AN ATTEMPT TO REPLICATE THE RISK MANAGEMENT ANALYSIS OF COSTS, BENEFITS, AND RISKS IN THE DECA-BDE AND TV CASE STUDY

Tom Muir (Environment Canada - Retired) 70 Townsend Avenue, Burlington, Ontario, Canada. L7T 1Y7

Abstract At the Dioxin 2006 meeting, an attempt to monetize the risks, costs and benefits of DecaBDE in TVs was made. No alternatives were examined, and it was asserted there are no environmental or health risk. An attempt to replicate found overstated benefits and understated costs. The case study used a small sample of TV fires, and other studies, to proportionally extrapolate fire, fatality and injury numbers to the EU. The Poisson 95% CI, for the 8 TV electrical fires observed, of 3.5 to 15.8, was used here. The benefits of reduced fatalities and injuries from TV fires, taking account evidence presented here, ranges from $321 million a year for the mean case study, to $96 million for the Poisson mean primary data. These benefits are mostly less than TV end of life costs ($110 to $393 million/yr). The evidence does not support the zero cost asserted for health effects of DecaBDE related exposures. In some jurisdictions, it appears there is no margin of safety remaining for further exposure to POPs, such as DecaBDE, for a significant population. In examples provided here, the possible adverse effects and monetary cost far outweigh the estimated benefits – billions compared to millions.

Introduction The brominated flame retardants (BFRs) are under regulatory and scientific investigation because of rising environmental presence, including in human blood and milk, and toxicological concerns such as endocrine disruption and neurotoxicity. The European Union has banned the Penta- and Octa-brominated diphenyl ethers (BDE), and the sole U.S. manufacturer has voluntarily ceased production. The DecaBDE mixture is undergoing a risk assessment in the EU, however, Sweden recently announced a ban. At the Dioxin 2006 meeting in Oslo, Norway, a study presented itself as a first attempt to establish the risks, costs and benefits of flame retardants (DecaBDE) in TVs, and put them in monetary terms.[1] Partly funded by industry, the results of this study are used to defend the use of BFRs and Deca-BDE. No alternatives to DecaBDE were examined. It was asserted that there is no environmental or health risk associated with exposure. These, and other omissions are sources of bias in the analysis and need to be addressed. The aim of this paper is provide a critical perspective on the DecaBDE case study cost-benefit model based on an analysis of these omissions, and in an attempt to replicate the study analysis and results.

Materials and Methods The cost-benefit model for fire safety – DecaBDE case study [1] is based on estimates of electrical audio-video or TV fires that are derived from a small sample of primary data collected in a study (hereafter the Vallingby study) of electrical fire incidents in suburbs around Stockholm, Sweden for the year 1994.[2] From this study, estimates of TV fires, fatality and injury rates for all of Sweden and the EU are assumed, based on comparisons with other studies, and fire statistics from a variety of government and institutional sources in various countries [3,4,5] (reference 4, by the U.K. Dept. of Trade and Industry, 1996, will hereafter be referred to as the Sambrook study). The detailed sampling and statistical methods of the Vallingby study are not generally accessible because the report is available only in Swedish. However, with effort, some primary data and sample properties can be abstracted. The Vallingby study reported a one-year total of 180 fire incidents, of which 30 were classified as audio-video or TV, and 8 of these were determined to be actual electrical TV fires. This small sample of 8 fires translates into a wide confidence interval (CI) for the Poisson rate, which is the number of TV fires observed (r) divided by the number of TVs in the sample population (n). Using this CI, the expected range for the number of fires/yr in an external population of N TVs, the Poisson mean, can be calculated as r/n*N. This 95% CI is calculated, and compared with Simonson et al (2000), and Simonson et al, (2006). Data from the Sambrook study and other sources is analyzed for comparison. Alternative estimates of TV fires, fatalities, injuries, and costs and benefits are developed.

The DecaBDE case study does not consider any alternative means for reducing fires, deaths and injuries. All the possible benefits are attributed to DecaBDE. This is contrary to economic first principles in that such benefits cannot be meaningfully discussed without consideration of the alternative means of achieving them. Such analysis needs to look beyond various BFRs as the only means, and that is done here.

The case study also asserts there are no adverse environmental or health effects due to exposure, and zero associated costs of using this BFR. It is asserted that there are large margins of safety, based on non-carcinogenic compounds with a toxicological threshold. These assertions are critically reviewed in terms of metabolism, degradation, toxicology, interactions with other related compounds, existing body burdens, and disease and endocrine status. Disposal activities, and accidental fires are also considered. Possible economic costs associated with current body burdens in some populations, and cumulative effects, are estimated based on the literature.

