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A Study of Carbon Footprint Calculation of Home Electronics Based on Life Cycle Assessment

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Abstract: Since, the world climate conference in Copenhagen 2009, low carbon has become the mainstream of the society. Low carbon gets trendy in the area of home electronics and the carbon emission calculation and evaluation draws attention from the home electronics enterprises that have already accumulated some knowledge on this issue. In this study, the carbon emission is assessed from the view of life cycle, consisting of both the direct emission and the indirect emission. Analysis of carbon footprint calculation results demonstrate that our method can help to make home electronics to be truly low carbon, conserve energy and reduce carbon emission, creating greater benefit for the enterprises and the society.

Key words: Low carbon manufacture, carbon footprint calculation, life cycle assessment

INTRODUCTION

Nowadays the low carbon and the environmental protection issues have attracted lots of public attention and the low carbon life has become fashionable (Goodall, 2007). Low carbon and sustainable development are promoted to an unprecedented height. The Government of China has made a solemn commitment on it: "By 2020, the value of carbon dioxide emission divide GDP will be 40-45% less than that of 2005 and the non-fossil energy consumed should account for about 15% of the primary energy by then". In the "Twelfth Five-Year development plan proposal", "energy-saving", "emission reduction" and "low carbon development" are written into national policy. This will promote the low-carbon fashion in home electronics, such as "energy saving", "electricity saving", "water saving" and "green and environmental protection". This fashion has become an important factor in the design process of the home electronics.

In order to evaluate whether the home electronics meet the criteria, we need to know how to calculate and evaluate the value of carbon emission of a product.

Carbon footprint calculation of home electronics: In order to calculate the carbon footprint (http://www.coolthewor ld.com/appliance_table.php), we need to go through the steps of PAS 2050 (http://shop.bsigroup.com/en/Browse-By-Subject/Environmental-Management-and-Sustainability/PAS-2050/), the flow chart of which is as Fig. 1 (Matthews *et al*., 2008).

Computation: Following the above flow chart, we begin to calculate the carbon footprint of home electrical products. In this study, we only consider the greenhouse gas emission (Kenny and Gray, 2009) among the raw material production stage, the manufacturing stage, the product transportation stage (Matthews *et al*., 2001), the consuming stage and the recycling stage. The equation is as Eq. 1:

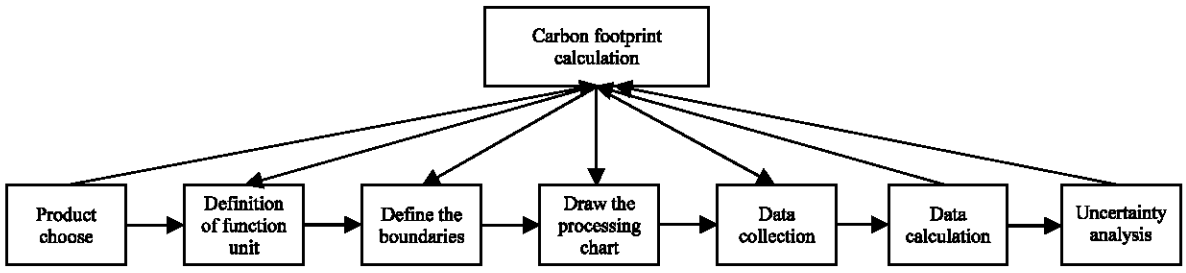

Fig. 1: Flow chart of the carbon footprint calculation

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$$G = G_s+G_m+G_t+G_u+G_r \quad (1)$$

G = Whole life cycle carbon emission of a product ($kgCO_2$)
G_s = Carbon emission of the raw material production stage ($kgCO_2e$)
G_m = Carbon emission of the manufacturing stage ($kgCO_2e$)
G_t = Carbon emission of the product transportation stage ($kgCO_2e$)
G_u = Carbon emission of the consuming stage ($kgCO_2e$)
G_r = Carbon emission of the recycling stage ($kgCO_2e$)

- **Raw material production stage:** This stage considers the direct emission of greenhouse gas generated in the raw material production process and the indirect emission (IPCC, 2007) of the energy consumed during the process. We do not consider the recycling issue during this stage. The equation is as Eq. 2:

$$G_s = \left(\sum_{i=1}^{n} E_i \times EF_i + \sum_{j=1}^{m} m_j \times CF_j\right) \quad (2)$$

