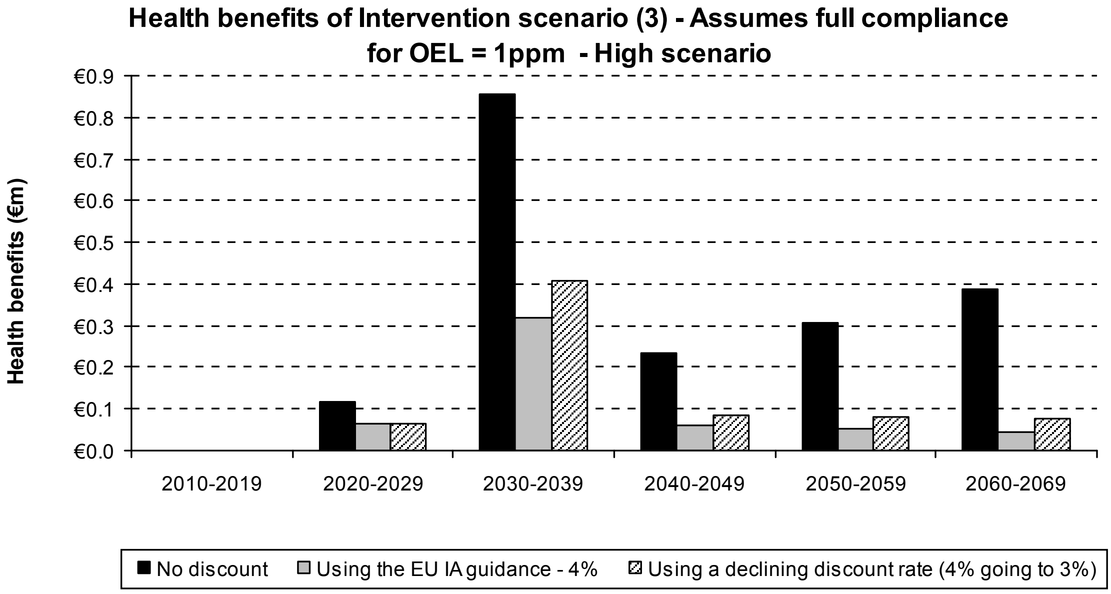
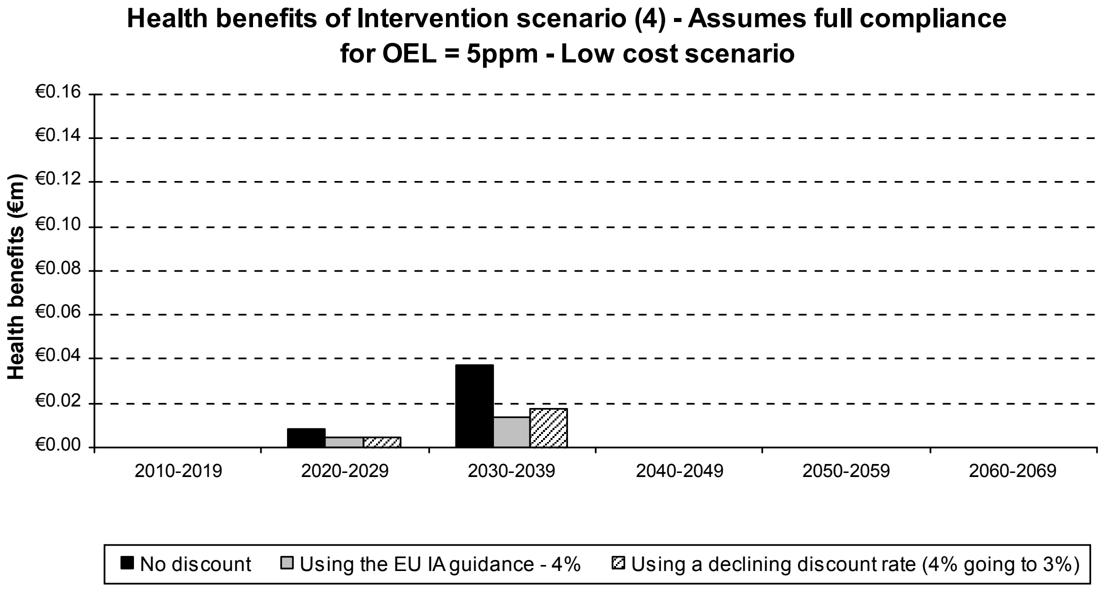


Figure 4.10 Impacts of discounting – Introducing an OEL of 1 ppm



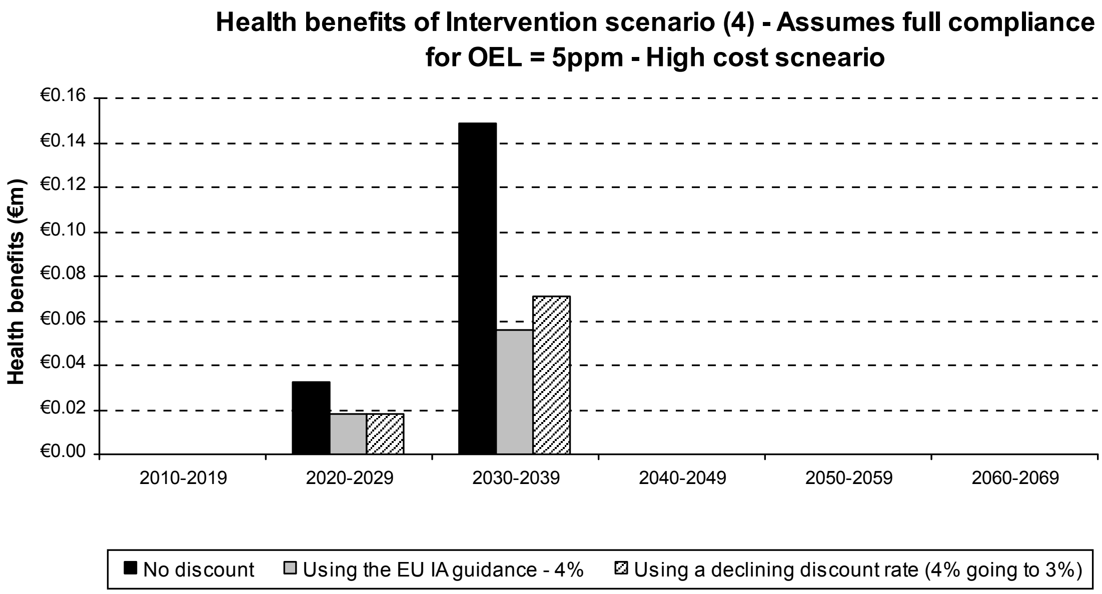


Figure 4.11 Impacts of discounting – Introducing an OEL of 5 ppm

Since the benefits of introducing a more stringent OEL are mostly realised in the period 2030-2039, the level of discounting has a significant impact on the overall size of health benefits. A limitation is that the benefits of any RMMs 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, which is not estimated in this study).

4.2 ECONOMIC IMPACTS

4.2.1 Operating costs and conduct of business

Number of firms affected

The largest industry sectors where workers are exposed to butadiene are those involved with its manufacture and those in polymer production plants. Based on exposure data presented in Section 2.3, it is reasonable to assume that:

- All firms in the manufacture of coke, refined petroleum products and nuclear fuel (NACE code 23) would meet the least stringent proposed OEL (5 ppm) given that the estimated geometric mean is 0.29 and the estimated geometric standard deviation is 2 ppm. However, some firms would require further control measures to meet the more stringent proposed OELs (0.5 and 1 ppm).
- Most firms in the manufacture of rubber products (NACE code 251) would fail to meet the most stringent proposed OEL (0.5 ppm) given that the estimated geometric mean is 0.82. The estimated geometric standard deviation is 3 ppm and therefore it is likely that a significant number of firms would require further control measures to meet an OEL of 1 ppm. A small number may require additional measures to meet an OEL of 5 ppm.

The mean exposure values have been used to simulate the exposure distribution across these two industries to estimate the percentage of all workers exposed (4,259) to 1,3-butadiene above each OEL. This is shown below in Table 4.4.

Table 4.4 Proportion (%) of workers exposed above the OEL

NACE CODE	% exposed above OEL			Number of workers exposed		
	0.5 PPM	1 PPM	5 PPM	0.5 PPM	1 PPM	5 PPM
23	0.67	0.02	0	11	0	0
25.1	67.4	42.8	5	1,769	1,123	131
Overall	45.8	27.8	4.5	1,780	1,123	131

Using the estimates of the number of workers exposed and Eurostat data on the distribution of firms by size (based on number of employees per enterprise) it was possible to broadly estimate the number of enterprises requiring further action to comply with each proposed OEL.

It is recognised that there are limitations to this approach, as it assumes affected workers are distributed across the NACE code sector in the same way as the average distribution for the NACE code. For example, if the sector is predominately made up of SMEs, then most workers affected will be employed in SMEs and the number of enterprises affected will be higher than if the sector is made up of enterprise employing over 250 workers; (whereby the number of enterprises affected will be smaller). In the absence of better data, this is seen as a reasonable approach to broadly estimating the number of enterprises affected.

The following tables (Table 4.5 and Table 4.6) set out the number of firms affected (by size and NACE code) for each proposed OEL. In total there is expected to be around:

- 251 firms affected by an OEL at 0.5ppm

- 158 firms affected by an OEL at 1ppm
- 19 firms affected by an OEL at 5ppm

Table 4.5 Number of enterprises affected in NACE code 25.1

NACE 251 No: of employees bands	Average composition of enterprises for all affected NACE sectors	0.5 PPM No of enterprises affected	1PPM No of enterprises affected	5PPM No of enterprises affected
Between 1 and 9	64%	226	144	17
Between 10 and 19	14%	17	11	1
Between 20 and 49	10%	5	3	0
Between 50 and 250	9%	1	1	0
Greater than 250	3%	0	0	0
Total affected	-	250	158	19
Percentage of affected firms relative to total number of firms in the sector	-	3.5%	2.2%	0.3%

Table 4.6 Number of enterprises affected in NACE code 23

NACE 23 No: of employees bands	Average composition of enterprises for all affected NACE sectors	O.5 PPM No of enterprises affected	1PPM No of enterprises affected	5PPM No of enterprises affected
Between 1 and 9	60%	1	0	0
Between 10 and 19	11%	0	0	0
Between 20 and 49	10%	0	0	0
Between 50 and 250	10%	0	0	0
Greater than 250	8%	0	0	0
Total	-	1	0	0
Percentage of affected firms relative to total number of firms in the sector	-	0.1%	0%	0%

Costs of compliance

According to the EU RAR (2002) "*where there is the potential for high exposure, EU industry indicates that exposures can be adequately controlled with LEV, changes in work practices or the wearing of appropriate respiratory protective equipment during specific operations. Personal exposure in situations such as sampling and loading/unloading will be mitigated by the use of appropriate respiratory protective equipment*".

Local exhaust ventilation systems capture and remove process emissions at or close to their source of generation and prior to their escape into the workplace environment. Cost data for ventilation units are based on estimates from ventilation suppliers. Costs per unit for 1,3-butadiene industries are increased as exhaust equipment requires a high efficiency particulate air (HEPA) filter, which is more costly than a standard filter. The range of costs is shown in Table 4.7.

Table 4.7 Capital costs per enterprise for ventilation units for stationary LEV

Type of cost	Stationary Machinery
Capital Cost (‘000)	€42 – 252
Annual Maintenance (‘000)	€1
Annual Testing (‘000)	€1-5
Filters changes every 5 years (‘000)	€5
Total annualised cost* (‘000)	€5.7 - 25

Notes: It is assumed that ventilation equipment last for 20 years and filters last for 5 years. Costs are based on a 4% discount rate as recommended by the EC IA guidelines (2009)

Appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE) also have an impact on the magnitude of workplace exposure to 1,3-butadiene. There are not expected to be any significant additional costs associated with enclosure, housekeeping, RPE/ PPE, which in any case would be considered to be good practice. It is assumed that costs range between €500 and €2,000 per year per enterprise (including costs of equipment and the cost of time spent of labour (e.g. cleaning) and administration).

This cost data has been used alongside the estimates of number of enterprises affected by the proposed OELs to estimate total compliance costs. Insufficient information was available to determine more accurately which measures might be required to meet each OEL for each firm size or sector. Therefore the following assumptions have been used based on expert judgement in the absence of better data:

- 20% of affected firms only incur costs of RPE to comply with the proposed OEL.
- 20% of affected firms have LEV but do not necessary use/maintain their system properly. Therefore costs to properly maintain and use of their LEVs and use of RPE will be sufficient to comply with the OEL.
- 60% of affected firms will incur costs associated with purchase, maintenance and use of LEV and use of RPE.

These estimates are subject to high uncertainty. Using this breakdown in approaches to compliance the costs of each possible OEL scenario is summarised below in Table 4.8.

Table 4.8 Summary of total costs of compliance

OEL (in ppm)	Number of firms affected	Total annual costs (€m in 2010)		Total costs 2010-2070 (€m)	
		Low	High	Low	High
0.5	251	€ 1	€ 4	€ 27	€ 100
1	158	€ 1	€ 3	€ 17	€ 63
5	19	€ 0.1	€ 0.3	€ 2	€ 7

Note: Most costs are round to nearest euro. Table 4.9 presents costs to 2d.p.

A more detailed breakdown of costs are also set out below by type of action required in the following tables (Table 4.9 and Table 4.10 and Table 4.11).