Results and Discussion

Estimates of TV Fires, Fatalities, and Injuries The Vallingby study primary data collection for 1994 consisted of 180 incidents that were investigated, of which 32 were judged to be electrical fires, and 8 (25%) were audio-visual or TV category fires. These observations were made on a population of 126,500 households, with about 265,000 people, representing about 231,495 TVs out of an estimated total number of 7.5 million TVs for all of Sweden. The Poisson 95% CI for the 8 TV electrical fires observed is 3.5 to 15.8. The expected number of fires per year for an external TV population of size N equals the CI limits divided by the number of TVs in the sample, 231,495, times the N, normalized here at 1 million. For the lower limit this is 3.5/231,495*1 million = 15/million. For the upper limit this equals 68/million, and for the observed number, 35/million. For Sweden this yields 113 to 510 (mean 263) TV fires per year.

This compares to the Simonson et al (2000) estimate of about 600-900/yr (750 mid), derived by multiplying a separately estimated range (2,400 to 3,500) of the total number of electrical fires in Sweden as a whole, by the extrapolated percentage of the Vallingby total electrical fires (32) that were audio-visual-TVs (8), which is 25%. This yielded about 100 TV fires/million TVs for Sweden and was extrapolated to the entire EU population of about 460,000,000 people and an estimated 230,000,000 TVs. This result was compared to the Sambrook estimate for the EU as a whole, of 2208 total, or 12.2 TV fires per million TVs/yr (range 8.2 to 17.5; Sweden 12.3), about 16 deaths and 197 injuries, of which most were reported as minor. Simonson et al (2000) then assumed an approximate 10 fold factor of their result over that of Sambrook, and asserted the 160 deaths and 2000 injuries used in the Simonson et al (2006) cost-benefit analysis. Other TV fire rates per million TVs noted range from 11 to 22 for the U.K. and the Netherlands, to from 50 to 78 for Sweden (Simonson et al, 2000). To be logically consistent as a correctly classified estimate of TV electrical fires comparable to the Sambrook definition, the number 8 has to be used as the observed sample number to calculate the above Poisson rates and means, and extrapolate to an external population of N TVs. These rates/means are not significantly different from several of the rates in the Sambrook study, or others cited above, however, they are significantly lower than the estimates in Simonson et al, (2000). EU deaths and injuries could be as low as Sambrook. The mean Vallingby rate translates to about 3 times Sambrook, or 48 deaths and 591 injuries, about 30% of Simonson et al (2006) estimates, and is in brackets in the economic valuation below.

Valuing Benefits of Lives Saved and Injuries Prevented The DecaBDE case study assumed that each life saved was valued at $5 million, and each injury was a severe burn case costing $200,000. Thus, the annual benefit of saving 160(48) lives and preventing 2000(591) injuries added up to $800($240) million and $400($120) million, respectively, or $1,200($360) million total. A value of life range typically used in valuation is $2.0 million to $5 million. Given that fire fatalities fall disproportionately on the older groups, the value of life measure could be put at $3.5 million, 30% lower. This makes the life saving benefit $560($168) million. The cost of injuries assumes severe burns for all cases, which is not supported by the evidence. The Sambrook study reported <5% burns and the rest minor smoke inhalation. This implies an expected value, of the cost of an injury, of $10,000 for burns (200,000*0.05), plus $1,900 for smoke inhalation ($2,000*0.95) (assuming smoke inhalation treatment costs $2,000 a case), equals $11,900. This amount is 94% lower, giving injury benefits estimates of $24(7.2) million.

Alternative Means of Saving Lives and Preventing Injuries The use of working smoke alarms has become the law in Ontario, Canada.[6] According to the Ontario Fire Marshal's Office (OFMO) most fatal fires occur at night when people are asleep, and often, victims never wake up. Fire statistics in Canada and the U.S. show that homes with smoke alarms typically have a death rate that is 40 to 50% less than the rate for homes without alarms.[6,7] The use of smoke alarms saves lives and injuries from all causes of fires, not just TVs. No matter what the estimate of deaths and injuries from TV fires, 40 to 50% can be prevented by mandatory working smoke alarms. Choosing 45% means the annual benefits are now $308($92.4) million and $13.2($4.0) million for lives and injuries respectively, for a total of $321($96) million. Recall that based on the CI these benefits could be as low as $41 million in total. It is only an assumption that FRs will prevent all the TV fires. In the U.S. and Canada, candle fires are increasing, and with smoking, still kill and injure many people despite the use of BFRs in TVs, upholstered furniture foams, and textiles. There are other FR materials reportedly being developed, including one in Sweden that uses citrus, such as oranges and lemons, to prevent fires in plastics and fabrics. Other non-halogenated, phosphorus based FRs are being developed, although it is not clear that they are without problems of persistence and/or toxicity. Also, regarding BFRs use in upholstery and fabrics, note that smoking materials cause about 30% of fatalities in Canada and the U.S., mostly furniture fires caused by cigarettes that typically smolder for half an hour after being put down. Cigarettes that extinguish in minutes are now mandatory in New York State, providing another alternative to BFRs that is effective in reducing fires and saving lives. There are other technologies, such as fireproof physical barriers, alternative polymers with built-in flame retardancy, and other practices and approaches that need to be investigated.