G_s = Carbon emission of the raw material production stage ($kgCO_2e$)
n = Raw materials and auxiliary materials of the product ($kgCO_2e$)
m_i = Mass of the ith material (including the wasted material) (kg)
Ef_i = Carbon emission factor of the ith material
m_j = Mass of the jth GHG gas produced in the manufacturing process
Cf_j = Carbon emission factor of the jth GHG gas

- **Manufacturing stage:** This stage considers the carbon emission during the product producing and assembling process. We consider both the direct and indirect carbon emissions. Again, we do not consider the recycling issue during this stage. The equation is as Eq. 3:

$$G_m = \left(\sum_{i=1}^{n} E_i \times EF_i + \sum_{j=1}^{m} m_j \times CF_j\right) \quad (3)$$

G_m = Carbon emission in the manufacturing stage ($kgCO_2e$)
E_i = ith energy consumption of the manufacturing process
Ef_i = Carbon emission factor of the ith energy
m_j = jth GHG gas mass in the manufacturing process (kg)
CF_j = Carbon emission factor of the jth GHG gas

- **Product transportation stage:** This stage considers the carbon emission generated during the production process from the factories to the retailers and the intra-factory transportation and the retailer-customer transportation are not considered here. The equation is as Eq. 4:

$$G_t = \frac{M \times \sum_{i=1}^{n} \sum_{j=1}^{i} D_{ij} \times N_{ij} \times EF_i}{N} \quad (4)$$

G_t = Carbon emission of the transportation stage (kgCO2e)
M = Gross weight of a product (ton (t))
D_{ij} = Transportation distance to place j using transportation mode i, km (km)
N_{ij} = No. of products transported to place j using transportation mode i
EF_i = Carbon emission factor of transportation modes i, (kg CO_2e/t.km)
N = Total number of products

- **Consuming stage:** Most carbon emission comes from the energy consumption in this stage. Assume that the energy is electric power. The emission factor is specified according to circumstances of regional electric net. Considering the standby and using time, the equation is as Eq. 5:

$$G_u = Y \times (W_1 \times H_1 + W_2 \times H_2) \times 365 \times EF \quad (5)$$

G_u = Carbon emission in the consuming stage
Y = TV service life time
W_1 = TV using power consumption rate
W_2 = TV stand by power consumption rate
H_1 = TV using time per day
H_2 = TV standby time per day
EF = Electric emission factor

- **Recycling stage:** This stage includes the dismantling, the material recycling, the reuse and the remanufacturing processes. These processes consume energy and generate greenhouse gas. The equation is as Eq. 6:

$$G_r = \sum_{i=1}^{n} E_i \times EF_i + \sum_{j=1}^{m} C_j \times CF_j \quad (6)$$

G_r = Carbon emission of the recycling stage
E_i = ith energy consumption in the recycling process
EF_i = Carbon emission factor of the ith energy
C_j = Emission of the jth greenhouse gas in the recycling process
CF_j = Carbon emission factor of the jth GHG gas

CASE STUDY

We study the manufacturing, transportation and recycling carbon emission of the 24 inch flat panel TV. In general, the television production process consists of assembling, aging and packaging, each of which consists of several work cells. Using the data collected from the production line, we get the energy consumption rate of the manufacturing stage which is 0.150 kWh, including the electric power and the compressed air which is converted to electric power during the manufacturing stage. The 0.150 kWh is equivalent to 0.146 kg CO_2 e. In the same way, the emission in the transportation and the recycling stages is 0.152 and 294.336 $KgCO_2e$, respectively.

CONCLUSION

This study reviews the current policies and details the product carbon footprint calculation process of home electronic enterprises. Above all, carbon footprint calculation involves too many factors such as the national policy, the manufacturing power, the market competitiveness, the calculation method and the data accuracy. Electronic enterprise should establish the system of carbon footprint calculation, improve the carbon interrogation ability and implement the enterprises' social responsibility of energy-saving and emission reduction, making contributions to the customers and the society.

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