

P-258 Evaluation of the Risk Trade-off Concerning Brominated Flame Retardants in EU – Phase Out of Deca-BDE and Increase of TV Fires –

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Abstract

Overview: We focused on Decabromodiphenyl ether (DecaBDE), which is known as cost-effective brominated flame retardant used in TV enclosure components, for the evaluation of risk trade-off caused by the avoidance of its use. **Background:** Risk trade-off framework, which enables to evaluate and compare the different type of risks, such as human health risk and fire risk is constructed. To date, several governments, especially in EU, made clear that their approach against environmental issue is based on the precautionary principle. Thus, there observed a tendency to place more value on human health risk than physical risk (i.e. fire risk in this case). **Strategy:** In the current study, we tried to quantify and compare these risks. **Result (1):** At first, we conducted a Cost Benefit Analysis (CBA) considering human health impacts of DecaBDE use and both economic and health damage by TV fires. The results suggested that net benefits of DecaBDE use were positive under all the five scenarios considered. **Result (2):** Secondly, we tried to re-evaluate the net benefits of DecaBDE use by replacing the rate of TV fires with more stringent one. Although it diminished fire rate by 75%, under the most realistic two scenarios, results showed positive net benefits of DecaBDE use.

1. Introduction

Application of DecaBDE:

In Late 90's, *Albemarle Corp.* declared that 85% of DecaBDE is used in HIPS for casings of EE appliances [1].

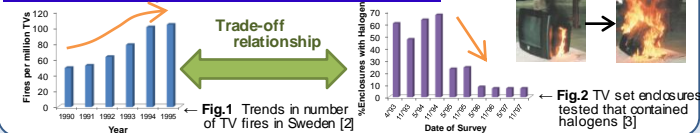
It is commonly said that:



Human health effects of DecaBDE:

European Chemicals Bureau (ECB) concluded that there were at present no need for further information and/or testing, and no need for risk reduction measures beyond those which had been taken already to protect both human health and the environment.

Trade-off relationship between DecaBDE use and TV fires:



2. Goal of this quantitative Cost Benefit Analysis

We tried to answer the following questions;

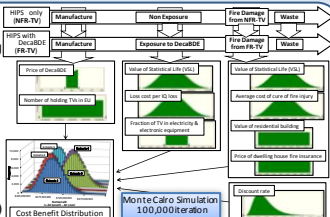
Do the benefits, which obtained as reducing number of TV fires, outweigh the human health risks caused by exposure to DecaBDE, and how much the margin of benefits are there?

3. Method

(is based on the CBA by Simonsen[4])

We improved Simonsen's CBA concerning about following points;

- 1) Assuming the costs and benefits as non-steady state
- 2) Excluding the cost for deposition of TV
- 3) Taking adverse effects to human health of DecaBDE used in TV enclosure components into account
- 4) Taking uncertainties of several parameters into account, using Monte Carlo Simulation



→Fig. 3 Schematic of DecaBDE CBA (Only the parameters with distribution are shown)

1) Wide spread pattern of FR-TV → Non-steady state

Steady state

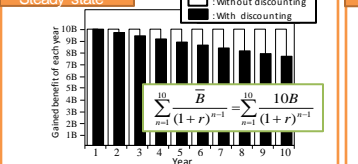


Fig. 4 Conceptual diagram for gained annual benefits (steady state, present value)

Non-Steady state

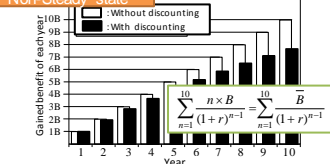


Fig. 5 Conceptual diagram for gained annual benefits (non-steady state, present value)

(B : gained annual benefits at present (practically in later 90's) when 10% FR-TV of all possessed TV have been replaced in EU (US\$/year); B' : gained annual benefits (US\$/year); r : discount rate; n : year)

$$\bar{B} = 10B \quad (1)$$

$$\bar{B} = \frac{r}{(1+r)} \sum_{n=1}^{10} \frac{n \times B}{(1+r)^{n-1}} \quad (2)$$

Simonson's CBA

$$\bar{B} = \sum_{n=1}^{10} \frac{B}{(1+r)^{n-1}} \quad (3)$$

Finally, We chose formula (2) (non-steady state), because 1) for the estimation of worst case scenario 2) for realistic consideration, such as gradual phase-out of DecaBDE in HIPS in EU

2) Estimation of human health risks caused by DecaBDE use



Table 1 Extrapolating the human health risks estimated in Washington state model into EU

Life-time health impact	Case number	Unit value	Time conversion index	Converted value (2005 price)
Annual Cancer	5	US\$ ₂₀₀₅ 26,976	1.034	US\$199,466
Annual Cancer Mortality	4	US\$ ₂₀₀₅ 4,800,000	1.495	US\$28,704,000
Annual Hypothyroid Case	2,400	US\$ ₂₀₀₅ 7,940	1.034	US\$19,703,904
Annual Subclinical Hypothyroid Pregnancies	30	US\$ ₂₀₀₅ 7,940	1.034	US\$246,299
Annual IQ impacts	210	US\$ ₂₀₀₅ 14,500	1.134	US\$3,453,030
Delay to replace electronics [3]			0.87	
Delay to dispose timing [3]			0.81	

Parameters in Washington state model: $Deca_{E,EU} / Deca_{E,WA} \times TV_{EU} / TV_{WA}$ (4)

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Annual costs in EU by loss of human health (median value) | US\$₂₀₀₅25,726,392