Table 4.9 Detailed breakdown of total costs of compliance with proposed EU wide OEL of 0.5ppm

Number of enterprises affected by an OEL of O.5ppm	Action required	Average annualised cost per enterprise (2010)		Total annual cost in millions (2010)		Total cost 2010-2070 in millions	
		Low	High	Low	High	Low	High
50	RPE	€ 500	€ 2,000	€ 0.03	€ 0.10	€ 1	€ 2
50	RPE + proper use of existing LEV	£3,123	£7,123	€ 0.16	€ 0.36	€ 4	€ 9
151	RPE + install and use LEV	€ 6,214	€ 25,666	€ 0.94	€ 3.86	€ 22	€ 89
251	-	-	-	€ 1.12	€ 4.32	€ 27.02	€ 100.33

Table 4.10 Detailed breakdown of total costs of compliance with proposed EU wide OEL of 1ppm

Number of enterprises affected by an OEL of 1ppm	Action required	Average annualised cost per enterprise (2010)		Total annual cost in millions (2010)		Total cost 2010-2070 in millions	
		Low	High	Low	High	Low	High
32	RPE	€ 500	€ 2,000	€ 0.02	€ 0.06	€ 0	€ 1
32	RPE + proper use of existing LEV	£3,123	£7,123	€ 0.10	€ 0.23	€ 3	€ 5
95	RPE + install and use LEV	€ 6,214	€ 25,666	€ 0.59	€ 2.44	€ 14	€ 56
158	-	-	-	€ 0.71	€ 2.73	€ 17.07	€ 63.36

Table 4.11 Detailed breakdown of total costs of compliance with proposed EU wide OEL of 5ppm

Number of enterprises affected by an OEL of 5ppm	Action required	Average annualised cost per enterprise (2010)		Total annual cost in millions (2010)		Total cost 2010-2070 in millions	
		Low	High	Low	High	Low	High
4	RPE	€ 500	€ 2,000	€ 0.00	€ 0.01	€ 0	€ 0
4	RPE + proper use of existing LEV	£3,123	£7,123	€ 0.01	€ 0.03	€ 0	€ 1
11	RPE + install and use LEV	€ 6,214	€ 25,666	€ 0.07	€ 0.29	€ 2	€ 7
19	-	-	-	€ 0.08	€ 0.32	€ 1.99	€ 7.40

Conduct of employers

The introduction of an EU-wide OEL may require those companies not already complying to reorganise their workplace to ensure that exposure to airborne emissions are minimised. There may also be additional training required to ensure that employees minimise their exposure by adhering to good practice in order to reducing exposure (e.g. good personal hygiene and wearing protective clothing).

Potential for closure of companies

As indicated in Table 4.5 and Table 4.6, 19 enterprises (<0.3% of all firms in the sector) are likely to be affected by the introduction of the least stringent proposed EU-wide OEL (5 ppm). This rises to 251 firms (3.5%) with the most stringent OEL (0.5ppm). Therefore there is unlikely to be any significant change in risks of closures. If compliance with the OEL can be achieved just by improving existing work practices and RPE, then the cost of compliance per enterprise (€500-2,000) is not thought to be prohibitative. If specific engineering control measures (such as LEV) are required then the cost of compliance is likely to be higher which may be of more concern to SMEs, especially obtaining finance related to the capital cost of LEV. However it is not known to what extent these costs can be passed onto customers through the service they provide.

Potential impacts for specific types of companies

The costs of compliance are likely to initially fall on those sectors that produce butadiene (mostly from steam cracking of hydrocarbons) and those that manufacture styrene-rubber (SBR) and styrene-butadiene latex. It is possible, however, that any additional costs may be passed on to downstream users using these synthetic rubber products.

The main advantage of an EU-wide OEL would be to create consistency in regulation across the EU and remove any competitive disadvantage to those Member States who previously had more stringent national OELs in place.

Administrative costs to employers and public authorities

The following table (Table 4.12) describes the administrative burden to employers already subject to the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.12 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 5. Consultation with employees on compliance with the Directive	11 – Information and training of workers 12 – Information for workers 13 – Consultation and participation with workers	Firms will already have been required to ensure training and adequate aware of risks and control measures to reduce/minimise exposure. Largely one-off cost if the revised OEL requires a change in control measures/working practice.	Low

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

The following table (Table 4.13) describes the administrative burden to competent authorities already enforcing the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.13 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.

Third countries

Most of the 1,3 butadiene consumed in the EU is produced by EU countries, and the introduction of an EU-wide OEL is not expected to lead to producers moving outside the EU given the high level of compliance already.

4.2.2 Impact on innovation and research

It is possible that introducing an EU wide OEL for may stimulate further R&D in protective equipment and LEV. However, given that the industry is predominately made up of smaller companies it is considered likely that these companies would tend to adopt products and compliance techniques that are already being applied within other parts of the industry.

4.2.3 Macroeconomic impact

Since compliance with an OEL would not involve changing the current manufacturing process there is unlikely to be any significant change to macro-economic impacts.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

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.

There are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of using of ventilation systems. 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[12].

4.3.2 Changes in end products

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

4.4 ENVIRONMENTAL IMPACTS

1,3-butadiene has a very high vapour pressure (measured at 2,351-2,500 hPa at 20ºC) and so is expected to rapidly volatilise from water or soil (EU, 2002). It is not expected to be persistent in air as it reacts rapidly with photochemically produced hydroxyl radicals (the estimated atmospheric half-life of butadiene is of the order of a few hours). Other reactions with butadiene that are expected to occur in the atmosphere are with ozone and nitrate radicals. The atmospheric half-life of 1,3-butadiene with ozone has been estimated at a few hours to a few days. No data are available on aquatic toxicity due to the high volatility and low water solubility of 1,3-butadiene. Water concentrations are not expected to be significant (Butadiene Product Stewardship Task Group, 2001).

The achievement of the OEL via the measures described in this report may lead to more direct emissions of 1,3-butadiene to the environment (through ventilation), but probably not to an increased overall environmental burden. Therefore it is assumed that an OEL would not increase the level of environmental harm. Having said this, a quantitative assessment of the amounts of 1,3-butadiene released into the environment as a result of the measures that would be put in place to achieve the OEL has not been done for the purposes of this study.

1,3-butadiene is not classified according to environment effects under Regulation (EC) no 1272/2008 on Classification, labelling & Packaging of Dangerous Substances.

5 COMPARISON OF OPTIONS

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

[12] "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.)

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

Baseline Scenario		**Intervention scenario (2) – Assumes full compliance for OEL = 0.5 ppm**		**Intervention scenario (3) – Assumes full compliance for OEL = 1 ppm**		**Intervention scenario (4) – Assumes full compliance for OEL = 5 ppm**	
Health Costs	**Health Benefits**	**Health Costs**	**Health Benefits**	**Health Costs**	**Health Benefits**	**Health Costs**	**Health Benefits**
As set out in section 2.5.1, the health costs of cancer (LH) over the period 2010-70 are estimated to be: Females: €13 –47m Males: €29 –120 m Total: €41 – 167 m This range takes into consideration tangible costs (e.g. lost income, lost output from reduced productivity, medical costs, life years lost) and intangible costs (e.g. emotional and physical suffering from having cancer).	It is assumed that exposures fall by 7% per year in the future, continuing the historical trend in reduced exposure. Therefore there is expected to be some reduction in health costs going forward in the absence of further regulatory intervention	None - There 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 in the period 2030-2039 onwards. It was also found that the monetised benefits are likely to affect men more than women given the industrial sectors most exposed to 1,3-butadiene. The monetised benefits were estimated as: Females: €0 -0.1 m Males - €0.1- 0.4 m Totals - €0.1 – 0.6 m There are also avoided health costs post-2070, which are not quantified in this study.	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 in the period 2030-2039 onwards. It was also found that the monetised benefits are likely to affect men more than women given the industrial sectors most exposed to 1,3-butadiene. The monetised benefits were estimated as: Females: €0 -0.1 m Males - €0.1- 0.4 m Totals - €0.1 – 0.5 m There are also avoided health costs post-2070, which are not quantified in this study.	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 in the period 2030-2039 onwards. It was also found that the monetised benefits are likely to affect men more than women given the industrial sectors most exposed to 1,3-butadiene. The monetised benefits were estimated as: Females: €0 - 0 m Males - €0 - 0.1 m Totals - €0 – 0.1 m There are also avoided health costs post-2070, which are not quantified in this study.

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

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

Baseline Scenario		**Intervention scenario (2) – Assumes full compliance for OEL = 0.5 ppm**		**Intervention scenario (3) – Assumes full compliance for OEL = 1 ppm**		**Intervention scenario (4) – Assumes full compliance for OEL = 5 ppm**	
Economic Costs	**Economic Benefits**	**Economic Costs**	**Economic Benefits**	**Economic Costs**	**Economic Benefits**	**Economic Costs**	**Economic Benefits**
There are expected to be costs to sectors exposed to 1,3-butadiene due to expected further spending on control measures to reduce exposure. These costs might relate to improving working practice or installation and use of engineering control measures (e.g. improved ventilation, improved loading/ unloading equipment).	-	There are expected to be economic costs related to the installation of control measures in order to meet the OEL for certain industrial sectors. It is estimated that 4% of enterprises (251 enterprises) will require some form of control measure to meet the proposed OEL. The remainder are assumed to already be meeting the proposed OEL and therefore will require no further action. It is assumed that the majority of those that cannot comply will require ventilation systems, with the rest able to implement 'best practice' low-cost measures to reduce exposure levels to meet the OEL. Whilst some enterprises may already own ventilation systems, others will have to purchase a new ventilation system. Cost per enterprise over the period 2010-2069 (NPV) is estimated at: • RPE: €0.5-2k • RPE + proper use of existing LEV: €3-7k • RPE + new LEV: €6-25k The total costs over the period 2010-2069 (NPV) are estimated at between €1– 89m	Having an EU-wide OEL level will remove any EU competitive distortions between EU Member States with different OELs.	There are expected to be economic costs related to the installation of control measures in order to meet the OEL for certain industrial sectors. It is estimated that between 2% of enterprises (159 enterprises) will require some form of control measure to meet the proposed OEL. The remainder are assumed to already be meeting the proposed OEL and therefore will require no further action. It is assumed that the majority of those that cannot currently comply will require ventilation systems, with the rest able to implement 'best practice' low-cost measures to reduce exposure levels to meet the OEL. Whilst some enterprises may already own ventilation systems, others will have to purchase a new ventilation system. Cost per enterprise over the period 2010-2069 (NPV) is estimated at: • RPE: €0.5-2k • RPE + proper use of existing LEV: €3-7k • RPE + new LEV: €6-25k The total costs over the period 2010-2069 (NPV) are estimated at between €0 – 56 m.	Having an EU-wide OEL level will remove any EU competitive distortions between EU Member States with different OELs.	There are expected to be economic costs related to the installation of control measures in order to meet the OEL for certain industrial sectors. It is estimated that <0.3% of enterprises (19 enterprises) will require some form of control measure to meet the proposed OEL. The remainder are assumed to already be meeting the proposed OEL and therefore will require no further action. It is assumed that the majority of those that cannot comply will require ventilation systems, with the rest able to implement 'best practice' low-cost measures to reduce exposure levels to meet the OEL. Whilst some enterprises may already own ventilation systems, others will have to purchase a new ventilation system. Cost per enterprise over the period 2010-2069 (NPV) is estimated at: • RPE: €0.5-2k • RPE + proper use of existing LEV: €3-7k • RPE + new LEV: €6-25k The total costs over the period 2010-2069 (NPV) are estimated at between €0 – 7 m.	Having an EU-wide OEL level will remove any EU competitive distortions between EU Member States with different OELs.

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

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

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.5 ppm		Intervention scenario (3) – Assumes full compliance for OEL = 1 ppm		Intervention scenario (4) – Assumes full compliance for OEL = 5 ppm	
Social Costs	**Social Benefits**	**Social Costs**	**Social Benefits**	**Social Costs**	**Social Benefits**	**Social Costs**	**Social Benefits**
There are not expected to be any noticeable social impacts under the baseline scenario at an EU level. At an installation level, some personnel may change their working practices (e.g. wearing RPE) to reduce risks of inhalation exposure regardless of further intervention over the period 2010-2070.		There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL. However, job patterns may be altered as it is recognised that in order to meet the OEL, behavioural change amongst employees and updating health and safety training will be required.	Mechanical ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled. If the mechanical ventilation includes a heat exchanger with high efficiency this might typically reduce the ventilation heat loss. The sectors (NACE 25.1 and 23) that experience the highest impact and thus cost are those that would experience the largest benefits from the control of exposure and meeting the OEL.	There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL. However, job patterns may be altered as it is recognised that in order to meet the OEL, behavioural change amongst employees and updating health and safety training will be required.	Mechanical ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled. If the mechanical ventilation includes a heat exchanger with high efficiency this might typically reduce the ventilation heat loss. The sectors (NACE 25.1 and 23) that experience the highest impact and thus cost are those that would experience the largest benefits from the control of exposure and meeting the OEL.	There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL. However, job patterns may be altered as it is recognised that in order to meet the OEL, behavioural change amongst employees and updating health and safety training will be required.	Mechanical ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled. If the mechanical ventilation includes a heat exchanger with high efficiency this might typically reduce the ventilation heat loss. The sectors (NACE 25.1 and 23) that experience the highest impact and thus cost are those that would experience the largest benefits from the control of exposure and meeting the OEL.

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

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

Baseline Scenario		**Intervention scenario (2) – Assumes full compliance for OEL = 0.5 ppm**		**Intervention scenario (3) – Assumes full compliance for OEL = 1 ppm**		**Intervention scenario (4) – Assumes full compliance for OEL = 5 ppm**	
Macro-economic Costs	**Macro-economic Benefits**	**Macro-economic Costs**	**Macro-economic Benefits**	**Macro-economic Costs**	**Macro-economic Benefits**	**Macro-economic Costs**	**Macro-economic Benefits**
There are not expected to be any noticeable macroeconomic impacts under the baseline scenario.		Since compliance with an OEL would not involve changing the current manufacturing process there is unlikely to be any significant change to macro-economic impacts.					

