Socio-economic analysis of usage restriction of brominated flame retardant HBCD

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Introduction

Hexabromocyclododecane (HBCD) is important synthetic additives which are used to reduce the flammability of articles. Despite their benefits, however, HBCD has been currently recognized as brominated flame retardant with properties such as persistent, bio-accumulative and toxic properties, as well as potential for long range transport. For these reasons, HBCD has been argued under the candidate list of substances of very high concern (SVHC) for authorization within REACH, under Stockholm Convention of persistent organic pollutants, RoHS Annex 4, and other regulatory agencies in the world. Because HBCD properties are on the cross road of border of these processes' criteria, correspondence regarding its restrictions and various use-control measures are yet to be concluded. This suggests why countries and international institutions are seeking more information on risks and management options. In this study, we sought to address this gap by assessing the socio-economic impacts of HBCD control measures with respect to costs, technical feasibility, and potential for risk reduction. Candidate substances of SVHC and POPs are supposed to be evaluated from the view point of socio-economic impact (ECHA 2008, POPRC 2009, UNECE 2009).

Materials and Methods

In Japan, HBCD accounts for 80% in manufacturing polystyrene foam in construction materials (80%), and 20% in textile-coating. In the current study, we tried to assess the socio-economic impact of HBCD use in polystyrene foam especially extruded polystyrene (XPS) foam in Japan. In essence, our study did not compare the management options from the view points of human health and environmental risk, but rather from that of social cost and global warming (equal to CO_2 emission). We considered two management phases: (i) alternative of substance and (ii) alternative of technique.

(i) Alternative of substance:

So far, many researches have been reported that there are no alternatives to HBCD (KEMI 2007a, KEMI 2007b, IOM 2008). However, second-generation flame retardants have been developing at the forefront of technological development (Edward & Sergei 2009). Comparing candidate alternative substances to HBCD with price list of Japanese flame retardants (CMC 1997), we could select choose one potential substitute: Tetrabromocyclooctane (CAS No: 3194-57-8, price: JPY 1,500/kg) as ex-alternative or post-alternative substance to HBCD (price: JPY 850/kg). Note that the suitability of Tetrabromocyclooctane as alternative to HBCD further put a dilemma of its usage as a result of its economic value and persistence.

(ii) Alternative of technique:

We assumed XPS (coefficient of thermal conductivity: λ=0.028 W/mK) as alternative to other insulation foams such as high-efficiency glass wool (GW, λ=0.038 W/mK) and hard polyurethane foam (PUR, λ=0.027 W/mK). We set up function unit as: 1) 30 years life-time and 2) same amount in terms of cost of cooling and heating during service phase. The life-cycle (LC) of each insulation foam was taken as the system boundary (Figure 1). Considering the lack of data on cost and CO_2 emission in demolition, transport and disposition phases and with the assumption that these parameters were almost same, we eliminated these phases from the calculation. Schematic processes of our calculation were illustrated in Figure 2.