Perspectives on the Assertion That DecaBDE Poses no Risk of Adverse Effects This assertion disregards existing exposures and body burdens of many chemicals with similar toxic actions. It also ignores several lines of evidence suggesting risk. DecaBDE is widely disbursed in the environment, especially air, sediment, and dust (and food), is bioavailable, and absorbed. There are observed body burdens in humans – in serum and milk, but is metabolized to lower brominated congeners, including hydroxylated metabolites, like other PBDEs. It also degrades in the environment photolytically and microbially. It can be absorbed and metabolized by fish and rodents, breaking down to debrominated, hydroxylated, methoxylated, and reactive intermediates. DecaBDE itself, or metabolites, may be carcinogenic and developmentally neurotoxic.[8] In experimental TV fires, the FR TV released more smoke, soot, CO, VOCs, PAH, benzene, PCBs, TCDD-TEQ, TBDD/F, and less CO2 than the NFR TV.[3] In incinerators, and accidental fires, PBDD/F are formed. Clothing of firemen, who are at increased risk of disease, is contaminated up to 2 ug/kg.[9] Even if FRs imply fewer TV fires, the larger total of fires still release these excess levels of the deadly asphyxiating gases.

There is evidence that existing environmental levels, and body burdens in various countries, of all PBDEs (including Deca), HBCD, TBBPA, other BFRs, Dioxin-TEQs, PCBs, DDT, HCB, PCP, PFCs, perchlorate, triclosan, BPA, mercury, and other compounds, act individually, and can interact additively and synergistically on thyroid, neurodevelopmental, and other endocrine endpoints, with no mechanism spared.[10,11] For Europe, dioxin TEQs are already at levels of concern for humans,[12,13] and these compounds have toxic actions on a number of downstream endpoints shared with PBDEs, PCBs, and DDT, including thyroid disruption and neurotoxicity. In North America, 5% of the population has PBDE levels greater than 400 ng/g, very close to reproductive and neurotoxicity doses in rodents. In Ontario, Canada, adding just PBDEs, PCBs, and DDT in human milk together, adjusted for PCB relative potency, shows that 2.5 to 5% of the exposed population of children is already at levels associated with IQ losses in humans (1.0-1.25 ug/g lw), and neurotoxicity in monkeys (1.65 ug/g lw) and rodents.[10,11] There is an unexplained prevalence of developmental problems in children that seems widespread in the industrial countries.[14,15] In Ontario, there is a rising incidence of thyroid disease and thyroid cancer, especially in young females, and data on associations with contaminated sites.[10,11] Based on these clinical conditions, and evidence, there is no margin of safety for a significant population for added exposure to any more compounds and/or metabolites with thyroid- or neuro-toxicity as downstream endpoints. This includes DecaBDE, which is reactive, and degrades to lower brominated and more toxic PBDEs, and OH-PBDES, and there are large environmental inventories. Only zero added exposure equals zero added risk.

Economic costs associated with such IQ deficits in exposed children in North America are very large, with just earnings losses amounting to about $60 billion per year per single IQ point.[15] These annual losses alone for the 2.5% exposed to levels associated with a 6.2 point IQ loss are 0.025*$60 billion*6.2 = $9.3 billion a year. Even 1 IQ point loss is worth $1.5 billion annually. Other costs and economic losses add many more billions annually.

Summary of Costs and Benefits The potential benefits of reduced fatalities and injuries from TV fires, taking into account the several factors brought into evidence here, ranges from a high of $321 million a year for the Simonson et al (2000; 2006) middle fire assumptions, to $96 million for the Poisson mean estimate from observed Vallingby study primary data. Based on the 95% CI, this latter benefit amount could be as low as $41 million a year. These benefits are mostly less than the end of life costs ($110 to $393 million/yr) in the case study. Notably, the 10-year TV life cycle acts to discount up to 75% of the fires that happen in TVs older than 10 years.[4,5] This life cycle implies an industry EU sales benefit of about $90 million/yr. The evidence does not support the zero cost assumed for potential adverse health effects of adding DecaBDE to the environment, and to human body burdens. In some jurisdictions, it appears that there is no margin of safety remaining for further exposure to POPs, such as DecaBDE, for a significant population. In the examples provided here, the adverse effects and their monetary cost far outweigh the estimated benefits – billions compared to millions.

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