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

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

Baseline Scenario		**Intervention scenario (2) – Assumes full compliance for OEL = 0.5 ppm**		**Intervention scenario (3) – Assumes full compliance for OEL = 1 ppm**		**Intervention scenario (4) – Assumes full compliance for OEL = 5 ppm**	
Environmental Costs	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**
Not estimated		The achievement of the OEL via the measures described in this report may lead to more direct emissions 1,3-butadiene to the environment (through ventilation), but probably not to an increased overall environmental burden and therefore would not increase the level of environmental risk.					

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

6 CONCLUSIONS

1,3-butadien may cause LH cancer. We have considered the impacts of introducing an OEL of 0.5, 1 or 5 ppm.

Most 1,3-butadiene is polymerized to produce synthetic rubber at a relatively small number of sites in Europe. The production capacity in 2006 in the EU was about 2.9 million tonnes. We estimated that about 27,600 workers in the EU are potentially exposed to 1,3-butadiene. It is estimated that about 4.3% of workers in the high exposure industries are exposed above 5 ppm, 27.8% above 1 ppm and 45.8% above 0.5 ppm. Exposure levels in the industries where 1,3-Butadiene is used are judged to be decreasing by 7% per annum over recent years.

We estimate that in 2010 in the EU there will be about one death from lymphohaematopoietic cancer, based on two incident cases, that might be attributable to past exposure to 1,3-butadiene, which corresponds to about 0.0014% of all LH cancer deaths amongst the exposed workers. If no specific actions are taken to reduce exposure to 1,3-butadiene the predicted numbers of liver cancer deaths increases slightly so that in 2060 there would be two attributable LH deaths. DALYs and YLL also increase; from 24 to 32 years and 19 to 25 years, respectively. Total estimated health costs associated with inaction range from €41m to €167m, which mostly fall on Germany, UK, France and Spain.

The introduction of an OEL is predicted to have little impact on risk of LH, regardless of the level it is set at. This is because we assume that exposures will continue to drop steadily so that most workers in the high exposed jobs will by 2030 be in the low exposure category (90% of the high exposed jobs < 0.6 ppm). However, we were unable to identify a level at which there was no risk for LH cancer and the low exposed workers still have associated elevated relative risk of 1.05. There are therefore no net health benefits from setting an OEL.

Potential improvements in handling 1,3-butadiene to ensure compliance with an OEL include, technical measures such as improved equipment for loading/unloading and leak detection, organisational measures, such as regular inspection of equipment, and greater use of personal respiratory protection.

The total compliance costs aggregated over the period 2010 to 2070 range from between €2m to €7m for an OEL of 5 ppm to €27 to €100m for an OEL of 0.5 ppm. In part the range of costs for each option depends on the relative use of engineering controls or personal protective equipment to control exposure to episodic releases. The sectors that experience the highest impact and thus cost are those that would experience the largest benefits from the control of exposure and meeting the OEL (NACE 25.1 and 23). No plant closures are foreseen as a consequence of introducing and OEL. There is unlikely to be any significant change to macro-economic impacts.

It is assumed that the introduction of an OEL would not increase the level of environmental harm.

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8 APPENDIX

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

Table 8.1.1 Number of workers exposed to beryllium by Member State and NACE code – males and females

	NACE CODE														
	23			24			251			252			29		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	Not Available[1]			242	196	46	18	14	3	106	86	20	8	7	2
Belgium	30	24	6	629	509	119	18	15	3	101	82	19	4	4	1
Bulgaria	24	13	12	233	121	112	20	10	9	86	45	42	7	4	3
Cyprus	Not Available			17	13	4	0	0	0	5	4	1	0	0	0
Czech Republic	15	10	5	372	242	130	114	74	40	237	154	83	16	11	6
Denmark	Not Available			268	196	72	8	6	2	83	60	22	6	5	2
Estonia	5	3	2	27	15	12	3	1	1	20	11	9	1	0	0
Finland	15	11	4	312	231	81	23	17	6	81	60	21	12	9	3
France	139	107	32	2471	1903	568	354	273	82	706	544	162	31	24	7
Germany	105	81	24	4114	3168	946	389	300	90	1313	1011	302	106	81	24
Greece	21	16	5	163	124	39	5	4	1	47	35	11	2	2	1
Hungary	32	20	12	288	181	106	53	33	20	133	84	49	7	4	3
Ireland	Not Available			223	167	56	4	3	1	40	30	10	1	1	0
Italy	172	129	43	0	0	0	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	39	23	16	2	1	1	19	11	8	1	0	0
Lithuania	Not Available			55	29	26	2	1	1	39	21	19	1	1	1
Luxembourg	0	0	0	10	8	1	20	18	3	10	9	1	0	0	0
Malta	Not Available			Not Available			Not Available			Not Available			Not Available		

	NACE CODE														
	23			24			251			252			29		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Netherlands	34	28	6	573	470	103	17	14	3	127	104	23	9	7	2
Poland	76	51	25	970	650	320	171	114	56	508	341	168	21	14	7
Portugal	Not Available			193	114	79	28	17	12	88	52	36	5	3	2
Romania	35	19	16	438	237	202	67	36	31	148	80	68	10	6	5
Slovakia	Not Available			115	74	42	34	22	12	62	40	22	5	3	2
Slovenia	0	0	0	126	83	43	19	12	6	43	29	15	3	2	1
Spain	0	0	0	1336	1042	294	246	192	54	570	445	125	0	0	0
Sweden	17	13	4	391	305	86	33	26	7	96	75	21	12	9	3
United Kingdom	122	99	23	1926	1560	366	148	120	28	775	627	147	28	23	5
TOTAL	843	623	219	15531	11659	3872	1796	1323	473	5444	4038	1406	295	217	78

	NACE Code														
	63			73			74			80			Grand Total		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	18	15	3	6	4	2	15	10	5	22	6	15	**440**	**343**	**97**
Belgium	16	14	2	7	5	2	22	14	7	37	12	26	**869**	**683**	**187**
Bulgaria	13	12	1	0	0	0	7	4	2	21	7	15	**415**	**218**	**198**
Cyprus	2	2	0	0	0	0	1	0	0	2	1	2	**28**	**20**	**8**
Czech Republic	14	11	2	7	4	3	19	11	7	28	7	21	**861**	**549**	**311**
Denmark	11	9	2	7	5	2	13	9	5	21	9	12	**422**	**301**	**121**

	NACE Code														
	63			73			74			80			Grand Total		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Estonia	4	3	1	0	0	0	2	1	1	6	1	5	**69**	**36**	**32**
Finland	9	7	2	1	1	1	15	9	6	7	2	4	**474**	**346**	**128**
France	88	70	19	46	29	17	126	80	47	176	56	119	**4140**	**3087**	**1054**
Germany	164	141	23	103	59	44	172	98	74	206	74	132	**6712**	**5044**	**1668**
Greece	13	12	1	10	6	4	15	9	6	30	11	19	**308**	**220**	**88**
Hungary	10	9	1	7	5	2	17	11	6	31	8	24	**582**	**358**	**224**
Ireland	6	6	1	3	2	1	7	5	2	13	3	9	**299**	**219**	**81**
Italy	0	0	0	58	37	22	0	0	0	152	36	115	**382**	**202**	**180**
Latvia	5	4	1	1	1	1	2	1	1	9	2	7	**79**	**43**	**36**
Lithuania	5	4	1	1	0	0	3	2	1	13	2	11	**122**	**60**	**61**
Luxembourg	1	1	0		Not Available		2	1	1	1	1	1	**43**	**36**	**7**
Malta		Not Available			Not Available			Not Available		1	0	1	**1**	**0**	**1**
Netherlands	29	25	4	37	25	13	66	43	22	53	22	31	**951**	**742**	**208**
Poland	25	22	3	5	3	2	35	23	13	112	27	85	**1936**	**1253**	**683**
Portugal	13	11	2	1	1	1	25	15	10	31	8	22	**386**	**222**	**164**
Romania	22	19	3	25	16	9	15	10	5	41	11	30	**804**	**435**	**369**
Slovakia	4	3	0	5	3	2	4	2	2	16	3	13	**244**	**150**	**95**
Slovenia	3	2	0	3	2	1	3	2	1	7	2	6	**207**	**134**	**74**
Spain	128	111	17	13	7	6	80	42	38	105	39	66	**2503**	**1896**	**607**
Sweden	19	16	3	12	8	4	19	13	6	48	12	36	**649**	**479**	**170**
United Kingdom	122	107	15	113	76	37	170	114	56	251	90	160	**3690**	**2845**	**845**
TOTAL	744	637	107	473	297	176	854	529	326	1440	452	988	**27615**	**19919**	**7696**

[1] Information was not available in the Eurostat database

8.2 EXPOSURE DATA FOR 1,3-BUTADIENE IN THE MANUFACTURE OF REFINED PETROLEUM PRODUCTS (NACE CODE 23)

Table 8.2.1 Summary exposure data for 1,3-butadiene in the manufacture of refined petroleum products (NACE CODE 23)

Reference	Year	Industry	Country	Type	Measurement period	N	AM (ppm)	SD (ppm)	Median (ppm)	GM (ppm)	GSD	Min (ppm)	Max (ppm)
IARC, 2006	1991 aprox	Monomer production	Finland	Personal	5.3 hrs	16	5.2		<0.1			< 0.1	477
IARC, 2006	1984-1985	Gasoline prod	13 EU	Personal	8-hrs TWA	15	0.54		0.40	0.51	4.20	0.05	6.40
									0.18	0.23	1.90	0.02	2.90
IARC, 2006 (ECETOC (1997)	1986-1993	butadiene prod plants	EU	Personal		1548	0.57	0.54	0.5	0.58	1.63	<1	>25
IARC, 2006 (ECETOC (1997)	1986-1993	butadiene extraction plants		Personal		1035	0.65	0.87	0.50	0.76	2.23		
EU, 2002	1995	15 monomer extraction and styrene-production plants	EU	Personal	8-hrs TWA							<0.01	2
												1.4	3.4
												<0.02	5
												<0.1	0.7
												0.03	1
												1	5
EU, 2002	1988-1993	One butadiene manufacturer	UK	Personal	8-hrs TWA	43	0.12					0.72	3.9
	1990-1994					225	0.44						
EU, 2002		Manufacture of butadiene monomer and polymers	UK	Personal	8-hrs TWA		90 % less than 5ppm with most of them less than 1ppm						

8.3 EXPOSURE DATA FOR 1,3-BUTADIENE IN THE RUBBER INDUSTRY (NACE CODE 251)

Table 8.3.1 Summary exposure data for 1,3-Butadiene in the rubber industry (NACE code 251)

Reference	Year	Industry	Country	Type	Measurement period	N	AM (ppm)	SD (ppm)	GM (ppm)	GSD	Median (ppm)	Min (ppm)	Max (ppm)
IARC, 2006	1984-1993	Styrene-butadiene rubber plants	27 EU plants			661		3.2	0.52	3.4	1.48	<0.5	>25
IARC,2006	1990-1997	Styrene-butadiene polymer production	Netherlands	Personal	8-hrs TWA	27	2.470					0.16	31.24
						19	0.500					0.04	1.3
						23	1.260					0.06	5.33
						38	1.300					0.07	5.94
						20	1.250					0.06	21.1
						14	0.240					0.05	4.48
Anttinen-Klemett *et al* 2006	1997	3 Styrene-butadiene latex plants	Finland	Personal	8-hrs TWA	885	0.165	0.12					
													%
Albertini *et al* 2003	1998	Polymer production	Czech Republic	Personal	8-hrs TWA	230	0.397	1.094			0.056	0.004	9.793
						300	0.808	1.663			0.241	0.004	12.583
International institute of synthetic rubber	2010		27 EU				1.5						5

8.4 ESTIMATED DEATHS AND REGISTRATIONS IN THE EU FROM LYMPHOHAEMATOPOIETIC CANCERS

Table 8.4.1 Forecast number of lymphohaematopoietic cancers in ages 25+ (ages 15+ for registrations), based on projected EU country populations

Lymphohaematopoietic cancer deaths	*MEN*						*WOMEN*					
FTY	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Austria	884	1,106	1,348	1,610	1,780	1,788	802	904	1,067	1,266	1,403	1,395
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	428	434	460	486	499	489	319	330	340	343	345	325
Cyprus	61	83	111	137	168	201	46	61	81	101	122	142
Czech Republic	978	1,228	1,518	1,714	1,939	2,103	899	1,062	1,253	1,369	1,480	1,599
Denmark	626	790	953	1,044	1,104	1,110	470	554	675	748	798	806
Estonia	112	125	143	168	190	212	141	149	160	170	174	179
Finland	581	752	935	1,005	1,016	1,058	541	643	780	852	851	849
France	7,181	8,628	10,611	12,232	13,187	13,790	6,096	6,968	8,254	9,624	10,235	10,340
Germany (including ex-GDR from 1991)	9,334	11,496	13,101	15,031	15,495	14,764	8,415	9,559	10,491	11,721	12,243	11,497
Greece	1,176	1,358	1,556	1,839	2,100	2,214	983	1,208	1,333	1,539	1,735	1,826
Hungary	891	1,007	1,144	1,284	1,431	1,536	861	949	1,028	1,094	1,149	1,195
Ireland	449	611	823	1,054	1,318	1,576	310	396	523	667	817	976
Italy	7,669	9,108	10,579	12,260	13,723	13,851	6,875	7,831	8,796	9,972	11,023	11,037
Latvia	182	189	209	227	244	252	183	187	192	205	203	209
Lithuania	243	270	308	353	391	408	294	319	345	393	408	407
Luxembourg	46	60	79	96	108	116	50	60	75	94	109	117
Malta	41	55	70	78	84	93	21	26	30	32	34	35
Netherlands	1,730	2,232	2,792	3,143	3,256	3,205	1,419	1,689	2,096	2,406	2,545	2,478
Poland	3,095	3,760	4,581	5,244	5,707	6,194	2,820	3,300	3,878	4,340	4,502	4,717
Portugal	948	1,103	1,292	1,506	1,690	1,792	835	975	1,111	1,265	1,393	1,448
Romania	1,289	1,413	1,596	1,776	1,919	1,931	1,024	1,099	1,215	1,306	1,374	1,362