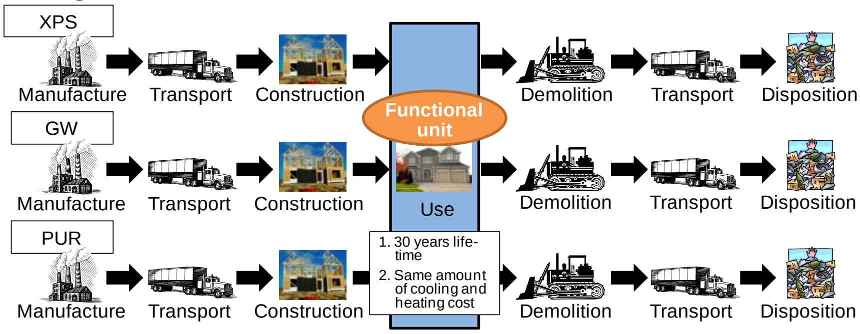

Figure 1 Function unit and system boundary of LC compared in the current study

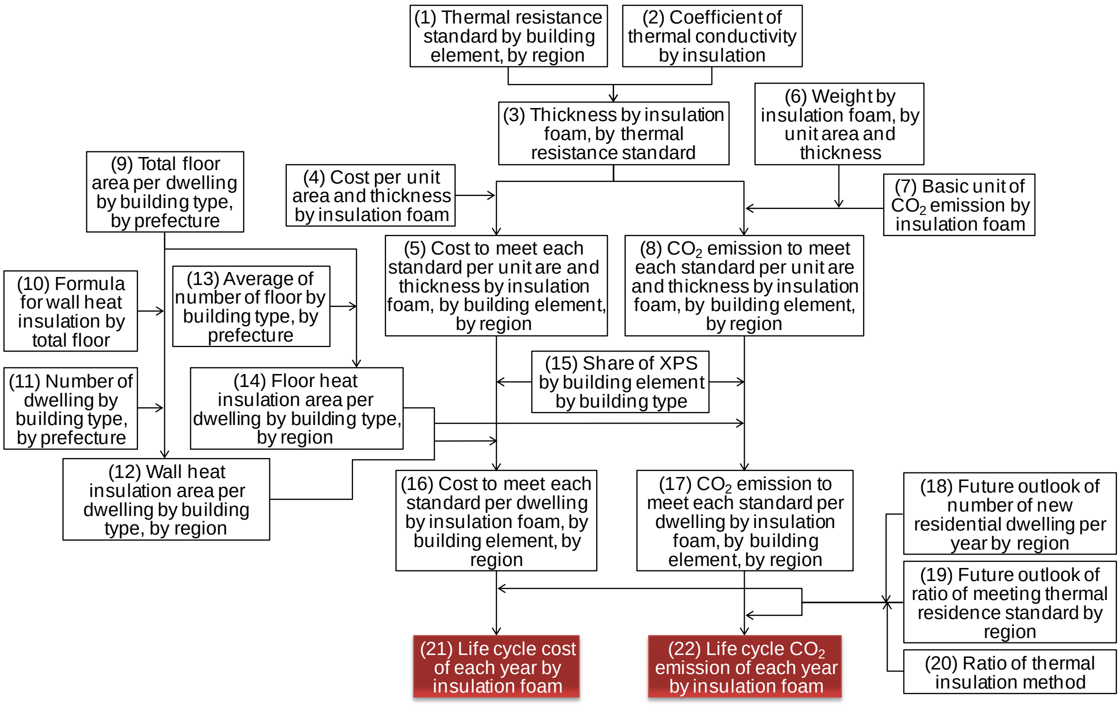

Figure 2 Schematic representation of the processes of calculating the LC-Cost and LC-CO_2

Detailed explanations of our calculation are listed as follows;

■ We decided the value of parameter (4) from reference (Building Environment Lab 2004). Cost of XPS, GW, PUR were 25.36, 17.37 and 42.97 JPY/m^2･mm respectively. Furthermore in the case of GW, we added 180 JPY/m^2 because damp-proof tape is required when using GW as insulation foam.

■ We assumed density (6) of XPS, GW and PUR were assumed to be 32, 16 and 30 kg/m^3 respectively.

■ We choose (7) as listed Table 1 (Architectural Institute of Japan 1999) based on 1) the basic units of insulation foams that are driven in one reference, and 2) the quoted frequency which is relatively high. CO_2 emission of damp-proof tape from inter-industry relation table (MIAC 2009) with value of 0.6554 kg-CO_2/m^2. We assumed a worst case scenario where all expanding agents could leak to the atmosphere as CO_2 emission (Table 2).

■ We estimated (18) by forecasting the future outlook of a number of new houses on sale (Development Bank of Japan 2008).

Table 1 Basic units of CO_2 emission

Insulation foam	System boundary type	Basic unit of CO_2 emission (kg-CO_2/kg)	
		Manufacture	Transport
GW	Only national	2.033	0.118
	International	2.380	0.131
XPS, PUR	Only national	2.533	0.136
	International	3.147	0.155

Table 2 Configuration of expanding agent type, its GWP and amount (NEDO 1998)

Insulation foam	Expanding agent	GWP	Amount (g-CO_2/kg)
XPS	Hydrocarbon	3.50	35.70
PUR	Water	2.44	12.20

Results and Discussion

(i) Alternative of substance:

Insulation foam made from XPS contains 1 to 3% (w/w) HBCD. We assumed the concentration of HBCD in XPS to be 3% (EU Risk assessment 2007). By using this information, the product of the price of flame retardants, as well as the recent HBCD usage amount for building insulation (2,000 t/year), we estimated an increase in cost of material by 1.3 billion JPY only in Japan.

(ii) Alternative of technique:

The results of the analysis are shown in Figures 4-7; these Figures were obtained by using the following formulae: (LC-$Cost_{GWorPUR}$ - LC-$Cost_{XPS}$) or (LC-CO_2 $_{GWorPUR}$ - LC-CO_2 $_{XPS}$). If a policy measure that considers GW as alternative to XPS is adopted from 2010 to 2030, GW offers and advantage of reduced CO_2 emission but with a high cost. However, XPS as an alternative to PUR is not feasible from both CO_2 emission and cost; as such, this policy measure is excluded in this discussion. The results were interpreted using marginal abatement costs and CO_2 in Japan (NIES 2009). It indicated that a reduction of 500-1,100 units/year amount of CO_2 could be achieved if the same amount in terms of costs were migrated into other policy measures.

