Global Initiative on UPCYCLE Carbon Footprint Certification and Label Systems for Creative Waste Management and Greenhouse Gas Reduction

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Abstract

Upcycling aims at turning scraps and wastes into new materials or products with equivalent quality or better than original through creative design. The upcycling processes are based on the direct use or the technology and production processing with consideration of potential environmental impacts and greenhouse gas. This is in line with the national policy on waste management by applying the principle of 3Rs (Reduce, Reuse and Recycle), as well as the reduction of greenhouse gas emissions associated with waste management. In addition, upcycling is seen as one way to add values on wastes and promote the development of creative economy. Under this context, the UPCYCLE Carbon Footprint certification and verification system was initiated and developed in June 2015 under the leadership of the Department of Environmental Quality Promotion, Ministry of Natural Resources and Environment. There are five criteria in the UPCYCLE Carbon Footprint certification scheme: (1) scraps and wastes, (2) upcycling process, (3) product quality, (4) creative design and (5) carbon footprint. For the requirement of carbon footprint, the avoided GHG emissions of upcycled materials or products shall be higher than theirs' life cycle GHG emissions. A case study of upcycled glass tiles was used to demonstrate how to calculate the associated carbon footprint. It aims to be used as a communication and marketing tool to ensure that the certified upcycled materials or products are made from wastes/scraps, fit for use, have a good quality, and friendly to the environment.

Keywords:

Carbon footprint, Creative design, Greenhouse gas reduction, Upcycle

1 INTRODUCTION

Continual increase in waste volumes within the manufacturing sector has led to the exploration of turning wastes into products. Upcycling activities in Thailand emerged as a business enterprise in 2006 with the success of Osisu Company. The upcycling has then been expanding into the industry especially small & medium enterprises (SMEs). In 2008, the concepts of 3Rs (Reduce, Reuse, and Recycle) was implemented with 37 SMEs for creative economy under the "Waste-to-Wealth" project initiated by the Industrial Technology Assistance Program (iTAP), National Science and Technology Development Agency, Thailand's Ministry of Science and Technology. Several kinds of wastes (such as wood off-cuts, leather remnants, wasted papers, packaging wastes, and dead-stock fabrics) were used to make more than 500 furniture and home décor products. In 2014, the concepts of upcycling (i.e., creative transformation of wastes for a new purpose with better-than-original environmental and economic values through design and doesn't require intensive processing) was introduced and the "Upcycling" project was launched as a continuation of Waste-to-Wealth project to stimulate creative waste management solutions and innovative design among SMEs [1]. Despite being creative with resource efficiency, these manufacturers were questioned about their upcycled products regarding their environmentally-friendliness and qualities.

In parallel, the Department of Environmental Quality Promotion (DEQP), Ministry of Natural Resources and Environment has developed a project titled the "Promotion of environmentally-friendly products" by developing its own "G(reen)-production" certification with the "G" label to encourage the application of cleaner production, resource efficiency and pollution prevention among small enterprises and to promote the G-label as a marketing tool. Hundreds of upcycled products were produced from these small enterprises in various parts of Thailand.

With the growth and popularity of upcycled products and materials in Thailand, in 2014, the "G-Upcycle" certification scheme was initiated by DEQP and used to certify upcycled products and materials in the country. The five criteria of G-Upcycle are: (1) source and amount

of scrap, (2) product quality according to relevant industrial standards, (3) production processing using cleaner technology, (4) creative design and (5) innovative solutions for waste management.

Based on the literature review, none of any certification is concerned about upcycled products. The most relevant certification scheme is the Cradle to Cradle Certified™ Product Standard that looks at a product through five quality categories: material health, material reutilization, renewable energy and carbon management, water stewardship, and social fairness [2]. This scheme is focused on the recycled contents and the use of renewable energy and carbon offsetting, but not really about upcycling and carbon footprinting.

2 DEVELOPMENT OF UPCYCLE CARBON FOOTPRINT CERTIFICATION AND LABELING SYSTEMS

Having recognized the national policies on waste management as well as climate change mitigation policy, the "UPCYCLE-Carbon Footprint" certification and labeling system has been initiated in 2015 as a national certification scheme under the cooperation of DEQP and Thailand Greenhouse Gas Management Organisation (TGO). The draft standard has been prepared by a national technical committee, using the G-Upcycle manual [3] and the Carbon Footprint national guideline [4] as the key references as well as related international standards, related mainly to reuse and recycling but none on upcycling. The draft document has been reviewed by experts in the field of creative design, certification and labeling, as well as environmental technology. The Standard document was presented to the stakeholders for consultation and finalized by the appointed national steering committee.