Lymphohaematopoietic cancer deaths	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Slovakia	418	524	652	770	863	924	369	437	534	607	657	695
Slovenia	215	289	367	452	494	517	214	251	291	338	359	360
Spain	4,194	5,071	6,237	7,752	9,155	9,695	3,584	4,207	5,017	6,110	7,111	7,515
Sweden	1,066	1,297	1,552	1,693	1,838	1,957	917	1,041	1,221	1,334	1,426	1,505
United Kingdom	6,864	8,163	9,675	10,955	12,148	13,025	5,528	6,152	7,236	8,312	9,252	9,804
European Union (27 countries)	51,351	61,729	73,271	84,707	92,983	96,446	45,052	51,560	59,447	67,884	73,543	75,106

Lymphohaematopoietic cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Austria	1,643	1,907	2,193	2,390	2,451	2,468	1,368	1,517	1,721	1,873	1,918	1,908
Belgium	2,444	2,817	3,189	3,435	3,545	3,655	1,826	2,036	2,269	2,441	2,514	2,558
Bulgaria	605	603	621	639	636	605	515	511	511	507	487	454
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	1,738	2,079	2,326	2,555	2,735	2,731	1,516	1,721	1,864	1,973	2,052	2,050
Denmark	1,209	1,416	1,549	1,616	1,624	1,667	861	979	1,075	1,124	1,135	1,151
Estonia	161	169	184	200	213	219	181	186	191	195	196	191
Finland	899	1,084	1,180	1,197	1,210	1,235	834	954	1,029	1,044	1,033	1,031
France	13,576	15,849	17,695	18,935	19,550	20,243	10,437	11,976	13,321	14,265	14,506	14,622
Germany (including ex-GDR from 1991)	17,221	19,226	21,136	21,917	21,377	20,494	14,822	15,824	17,032	17,550	17,133	16,320
Greece	1,645	1,838	2,061	2,279	2,382	2,331	1,262	1,392	1,511	1,625	1,672	1,626
Hungary	1,524	1,675	1,826	2,011	2,179	2,224	1,480	1,590	1,664	1,732	1,791	1,788
Ireland	711	921	1,148	1,382	1,610	1,725	499	633	786	946	1,091	1,173
Italy	14,713	16,649	18,617	20,303	20,678	20,276	11,535	12,750	14,020	15,164	15,401	14,921

Lymphohaematopoietic cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Latvia	267	281	318	354	385	404	289	293	311	323	334	338
Lithuania	402	434	490	541	580	593	434	458	495	520	524	513
Luxembourg	98	124	151	172	186	199	72	87	105	121	132	142
Malta	67	78	84	88	92	93	67	79	87	91	94	96
Netherlands	3,021	3,666	4,128	4,324	4,272	4,284	2,326	2,720	3,063	3,242	3,212	3,173
Poland	4,671	5,351	5,969	6,393	6,723	6,727	3,979	4,447	4,848	5,052	5,157	5,070
Portugal	1,654	1,868	2,112	2,338	2,474	2,496	1,451	1,621	1,789	1,926	1,996	1,982
Romania	1,771	1,871	2,027	2,187	2,245	2,187	1,426	1,486	1,565	1,644	1,658	1,598
Slovakia	679	822	969	1,087	1,180	1,188	612	708	806	878	918	905
Slovenia	299	360	411	442	449	429	304	340	377	399	403	386
Spain	8,005	9,532	11,350	12,986	13,734	13,429	6,486	7,595	8,870	10,037	10,647	10,472
Sweden	1,920	2,225	2,445	2,615	2,729	2,883	1,495	1,670	1,827	1,950	2,021	2,112
United Kingdom	12,939	14,868	16,664	18,176	19,312	20,775	10,326	11,510	12,908	14,162	14,985	15,866
European Union (27 countries)	93,148	106,694	119,806	129,734	134,168	134,880	76,040	84,786	93,712	100,524	102,987	102,320

8.5 SUPPLEMENTARY TABLES - COSTS UNDER THE BASELINE SCENARIO

Table 8.5.1: Health costs – baseline scenario – Member State breakdown - Based on a 4% discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0.2	€ 0.5	€ 0.7	Austria	€ 0.6	€ 2.0	€ 2.6
Belgium	€ 0.0	€ 0.1	€ 0.2	Belgium	€ 1.2	€ 4.6	€ 5.8
Bulgaria	€ 0.2	€ 0.2	€ 0.3	Bulgaria	€ 0.5	€ 0.5	€ 1.0
Czech Republic	€ 0.5	€ 0.6	€ 1.2	Czech Republic	€ 1.9	€ 3.2	€ 5.1
Cyprus	€ 0.0	€ 0.1	€ 0.0	Cyprus	€ 0.0	€ 0.0	€ 0.0
Denmark	€ 0.2	€ 0.4	€ 0.6	Denmark	€ 0.7	€ 2.0	€ 2.7
Estonia	€ 0.1	€ 0.0	€ 0.1	Estonia	€ 0.2	€ 0.1	€ 0.3
Finland	€ 0.2	€ 0.5	€ 0.7	Finland	€ 0.8	€ 1.8	€ 2.6
France	€ 2.0	€ 5.1	€ 7.1	France	€ 7.3	€ 21.2	€ 28.4
Germany	€ 3.0	€ 7.9	€ 10.9	Germany	€ 11.8	€ 32.1	€ 44.0
Greece	€ 0.1	€ 0.3	€ 0.4	Greece	€ 0.4	€ 1.0	€ 1.4
Hungary	€ 0.4	€ 0.5	€ 0.8	Hungary	€ 1.3	€ 1.9	€ 3.2
Ireland	€ 0.1	€ 0.3	€ 0.4	Ireland	€ 0.4	€ 1.1	€ 1.5
Italy	€ 0.6	€ 0.7	€ 1.3	Italy	€ 2.0	€ 3.1	€ 5.0
Latvia	€ 0.0	€ 0.0	€ 0.1	Latvia	€ 0.2	€ 0.2	€ 0.4
Lithuania	€ 0.1	€ 0.1	€ 0.1	Lithuania	€ 0.3	€ 0.3	€ 0.6
Luxembourg	€ 0.0	€ 0.1	€ 0.1	Luxembourg	€ 0.1	€ 0.4	€ 0.5
Malta	€ 0.0	€ 0.0	€ 0.0	Malta	€ 0.0	€ 0.0	€ 0.0
Netherlands	€ 0.4	€ 1.1	€ 1.5	Netherlands	€ 1.3	€ 4.3	€ 5.6
Poland	€ 1.1	€ 1.6	€ 2.6	Poland	€ 3.0	€ 5.3	€ 8.3
Portugal	€ 0.2	€ 0.3	€ 0.5	Portugal	€ 0.9	€ 1.1	€ 1.9
Romania	€ 0.4	€ 0.4	€ 0.7	Romania	€ 1.0	€ 1.2	€ 2.2
Slovakia	€ 0.1	€ 0.2	€ 0.3	Slovakia	€ 0.5	€ 0.7	€ 1.2
Slovenia	€ 0.1	€ 0.2	€ 0.3	Slovenia	€ 0.5	€ 0.7	€ 1.1
Spain	€ 1.1	€ 3.0	€ 4.1	Spain	€ 4.0	€ 12.0	€ 16.0
Sweden	€ 0.3	€ 0.7	€ 1.0	Sweden	€ 1.1	€ 2.9	€ 4.0
United Kingdom	€ 1.3	€ 3.9	€ 5.1	United Kingdom	€ 5.2	€ 16.2	€ 21.3
TOTAL	**€ 12.7**	**€ 28.6**	**€ 41.3**	**TOTAL**	**€ 47.1**	**€ 119.7**	**€ 166.8**

Table 8.5.2: Health costs - baseline scenario - Industry group breakdown - Based on a 4% discount rate

Low	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 0.6	€ 1.4	€ 2.0
Manufacture of chemicals and chemical products	€ 6.1	€ 15.7	€ 21.8
TOTAL	**€ 13.3**	**€ 29.1**	**€ 42.4**

High	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 2.2	€ 5.8	€ 8.0
Manufacture of chemicals and chemical products	€ 22.2	€ 63.4	€ 85.6
TOTAL	**€ 48.2**	**€ 117.7**	**€ 165.9**

Table 8.5.3: Health costs – baseline scenario – Member State breakdown - Based on a declining discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0.2	€ 0.6	€ 0.8	Austria	€ 0.8	€ 2.6	€ 3.4
Belgium	€ 0.0	€ 0.2	€ 0.2	Belgium	€ 1.6	€ 5.8	€ 7.3
Bulgaria	€ 0.2	€ 0.2	€ 0.4	Bulgaria	€ 0.6	€ 0.7	€ 1.3
Czech Republic	€ 0.6	€ 0.8	€ 1.6	Czech Republic	€ 2.4	€ 4.1	€ 6.5
Cyprus	€ 0.0	€ 0.1	€ 0.0	Cyprus	€ 0.0	€ 0.0	€ 0.0
Denmark	€ 0.2	€ 0.5	€ 0.8	Denmark	€ 0.9	€ 2.5	€ 3.4
Estonia	€ 0.1	€ 0.1	€ 0.1	Estonia	€ 0.2	€ 0.2	€ 0.4
Finland	€ 0.3	€ 0.6	€ 0.9	Finland	€ 1.0	€ 2.3	€ 3.3
France	€ 2.5	€ 6.3	€ 8.9	France	€ 9.0	€ 26.1	€ 35.1
Germany	€ 3.9	€ 10.0	€ 13.9	Germany	€ 15.0	€ 40.8	€ 55.8
Greece	€ 0.2	€ 0.4	€ 0.5	Greece	€ 0.5	€ 1.3	€ 1.8
Hungary	€ 0.4	€ 0.6	€ 1.0	Hungary	€ 1.7	€ 2.4	€ 4.1
Ireland	€ 0.1	€ 0.4	€ 0.5	Ireland	€ 0.5	€ 1.4	€ 1.9
Italy	€ 0.7	€ 0.8	€ 1.5	Italy	€ 2.5	€ 3.6	€ 6.0
Latvia	€ 0.1	€ 0.1	€ 0.1	Latvia	€ 0.2	€ 0.2	€ 0.5
Lithuania	€ 0.1	€ 0.1	€ 0.2	Lithuania	€ 0.4	€ 0.3	€ 0.7
Luxembourg	€ 0.0	€ 0.1	€ 0.1	Luxembourg	€ 0.1	€ 0.5	€ 0.5
Malta	€ 0.0	€ 0.0	€ 0.0	Malta	€ 0.0	€ 0.0	€ 0.0
Netherlands	€ 0.5	€ 1.4	€ 1.9	Netherlands	€ 1.6	€ 5.5	€ 7.1
Poland	€ 1.3	€ 2.0	€ 3.3	Poland	€ 3.8	€ 6.7	€ 10.6
Portugal	€ 0.3	€ 0.4	€ 0.7	Portugal	€ 1.1	€ 1.4	€ 2.5
Romania	€ 0.4	€ 0.5	€ 0.9	Romania	€ 1.2	€ 1.5	€ 2.7
Slovakia	€ 0.2	€ 0.2	€ 0.4	Slovakia	€ 0.6	€ 0.9	€ 1.5
Slovenia	€ 0.2	€ 0.3	€ 0.4	Slovenia	€ 0.6	€ 0.8	€ 1.4
Spain	€ 1.4	€ 3.9	€ 5.4	Spain	€ 5.3	€ 15.7	€ 21.0
Sweden	€ 0.4	€ 0.9	€ 1.2	Sweden	€ 1.4	€ 3.7	€ 5.1
United Kingdom	€ 1.6	€ 4.7	€ 6.3	United Kingdom	€ 6.4	€ 19.7	€ 26.1
TOTAL	€ 16.0	€ 36.1	€ 52.2	**TOTAL**	€ 59.6	€ 150.6	€ 210.2

Table 8.5.4: Health costs – baseline scenario – Industry group breakdown - Based on a declining discount rate

Low	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 0.7	€ 1.7	€ 2.4
Manufacture of chemicals and chemical products	€ 7.8	€ 19.9	€ 27.7
TOTAL	**€ 16.8**	**€ 36.7**	**€ 53.6**

High	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 2.5	€ 6.8	€ 9.3
Manufacture of chemicals and chemical products	€ 28.1	€ 80.6	€ 108.7
TOTAL	**€ 61.0**	**€ 148.5**	**€ 209.5**

Table 8.5.5: Summary of health costs

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	3 to 11	2 to 9	3 to 10	3 to 10	3 to 10	3 to 9
Male	7 to 29	5 to 23	6 to 26	6 to 25	6 to 24	6 to 23
Total	**10 to 40**	**8 to 32**	**9 to 36**	**9 to 36**	**9 to 34**	**8 to 32**

Table 8.5.6: Health costs – baseline scenario – Member State breakdown - Based on a no discounting approach