4. Results and Discussion

1) Monte Carlo Simulation (100,000 iterations)

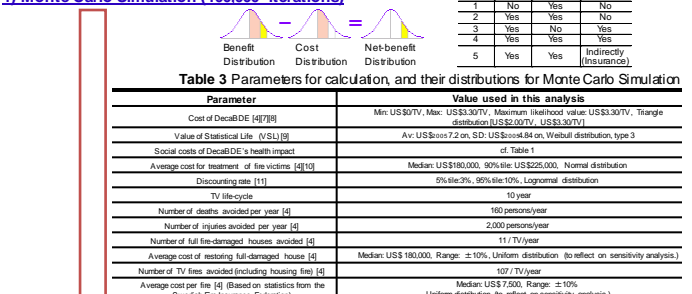


Fig. 6 Distribution of annual net benefits (before VSL was re-evaluated) Fig. 7 Sensitivity Analysis between net benefits and parameters (Fig. 6, scenario 4)

Fig. 6 suggested that:
 ① The benefits gained by adding inflammability outweighed its costs (= risk) even when human health impacts were included.
 ② It was strongly suggested that human health risks were too small to be ignored (comparing the Scenario 3 and 4).
 ③ One parameter, which was average cost per house, affected the result considerably (comparing the Scenario 3, 4 and other scenarios).

2) Re-evaluate VSL (Value of Statistical Life) as realistic value

Table 4 List of official VSLs in several EU countries
 Av.: US\$₂₀₀₅1.77 million
 SD: US\$₂₀₀₅0.38 million

Country	Official VSL of every country (VSL, US\$ ₂₀₀₅)
United Kingdom	£1997 1.00–1.60 million 1.60–2.56 million
France	€1998 1.05 million 1.94 million
Sweden	SEK1997 14.3 million 1.58 million
Finland	FM1999 11.28 million 1.26 million
Germany	¥2002 177 million 1.20 million
Netherlands	¥2002 296 million 2.02 million

By adopting lognormal distribution Official value of VSL in EU

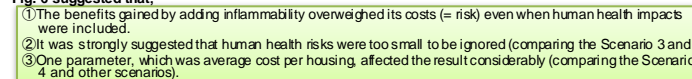


Fig. 8 Distribution of annual net benefits (after VSL was re-evaluated) Fig. 9 Sensitivity Analysis between net benefits and parameters (Fig. 8, scenario 4)

Fig. 9 represents that the sensitivity of VSL clearly decreased while sensitivity of other parameters increased.
 ② The results shown in Fig. 8 suggested that all the scenarios assumed distribution was reconstructed with relatively narrow ranges, and the median shifted to lower net benefit.
 ③ Human health impacts affected net benefits only by 0.36% increase.

3) Re-evaluation of TV fire using more stringent data

Table 5 Data of fire damage rate (Unit: person/year/million TV)

	Deaths avoided	Injuries avoided
Simonson	0.696	8.70
Clarke [12]	0.415	5.18
Muir [13] 0.200 (0.087-0.387) 2.50 (1.05-4.77)		

Scenario 1, 2, 5 (unrealistic scenario): There is a possibility that the net benefits were negative (respectively 15%, 10%, 2%).
 Scenario 3, 4 (realistic scenario): It was impossible for the net benefits of Scenario 3 and 4 to be negative.

It is summarized as follows:
 Although we decreased TV fire rate by 75% (Muir's estimation), the results even showed positive net benefits of DecaBDE use at the very least under the most realistic scenarios.

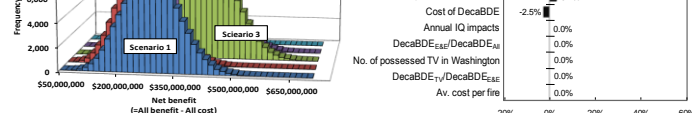


Fig. 10 Distribution of annual net benefits by using Muir's estimation of TV fire's data

References: [1] Laisewitz A, Kruse H, Schramm E, Substituting Environmentally Relevant Flame Retardants: Assessment Fundamentals. Resultant Summary Overview. 2001. [2] Shihung Warentes 4 (1993) p. 23. [3] Laisewitz A, Kruse H, Schramm E, Substituting Environmentally Relevant Flame Retardants: Assessment Fundamentals. Resultant Summary Overview. 2001. [4] Simonson M, Fire and Materials 2000; 26: 53. [5] Simonson M, Anderson P, van den Berg M, SP report 2002/08. [6] Washington State Department of Ecology and Health, Washington State PBDE Chemical Action Plan Final Plan, 2006. [7] Lassen et al., DecaBDE and Alternatives in Electrical and Electronic Equipment. Danish EPA, 2006. [8] Stevens G.C., Mann A.H., DTR Report: URN08/1028. 1998. [9] Pure Strategies, Inc. Decabromodiphenyl ether: An Investigation of Nonhalogenated Substitutes in Electronics Enclosure and Textile Applications. 2006. [10] U.S. EPA, The Benefits and Costs of the Clean Air Act 1990 to 2010, EPA Report Congress. 1998. [11] RPA Risk Reduction Strategy and Analysis of Alternatives for DecaBDE. Final Report. 2002. [12] MIC Japan, Committee for Policy Assessment of Regulatory, Final Report. 2007. [13] MIA, T. Organizational comparison 2007. 08. 2011. [14] Clarke F., The life safety benefits of brominated flame retardants in the United States. Final Report to the Chemical Manufacturers Association/Brominated Flame Retardant Industry Panel. Benjamin/Chen Associates. 1997.