The purpose of using building insulation is to cut down cooling and heating costs, which also means reduced CO_2 emission. Thus, policy measure that actually increases CO_2 emission is contradictory towards its policy objective. However, the same policy potentially reduces HBCD emission into the environment. This raises a concern whether it is justifiable to reduce HBCD emission by increasing CO_2 emission. Furthermore, to what extent could costs and increasing CO_2 emission be compromised while reducing HBCD emission?

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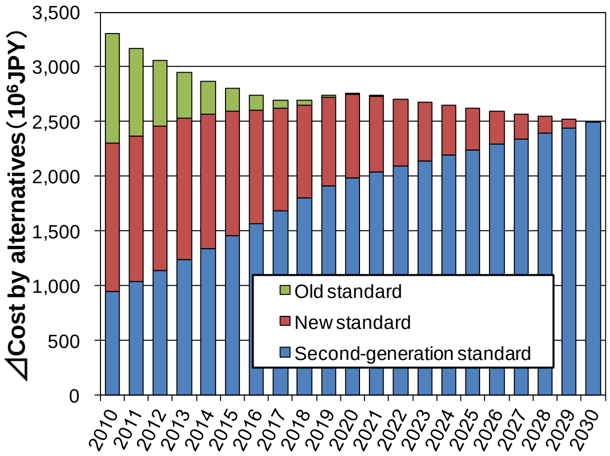

Figure 4 ⊿Cost arising from alternate XPS to GW

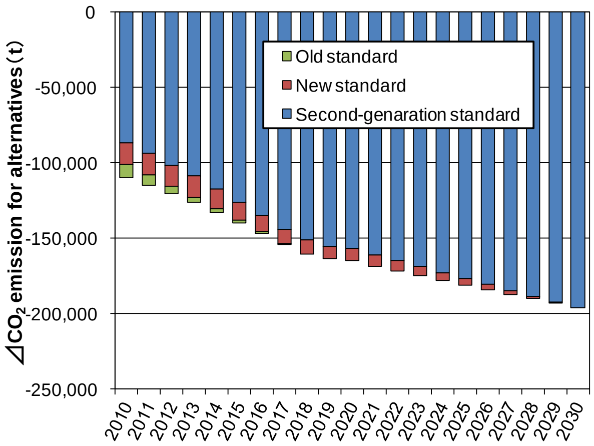

Figure 5 ⊿CO_2 emission arising from alternate XPS to GW

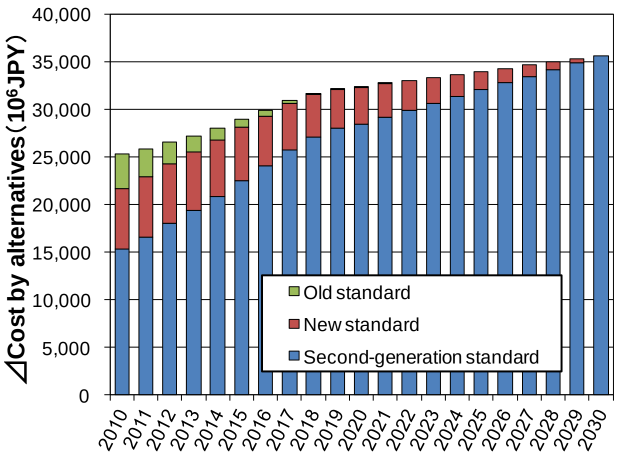

Figure 6 ⊿Cost arising from alternate XPS to PUR

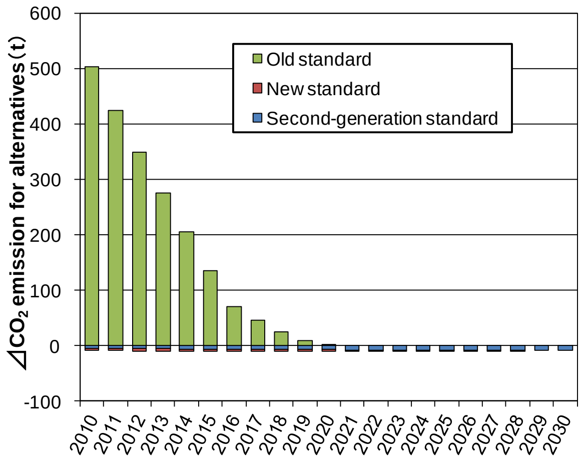

Figure 7 ⊿CO_2 emission arising from alternate XPS to PUR

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