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0.6	€ 1.8	€ 2.4	Austria	€ 2.2	€ 7.2	€ 9.4
Belgium	€ 0.1	€ 0.4	€ 0.6	Belgium	€ 4.3	€ 15.9	€ 20.2
Bulgaria	€ 0.5	€ 0.5	€ 1.0	Bulgaria	€ 1.7	€ 1.8	€ 3.5
Czech Republic	€ 1.7	€ 2.3	€ 4.3	Czech Republic	€ 6.7	€ 11.4	€ 18.1
Cyprus	€ 0.0	€ 0.3	€ 0.1	Cyprus	€ 0.0	€ 0.0	€ 0.0
Denmark	€ 0.7	€ 1.5	€ 2.1	Denmark	€ 2.6	€ 6.8	€ 9.4
Estonia	€ 0.2	€ 0.1	€ 0.3	Estonia	€ 0.6	€ 0.5	€ 1.1
Finland	€ 0.8	€ 1.7	€ 2.6	Finland	€ 2.7	€ 6.3	€ 9.0
France	€ 6.8	€ 16.7	€ 23.5	France	€ 23.9	€ 68.1	€ 92.0
Germany	€ 10.8	€ 28.0	€ 38.7	Germany	€ 41.7	€ 113.2	€ 154.9
Greece	€ 0.4	€ 1.1	€ 1.5	Greece	€ 1.4	€ 3.6	€ 5.0
Hungary	€ 1.2	€ 1.6	€ 2.8	Hungary	€ 4.6	€ 6.6	€ 11.3
Ireland	€ 0.4	€ 1.1	€ 1.6	Ireland	€ 1.4	€ 4.0	€ 5.4
Italy	€ 1.8	€ 1.9	€ 3.8	Italy	€ 6.5	€ 8.3	€ 14.7
Latvia	€ 0.2	€ 0.2	€ 0.3	Latvia	€ 0.7	€ 0.7	€ 1.4
Lithuania	€ 0.3	€ 0.2	€ 0.5	Lithuania	€ 1.2	€ 1.0	€ 2.1
Luxembourg	€ 0.1	€ 0.2	€ 0.3	Luxembourg	€ 0.2	€ 1.1	€ 1.3
Malta	€ 0.0	€ 0.0	€ 0.0	Malta	€ 0.0	€ 0.0	€ 0.0
Netherlands	€ 1.3	€ 3.9	€ 5.2	Netherlands	€ 4.6	€ 15.4	€ 19.9
Poland	€ 3.8	€ 5.6	€ 9.4	Poland	€ 10.8	€ 19.0	€ 29.8
Portugal	€ 0.9	€ 1.0	€ 1.8	Portugal	€ 3.1	€ 3.8	€ 6.9
Romania	€ 1.2	€ 1.4	€ 2.6	Romania	€ 3.4	€ 4.2	€ 7.6
Slovakia	€ 0.5	€ 0.7	€ 1.2	Slovakia	€ 1.8	€ 2.6	€ 4.4
Slovenia	€ 0.5	€ 0.7	€ 1.2	Slovenia	€ 1.7	€ 2.4	€ 4.0
Spain	€ 4.3	€ 11.8	€ 16.1	Spain	€ 15.8	€ 47.0	€ 62.8
Sweden	€ 1.0	€ 2.3	€ 3.4	Sweden	€ 3.8	€ 10.0	€ 13.9
United Kingdom	€ 4.2	€ 12.1	€ 16.3	United Kingdom	€ 17.0	€ 50.5	€ 67.5
TOTAL	€ 44.4	€ 99.1	€ 143.6	**TOTAL**	€ 164.4	€ 411.2	€ 575.6

Table 8.5.7: Health costs – baseline scenario – Industry group breakdown - Based on a no discounting approach

Low	**Female**	**Male**	**Total**
	€ 1.6	€ 3.8	€ 5.4
	€ 21.6	€ 55.6	€ 77.2
TOTAL	€ 46.7	€ 101.1	€ 147.8

High	**Female**	**Male**	**Total**
Fishing, fish farming and related service activities	€ 5.7	€ 15.4	€ 21.1
Mining of coal and lignite; extraction of peat	€ 78.2	€ 224.3	€ 302.5
TOTAL	€ 168.6	€ 408.0	€ 576.6

Table 8.5.8: Summary of health costs

Costs by Gender (€m)	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
Female	4 to 13	4 to 16	6 to 22	8 to 29	10 to 37	13 to 47
Male	8 to 35	10 to 42	13 to 54	17 to 71	22 to 93	28 to 116
Total	**12 to 48**	**14 to 58**	**19 to 76**	**25 to 100**	**33 to 130**	**41 to 163**

8.6 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

Table 8.6.1 Proportions exposed above the exposure limits being tested by country, forecast scenario

Forecast Scenario	**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**
OEL			***0.5 ppm***						***1 ppm***						***5 ppm***			
Austria	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Belgium	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Bulgaria	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Cyprus	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Czech Republic	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Denmark	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Estonia	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Finland	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
France	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Germany	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Greece	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Hungary	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Ireland	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Italy	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Latvia	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Lithuania	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Luxembourg	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Malta	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Netherlands	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Poland	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Portugal	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003

Forecast Scenario	**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**
OEL			***0.5 ppm***						***1 ppm***						***5 ppm***			
Romania	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Slovakia	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Slovenia	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Spain	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
Sweden	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
United Kingdom	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003
TOTAL	0.922	0.818	0.656	0.458	0.270	0.131	0.824	0.664	0.467	0.278	0.136	0.054	0.423	0.242	0.114	0.043	0.013	0.003

Table 8.6.2 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 (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Number ever exposed in the REP																	
Austria	1,230	1,271	1,304	1,317	1,317	1,317	1,304	1,317	1,317	1,317	1,304	1,317	1,317	1,317	1,304	1,317	1,317	1,317
Belgium	2,426	2,481	2,525	2,542	2,542	2,542	2,525	2,542	2,542	2,542	2,525	2,542	2,542	2,542	2,525	2,542	2,542	2,542
Bulgaria	1,271	1,298	1,320	1,329	1,329	1,329	1,320	1,329	1,329	1,329	1,320	1,329	1,329	1,329	1,320	1,329	1,329	1,329
Cyprus	79	83	86	87	87	87	86	87	87	87	86	87	87	87	86	87	87	87
Czech Republic	2,533	2,579	2,615	2,629	2,629	2,629	2,615	2,629	2,629	2,629	2,615	2,629	2,629	2,629	2,615	2,629	2,629	2,629
Denmark	1,209	1,243	1,271	1,282	1,282	1,282	1,271	1,282	1,282	1,282	1,271	1,282	1,282	1,282	1,271	1,282	1,282	1,282
Estonia	209	217	224	226	226	226	224	226	226	226	224	226	226	226	224	226	226	226
Finland	1,352	1,373	1,390	1,397	1,397	1,397	1,390	1,397	1,397	1,397	1,390	1,397	1,397	1,397	1,390	1,397	1,397	1,397
France	12,388	12,012	11,875	11,297	11,297	11,297	11,875	11,297	11,297	11,297	11,875	11,297	11,297	11,297	11,875	11,297	11,297	11,297
Germany	18,970	19,400	19,747	19,881	19,881	19,881	19,747	19,881	19,881	19,881	19,747	19,881	19,881	19,881	19,747	19,881	19,881	19,881
Greece	877	922	959	973	973	973	959	973	973	973	959	973	973	973	959	973	973	973
Hungary	1,723	1,768	1,804	1,818	1,818	1,818	1,804	1,818	1,818	1,818	1,804	1,818	1,818	1,818	1,804	1,818	1,818	1,818
Ireland	852	872	888	894	894	894	888	894	894	894	888	894	894	894	888	894	894	894
Italy	1,136	1,284	1,404	1,449	1,449	1,449	1,404	1,449	1,449	1,449	1,404	1,449	1,449	1,449	1,404	1,449	1,449	1,449
Latvia	239	251	261	264	264	264	261	264	264	264	261	264	264	264	261	264	264	264
Lithuania	374	390	402	407	407	407	402	407	407	407	402	407	407	407	402	407	407	407
Luxembourg	122	125	127	128	128	128	127	128	128	128	127	128	128	128	127	128	128	128
Malta	4	5	5	6	6	6	5	6	6	6	5	6	6	6	5	6	6	6
Netherlands	2,651	2,773	2,872	2,910	2,910	2,910	2,872	2,910	2,910	2,910	2,872	2,910	2,910	2,910	2,872	2,910	2,910	2,910
Poland	5,674	5,797	5,896	5,934	5,934	5,934	5,896	5,934	5,934	5,934	5,896	5,934	5,934	5,934	5,896	5,934	5,934	5,934

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Portugal	1,157	1,204	1,242	1,257	1,257	1,257	1,242	1,257	1,257	1,257	1,242	1,257	1,257	1,257	1,242	1,257	1,257	1,257
Romania	2,445	2,514	2,571	2,592	2,592	2,592	2,571	2,592	2,592	2,592	2,571	2,592	2,592	2,592	2,571	2,592	2,592	2,592
Slovakia	725	745	761	767	767	767	761	767	767	767	761	767	767	767	761	767	767	767
Slovenia	609	620	629	632	632	632	629	632	632	632	629	632	632	632	629	632	632	632
Spain	6,267	7,705	9,101	9,952	9,952	9,952	9,101	9,952	9,952	9,952	9,101	9,952	9,952	9,952	9,101	9,952	9,952	9,952
Sweden	1,838	1,905	1,959	1,979	1,979	1,979	1,959	1,979	1,979	1,979	1,959	1,979	1,979	1,979	1,959	1,979	1,979	1,979
United Kingdom	11,409	10,161	9,130	8,723	8,723	8,723	9,130	8,723	8,723	8,723	9,130	8,723	8,723	8,723	9,130	8,723	8,723	8,723
TOTAL	**79,768**	**80,993**	**82,366**	**82,669**	**82,669**	**82,669**	**82,366**	**82,669**	**82,669**	**82,669**	**82,366**	**82,669**	**82,669**	**82,669**	**82,366**	**82,669**	**82,669**	**82,669**

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	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	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	0.03	0.03	0.03	0.03
Bulgaria	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03
Cyprus	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	0.01	0.01	0.01	0.01
Czech Republic	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04
Denmark	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	0.03	0.03	0.03	0.03
Estonia	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03
Finland	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.04
France	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	0.02	0.02	0.02	0.02
Germany	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	0.03	0.03	0.04	0.04
Greece	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	0.01	0.01	0.01	0.01
Hungary	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.03
Ireland	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	0.02	0.02	0.02	0.02
Italy	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	0.00	0.00	0.00	0.00
Latvia	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	0.02	0.02	0.02	0.02
Lithuania	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	0.02	0.02	0.02	0.02	0.02
Luxembourg	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	0.03	0.03	0.02	0.02
Malta	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	0.00	0.00	0.00	0.00
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	0.02	0.02	0.02	0.02
Poland	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03
Portugal	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	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	0.02	0.02	0.02	0.02

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
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	0.02	0.02	0.02	0.02
Slovenia	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05
Spain	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.03
Sweden	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.02
United Kingdom	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	0.02	0.02	0.02	0.02
TOTAL	**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**	**0.02**	**0.02**	**0.02**	**0.02**

Table 8.6.3 Results for baseline and intervention[1] scenarios for lung cancer, by county, men plus women

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Fraction																	
Austria	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	0.001	0.001	0.001	0.001
Belgium	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	0.002	0.002	0.002	0.002	0.002
Bulgaria	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002	0.001	0.001	0.002	0.002
Cyprus	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	0.001	0.001	0.001	0.001
Czech Republic	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	0.002	0.002	0.002	0.002	0.002
Denmark	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	0.002	0.002	0.002	0.002	0.002
Estonia	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	0.001	0.001	0.001	0.001
Finland	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	0.002	0.002	0.002	0.002	0.002
France	0.002	0.002	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	0.001	0.001
Germany	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	0.002	0.002	0.002	0.002	0.002
Greece	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	0.001	0.001	0.001	0.001
Hungary	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002
Ireland	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	0.001	0.001	0.001	0.001
Italy	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	0.000	0.000	0.000	0.000
Latvia	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	0.001	0.001	0.001	0.001
Lithuania	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	0.001	0.001	0.001	0.001
Luxembourg	0.006	0.003	0.002	0.002	0.002	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Malta	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	0.000	0.000	0.000	0.000
Netherlands	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	0.001	0.001	0.001	0.001
Poland	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	0.001	0.001	0.001	0.001

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Portugal	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	0.001	0.001	0.001	0.001
Romania	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	0.001	0.001	0.001	0.001
Slovakia	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	0.001	0.001	0.001	0.001
Slovenia	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.002	0.003	0.003	0.002	0.002	0.003	0.003
Spain	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.002
Sweden	0.002	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	0.001	0.001	0.001
United Kingdom	0.002	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	0.001	0.001	0.001
TOTAL	**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**	**0.001**	**0.001**	**0.001**	**0.001**

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	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	0	0	0	0
Belgium	0	0	0	0	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	0	0	0	0
Cyprus	0	0	0	0	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	0	0	0	0
Denmark	0	0	0	0	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	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Greece	0	0	0	0	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	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	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	0	0	0	0
Luxembourg	0	0	0	0	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	0	0	0	0
Netherlands	0	0	0	0	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	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Romania	0	0	0	0	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	0	0	0	0
Slovenia	0	0	0	0	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	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**1**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	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	0	0	0	0
Belgium	0	0	0	0	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	0	0	0	0
Cyprus	0	0	0	0	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	0	0	0	0
Denmark	0	0	0	0	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	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Greece	0	0	0	0	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	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	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	0	0	0	0
Luxembourg	0	0	0	0	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	0	0	0	0
Netherlands	0	0	0	0	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	0	0	0	0
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Romania	0	0	0	0	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	0	0	0	0
Slovenia	0	0	0	0	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	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lost (YLLs)																	
Austria	0	0	0	0	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	0	0	0	0
Bulgaria	0	0	0	0	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	0	0	0	0
Czech Republic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Denmark	0	0	0	0	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	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	4	3	4	4	4	4	3	4	4	4	3	4	4	4	4	4	4	4
Germany	5	5	5	6	7	7	5	6	7	7	5	6	7	7	5	6	7	7
Greece	0	0	0	0	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	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	1	1	1	1	1	1	0	0	1	1	0	0	1	1	0	1	1	1
Latvia	0	0	0	0	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	0	0	0	0
Luxembourg	0	0	0	0	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	0	0	0	0
Netherlands	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Poland	1	1	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2
Portugal	0	0	0	0	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	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Slovakia	0	0	0	0	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	0	0	0	0
Spain	1	2	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3
Sweden	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
United Kingdom	3	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3
TOTAL	**19**	**19**	**21**	**23**	**25**	**25**	**20**	**23**	**24**	**25**	**21**	**23**	**24**	**25**	**21**	**23**	**25**	**26**

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Years of Life Lived with Disability (DALYs)																	
Austria	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
Belgium	0	0	0	0	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	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Denmark	0	0	0	0	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	0	0	0	0
Finland	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
France	5	4	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
Germany	6	6	7	8	8	8	7	8	8	8	7	8	8	8	7	8	8	8
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	1	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Latvia	0	0	0	0	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	0	0	0	0
Luxembourg	0	0	0	0	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	0	0	0	0
Netherlands	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Poland	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	1	1	0	0	1	1	0	0	1	1	0	1	1	1

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Country	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Slovakia	0	0	0	0	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	0	0	0	0
Spain	2	2	3	3	4	4	2	3	4	4	2	3	4	4	2	3	4	4
Sweden	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
United Kingdom	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
TOTAL	**24**	**24**	**26**	**28**	**30**	**32**	**26**	**28**	**30**	**31**	**26**	**28**	**30**	**32**	**26**	**29**	**31**	**32**

[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 8.6.4 Numbers and proportions of the EU population ever exposed, by industry, men plus women

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Number ever exposed in the REP																	
Manufacture of coke, refined petroleum products and nuclear fuel	2,469	2,376	2,306	2,259	2,259	2,259	2,306	2,259	2,259	2,259	2,306	2,259	2,259	2,259	2,306	2,259	2,259	2,259
Manufacture of chemicals and chemical products	44,710	43,944	43,566	43,257	43,257	43,257	43,566	43,257	43,257	43,257	43,566	43,257	43,257	43,257	43,566	43,257	43,257	43,257
Manufacture of rubber and plastic products	566	561	559	561	561	561	559	561	561	561	559	561	561	561	559	561	561	561
Manufacture of rubber products	5,150	5,141	5,175	5,173	5,173	5,173	5,175	5,173	5,173	5,173	5,175	5,173	5,173	5,173	5,175	5,173	5,173	5,173
Manufacture of plastic products	15,694	15,457	15,352	15,291	15,291	15,291	15,352	15,291	15,291	15,291	15,352	15,291	15,291	15,291	15,352	15,291	15,291	15,291
Manufacture of other non-metallic mineral products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of machinery and equipment n.e.c.	856	835	819	808	808	808	819	808	808	808	819	808	808	808	819	808	808	808
Land transport; transport via pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	2,012	2,472	2,847	2,991	2,991	2,991	2,847	2,991	2,991	2,991	2,847	2,991	2,991	2,991	2,847	2,991	2,991	2,991
Research and development	1,362	1,674	1,926	2,023	2,023	2,023	1,926	2,023	2,023	2,023	1,926	2,023	2,023	2,023	1,926	2,023	2,023	2,023
Other business activities	2,465	3,028	3,484	3,659	3,659	3,659	3,484	3,659	3,659	3,659	3,484	3,659	3,659	3,659	3,484	3,659	3,659	3,659
Education	4,484	5,506	6,332	6,646	6,646	6,646	6,332	6,646	6,646	6,646	6,332	6,646	6,646	6,646	6,332	6,646	6,646	6,646
Health and social work	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Proportion of the population exposed																	
Manufacture of coke, refined petroleum products and nuclear fuel	0.00062	0.00059	0.00056	0.00056	0.00058	0.00061	0.00056	0.00056	0.00058	0.00061	0.00056	0.00056	0.00058	0.00061	0.00056	0.00056	0.00058	0.00061
Manufacture of chemicals and chemical products	0.01122	0.01083	0.01067	0.01078	0.01120	0.01158	0.01067	0.01078	0.01120	0.01158	0.01067	0.01078	0.01120	0.01158	0.01067	0.01078	0.01120	0.01158
Manufacture of rubber and plastic products	0.00014	0.00014	0.00014	0.00014	0.00015	0.00015	0.00014	0.00014	0.00015	0.00015	0.00014	0.00014	0.00015	0.00015	0.00014	0.00014	0.00015	0.00015
Manufacture of rubber products	0.00129	0.00127	0.00127	0.00129	0.00134	0.00139	0.00127	0.00129	0.00134	0.00139	0.00127	0.00129	0.00134	0.00139	0.00127	0.00129	0.00134	0.00139
Manufacture of plastic products	0.00394	0.00381	0.00376	0.00381	0.00396	0.00409	0.00376	0.00381	0.00396	0.00409	0.00376	0.00381	0.00396	0.00409	0.00376	0.00381	0.00396	0.00409
Manufacture of other non-metallic mineral products	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Manufacture of machinery and equipment n.e.c.	0.00021	0.00021	0.00020	0.00020	0.00021	0.00022	0.00020	0.00020	0.00021	0.00022	0.00020	0.00020	0.00021	0.00022	0.00020	0.00020	0.00021	0.00022
Land transport; transport via pipelines	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Supporting and auxiliary transport activities; activities of travel agencies	0.00050	0.00061	0.00070	0.00075	0.00077	0.00080	0.00070	0.00075	0.00077	0.00080	0.00070	0.00075	0.00077	0.00080	0.00070	0.00075	0.00077	0.00080
Research and development	0.00019	0.00023	0.00027	0.00029	0.00030	0.00031	0.00047	0.00050	0.00052	0.00054	0.00047	0.00050	0.00052	0.00054	0.00047	0.00050	0.00052	0.00054
Other business activities	0.00062	0.00075	0.00085	0.00091	0.00095	0.00098	0.00085	0.00091	0.00095	0.00098	0.00085	0.00091	0.00095	0.00098	0.00085	0.00091	0.00095	0.00098
Education	0.00113	0.00136	0.00155	0.00166	0.00172	0.00178	0.00155	0.00166	0.00172	0.00178	0.00155	0.00166	0.00172	0.00178	0.00155	0.00166	0.00172	0.00178
Health and social work	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table 8.6.5 Occupational attributable fractions, deaths, registrations, YLLs and DALYs for lung cancer by industry, men plus women

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Attributable Fraction																	
Manufacture of coke, refined petroleum products and nuclear fuel	0.00013	0.00006	0.00004	0.00003	0.00004	0.00004	0.00003	0.00003	0.00003	0.00004	0.00003	0.00003	0.00003	0.00004	0.00004	0.00004	0.00004	0.00004
Manufacture of chemicals and chemical products	0.00066	0.00064	0.00063	0.00064	0.00066	0.00069	0.00063	0.00064	0.00066	0.00069	0.00063	0.00064	0.00066	0.00069	0.00063	0.00064	0.00066	0.00069
Manufacture of rubber and plastic products	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Manufacture of rubber products	0.00022	0.00011	0.00008	0.00008	0.00008	0.00008	0.00007	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00008	0.00009
Manufacture of plastic products	0.00023	0.00023	0.00022	0.00023	0.00023	0.00024	0.00022	0.00023	0.00023	0.00024	0.00022	0.00023	0.00023	0.00024	0.00022	0.00023	0.00023	0.00024
Manufacture of other non-metallic mineral products	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Manufacture of machinery and equipment n.e.c.	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001
Land transport; transport via pipelines	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Supporting and auxiliary transport activities; activities of travel agencies	0.00003	0.00004	0.00004	0.00005	0.00005	0.00005	0.00004	0.00005	0.00005	0.00005	0.00004	0.00005	0.00005	0.00005	0.00004	0.00005	0.00005	0.00005
Research and development	0.00002	0.00002	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Other business activities	0.00003	0.00004	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00006	0.00005	0.00005	0.00005	0.00006
Education	0.00006	0.00007	0.00008	0.00009	0.00009	0.00009	0.00008	0.00009	0.00009	0.00009	0.00008	0.00009	0.00009	0.00009	0.00008	0.00009	0.00009	0.00009
Health and social work	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Attributable Deaths																	
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of rubber products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of other non-metallic mineral products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of machinery and equipment n.e.c.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land transport; transport via pipelines	0	0	0	0	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	0	0	0	0
Research and development	0	0	0	0	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	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and social work	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
	Attributable Registrations																	
Manufacture of coke, refined petroleum products and nuclear fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of chemicals and chemical products	1	1	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of rubber products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of plastic products	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Manufacture of other non-metallic mineral products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of machinery and equipment n.e.c.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land transport; transport via pipelines	0	0	0	0	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	0	0	0	0
Research and development	0	0	0	0	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	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and social work	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Attributable Years of Life Lost (YLLs)																	
Manufacture of coke, refined petroleum products and nuclear fuel	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manufacture of chemicals and chemical products	9	10	11	12	13	13	11	12	13	13	11	12	13	13	11	12	13	13
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of rubber products	3	2	1	1	2	2	1	1	2	2	1	1	2	2	1	2	2	2
Manufacture of plastic products	3	4	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
Manufacture of other non-metallic mineral products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of machinery and equipment n.e.c.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land transport; transport via pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Research and development	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1	1
Other business activities	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Education	1	1	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2
Health and social work	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario[1]	All Scenarios		Baseline (trend) scenario (1)[2] - Linear employment and exposure level trends assumed to 2021-30, constant thereafter.				Intervention scenario (2) - Assume 99% compliance for OEL = 0.5 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm				Intervention scenario (4) - Assume 99% compliance for OEL = 5 ppm			
Industry sector	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
	Attributable Years of Life Lived with Disability (DALYs)																	
Manufacture of coke, refined petroleum products and nuclear fuel	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manufacture of chemicals and chemical products	11	12	14	15	16	16	14	15	16	16	14	15	16	16	14	15	16	16
Manufacture of rubber and plastic products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of rubber products	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Manufacture of plastic products	4	4	5	5	6	6	5	5	6	6	5	5	6	6	5	5	6	6
Manufacture of other non-metallic mineral products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manufacture of machinery and equipment n.e.c.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land transport; transport via pipelines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supporting and auxiliary transport activities; activities of travel agencies	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Research and development	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other business activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Education	1	2	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3
Health and social work	0	0	0	0	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

8.7 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

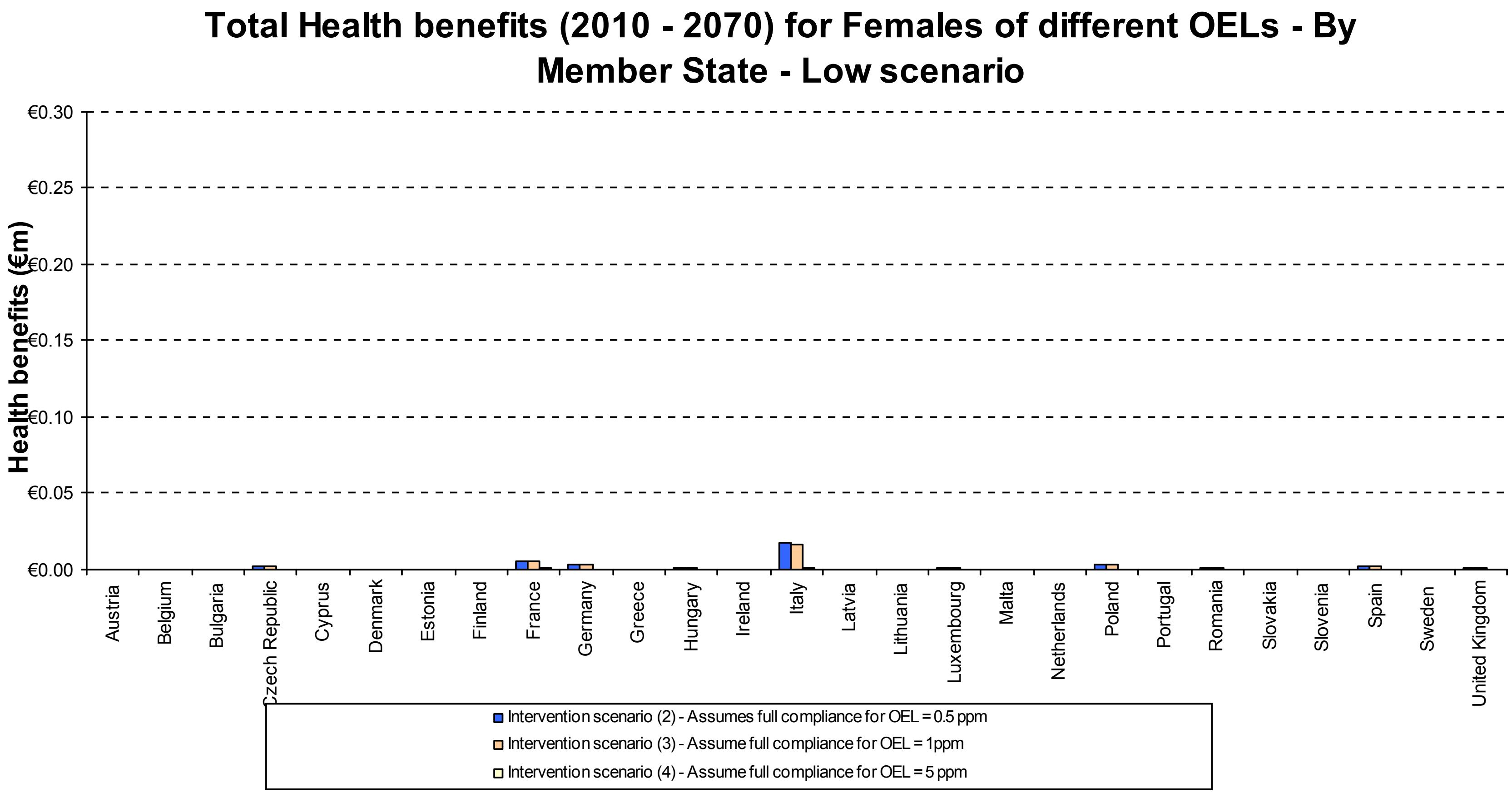

Figure 8.7.1: Total health benefits to females of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

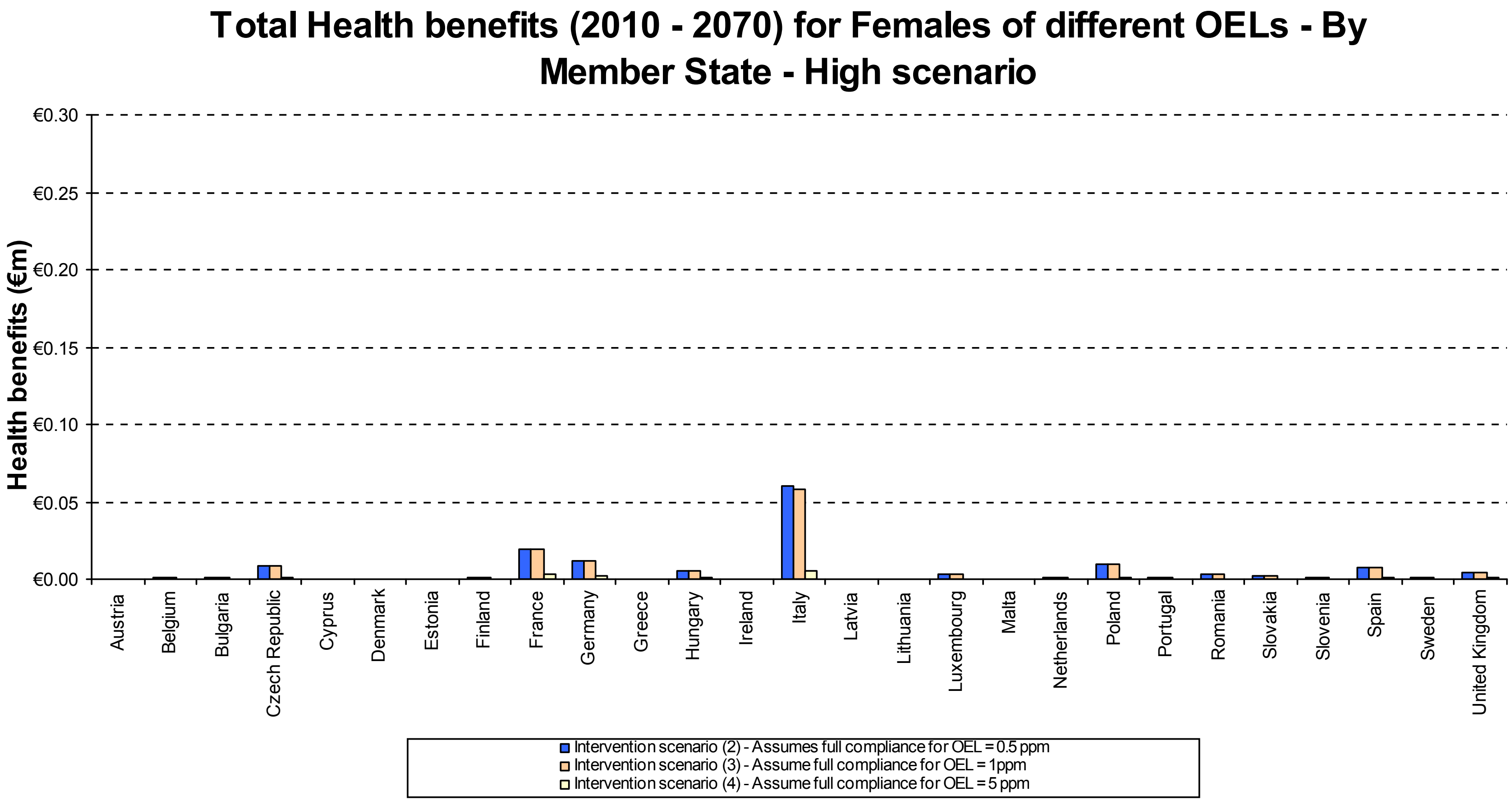

Figure 8.7.2: Total health benefits for females of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

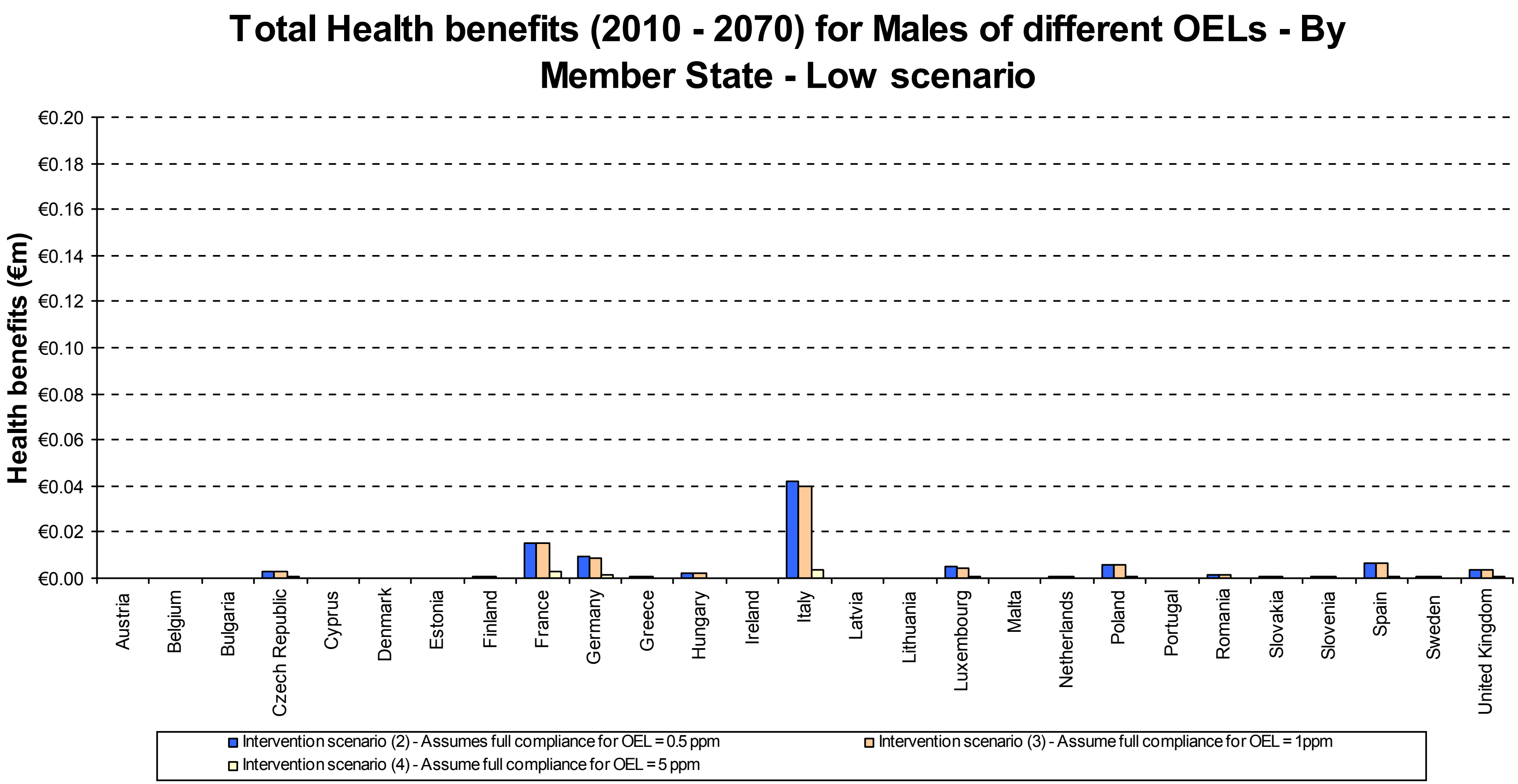

Figure 8.7.3: Total health benefits to males of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

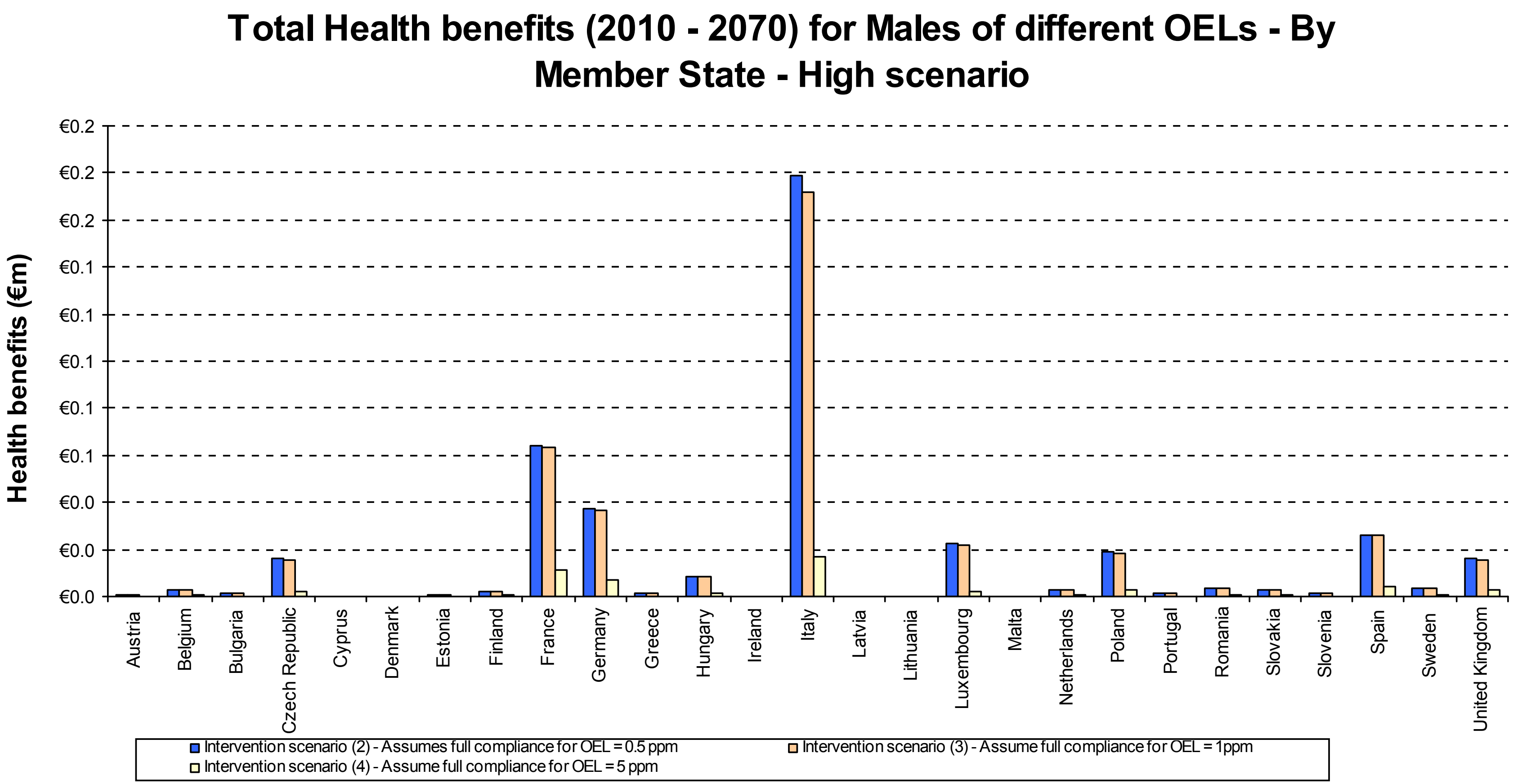

Figure 8.7.4: Total health benefits for males of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

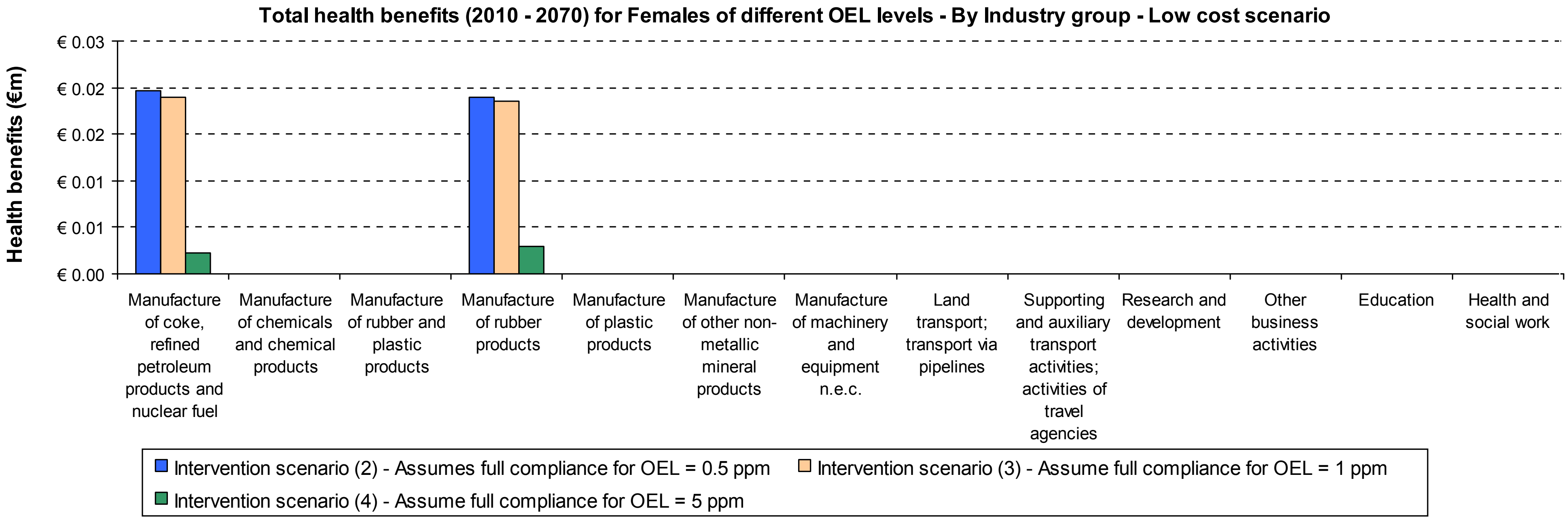

Figure 8.7.5: Total health benefits to females of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

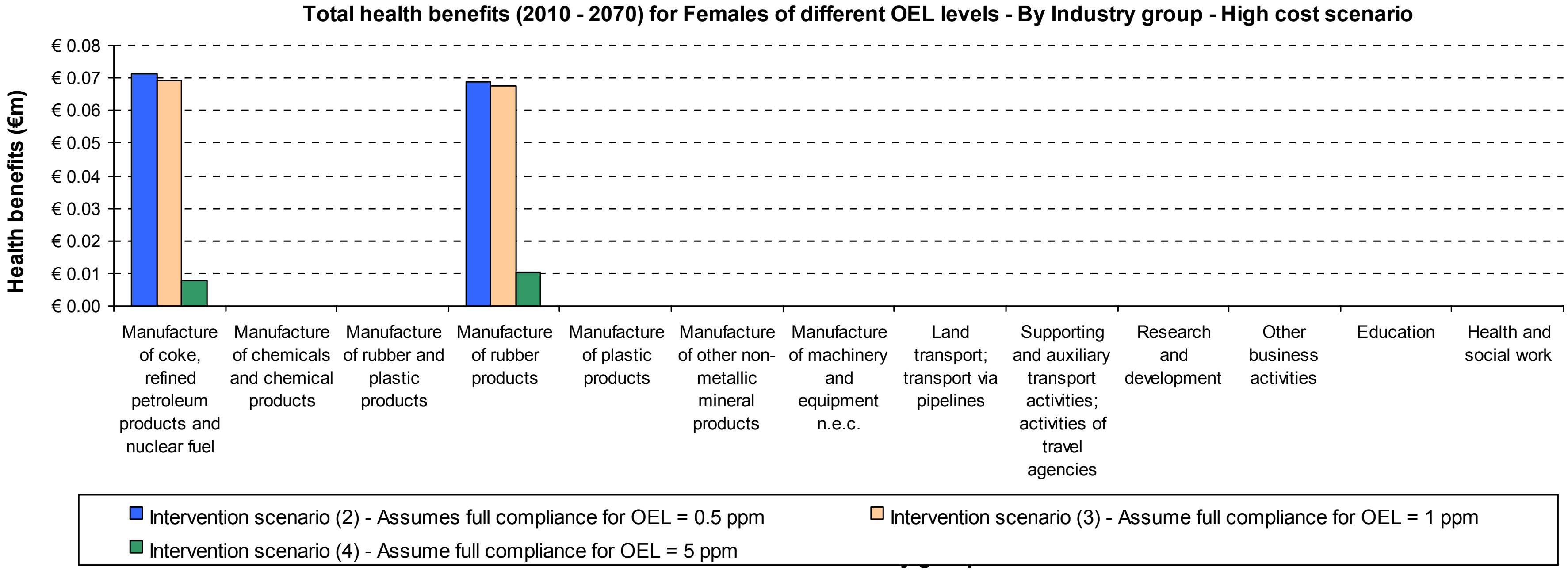

Figure 8.7.6: Total health benefits to females of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

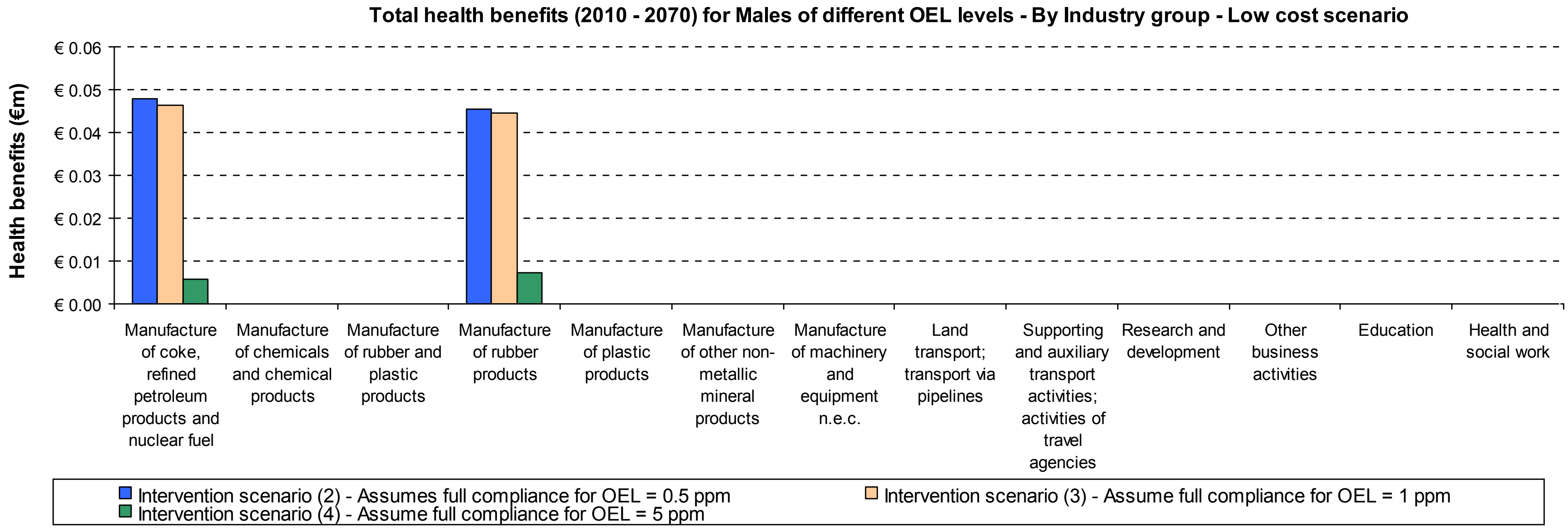

Figure 8.7.7: Total health benefits to males of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

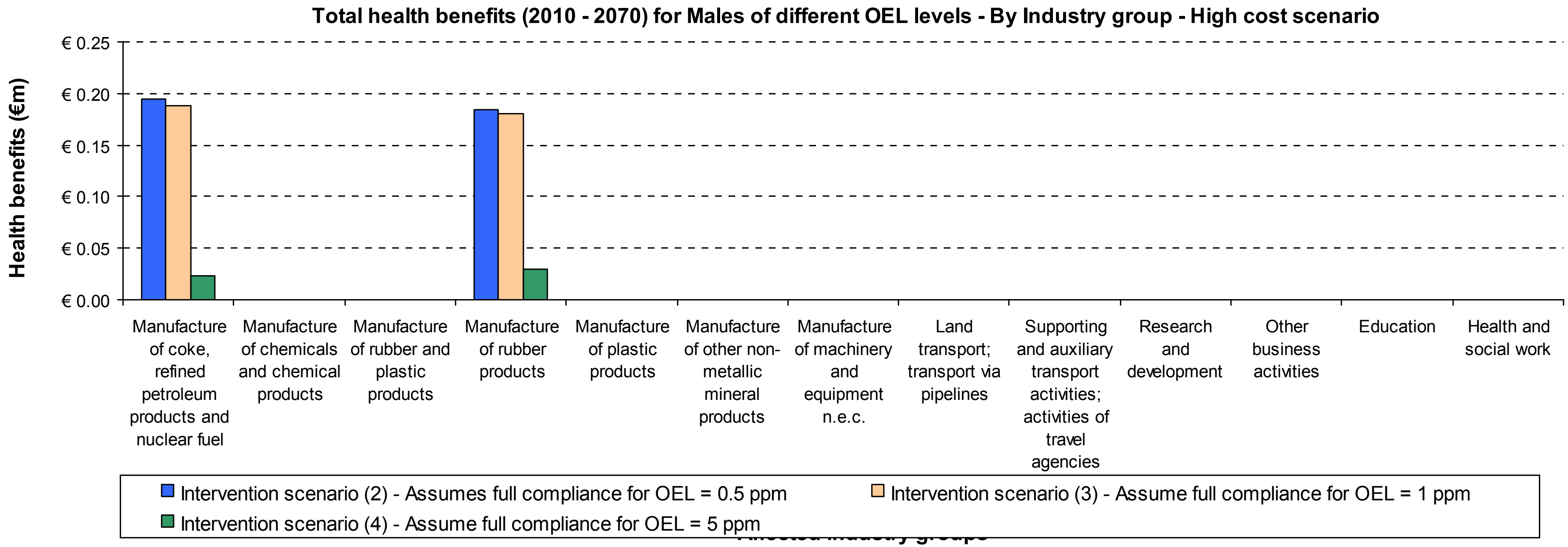

Figure 8.7.8: Total health benefits to males of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

8.8 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 8.8.1: Introducing an OEL of 0.5ppm

1,3-butadiene	Option 2 - Assume Full compliance for OEL = 0.5 ppm						
	Gender	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
Range of costs (€m)	Females	0 to 0	0 to 0	0.1 to 0.2	0 to 0.1	0 to 0.1	0 to 0.1
	Males	0 to 0	0 to 0.1	0.2 to 0.6	0 to 0.2	0.1 to 0.2	0.1 to 0.3
	Totals	0 to 0	0 to 0.1	0.2 to 0.9	0.1 to 0.3	0.1 to 0.3	0.1 to 0.4
	Gender	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
	Females	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0.1 to 0.2	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0.1	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0
	Gender	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
	Females	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0.1
	Totals	0 to 0	0 to 0.1	0.1 to 0.4	0 to 0.1	0 to 0.1	0 to 0.1

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 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
Bulgaria	€ 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
Cyprus	€ 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
Estonia	€ 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
France	€ 0.1	€ 0.1	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Germany	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.1
Greece	€ 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
Ireland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Italy	€ 0.2	€ 0.2	€ 0.1	€ 0.2	€ 0.1	€ 0.3

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Latvia	€ 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
Luxembourg	€ 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
Netherlands	€ 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
Portugal	€ 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
Slovakia	€ 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
Spain	€ 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
United Kingdom	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of coke, refined petroleum products and nuclear fuel	€ 0.2	€ 1.0	€ 0.1	€ 0.3	€ 1	€ 2
Manufacture of rubber and plastic products	€0.0	€0.0	€ 0.0	€0.0	€0.1	€0.4

Table 8.8.2: Introducing an OEL of 1ppm

1,3-butadiene	Option 3 - 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	0.1 to 0.2	0 to 0.1	0 to 0.1	0 to 0.1
	Males	0 to 0	0 to 0.1	0.2 to 0.6	0 to 0.2	0.1 to 0.2	0.1 to 0.3
	Totals	0 to 0	0 to 0.1	0.2 to 0.9	0.1 to 0.2	0.1 to 0.3	0.1 to 0.4
	Gender	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
	Females	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0.1 to 0.2	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0.1	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0
	Gender	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**
	Females	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0.1 to 0.3	0 to 0.1	0 to 0.1	0 to 0.1
	Totals	0 to 0	0 to 0.1	0.1 to 0.4	0 to 0.1	0 to 0.1	0 to 0.1

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 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
Bulgaria	€ 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
Cyprus	€ 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
Estonia	€ 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
France	€ 0.1	€ 0.0	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Germany	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.1
Greece	€ 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
Ireland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.1	€ 0.0
Italy	€ 0.2	€ 0.1	€ 0.1	€ 0.2	€ 0.0	€ 0.3
Latvia	€ 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
Luxembourg	€ 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
Netherlands	€ 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
Portugal	€ 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
Slovakia	€ 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
Spain	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Sweden	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
United Kingdom	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of coke, refined petroleum products and nuclear fuel	€ 0.2	€ 0.9	€ 0.1	€ 0.3	€ 0.1	€ 0.3
Manufacture of rubber and plastic products	€0.0	€0.0	€0.0	€0.0	€0.0	€0.0

Table 8.8.3: Introducing an OEL of 5ppm

1,3-butadiene	**Option 4 - Assume full compliance for OEL = 5ppm**						
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 0
	Males	0 to 0	0 to 0	0 to 0.1	0 to -0.5	0 to -0.7	0 to -0.9
	Totals	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0
	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 0.1	0 to 0	0 to 0	0 to 0
	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 0.1	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0	0 to 0.1	0 to 0	0 to 0	0 to 0

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 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
Bulgaria	€ 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
Cyprus	€ 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
Estonia	€ 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
France	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Germany	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Greece	€ 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
Ireland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Italy	€ 0.0	€ 0.1	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Latvia	€ 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
Luxembourg	€ 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
Netherlands	€ 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
Portugal	€ 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
Slovakia	€ 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
Spain	€ 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
United Kingdom	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of coke, refined petroleum products and nuclear fuel	€0.0	€ 0.1	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Manufacture of rubber and plastic products	€0.0	€0.0	€0.0	€0.0	€0.0	€0.0

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