3 REQUIREMENTS OF UPCYCLE CARBON FOOTPRINT CERTIFICATION

Products shall be described in one of the following product categories: (i) Materials (e.g., artificial stone, cement blocks, ceiling, wall, yarns, paper, tile, etc.), (ii) Furniture (e.g., desk, chair, shelve, etc.), (iii) Home decoration (e.g., lamp, carpet, pot, etc.), (iv) Fashion (e.g., bag, belt, necklace, shoes, hat, bag, etc.), and (v) Others.

There are 5 criteria for the UPCYCLE Carbon Footprint certification [5], which are:

3.1 Scraps and wastes

Scraps and wastes are referred to wasted materials, reclaimed materials, or dead stock materials or products that are environmental burdens for disposal by landfilling or incinerating.

Use of wastes and scraps shall be based on these following requirements:

3.1.1 Ratios of scraps and wastes

At least 20% of reclaimed material contents (by weight) shall be used for upcycled materials or products

3.1.2 Sources of scraps and wastes

Sources of scraps and wastes shall be identified (e.g., post-consumer wastes, post-industrial wastes, or wastes from temporary uses) and transported with consideration of potential environmental impacts and greenhouse gas emissions.

Post-consumer wastes are referred to post-consumer wastes or community wastes. They are dispersed and not easy to collect for manufacturing such as snack packages, plastic bags, milk pouches, coffee bags, plastic straws, Styrofoam containers, fruit juice packages, or construction debris.

Post-industrial wastes and scraps are referred to manufacturing off-cuts, leftover materials or products generated by manufacturers or service providers, material dead stocks as well as agricultural wastes. They are abundance and highly redundant, easy to collect for manufacturing, such as leather & fabric remnants, glass off-cuts, steel scraps or wood off-cuts.

Wastes from temporary uses are referred to wastes that remain after short-term uses from exhibitions and fairs, public-relation activities, such as carpets, papers or advertising boards.

3.1.3 Preparation of scraps and wastes

Levels of effort and resources used to prepare scraps and wastes for re-manufacturing shall be minimized to encourage the direct use or the processes that minimize amounts of water, energy or new resources by applying these following methods:

3.1.3.1 Preparation of scraps and wastes by using renewable energy, alternative sources of energy or human labor

3.1.3.2 Preparation of scraps and wastes that avoids toxic chemicals such as chlorine, solvents, etc.

3.1.3.3 Use of production process with energy-saving policies

3.2 Upcycling

Upcycling processes shall be based on the direct use or the technology and production process with consideration of potential environmental impacts and greenhouse gas, as follows:

3.2.1 Upcycling processes with environmental management of chemicals, energy, pollutions and wastes.

3.2.2 Upcycling processes with safety management for healthy workplaces.

3.2.3 Upcycling processes with labor management for social responsibility by hiring elderly people, imprisoned persons, disables or the local workforce.

3.2.4 Upcycling processes with skill development management by supporting personnel in various capacity-building such as attending seminars, training or taking

field trips on product design, waste management or related know-how.

3.3 Quality

Upcycled materials or products shall have equivalent or better quality than their original, and fit for use, through quality control systems to ensure that their quality meet specifications or comply with the required industrial standard (if any).

3.4 Creative design

Upcycled materials or products shall be developed with creative design to distinguish themselves from others in the market and enhance the use of reclaimed materials.

3.5 Carbon footprint

The avoided GHG emissions of upcycled materials or products shall be higher than theirs' life cycle GHG emissions.

The calculation of life cycle GHG emissions of upcycled materials or products must be based on the requirements as specified in the national guideline for product carbon footprinting as well as the method specified in the Product Category Rules (PCRs) of a specific product or group products (if available).

The calculation method for the avoided GHG emissions associated with the disposal of wastes is based on the assumption that if the scraps and wastes are not used for upcycled products then they will be disposed of by landfilling and emits GHGs. The calculation method of the avoided GHG emissions associated with the disposal of wastes shall be based on the IPCC Guideline for National Greenhouse Gas Inventories – Volume 5: Waste, on waste disposal in a shallow landfill (Table 1).

Table 1: GHG emissions from a shallow landfill

Waste type	GHG emissions (tCO_2e per ton of waste (dry weight))
Paper	2.93
Fabric	2.00
Food	2.53
Wood	3.33
Garden wastes (i.e. leaves, grass)	3.27
Paper diaper	4.00
Rubber and leather	3.13

The calculation of the avoided GHG emissions associated with the production of virgin materials is based on the assumption that if the scraps and wastes are used for upcycled products then the GHG emissions associated with the production of virgin materials will be avoided. The GHG emissions of production of virgin materials shall be based on these following sources, in decreasing order of preference:

- Source 1: National Life Cycle Inventory (LCI) databases on the TGO's website (the latest version) and list of Emission Factors (EFs)
- Source 2: LCI data from the theses and research projects conducted in Thailand
- Source 3: Peer-reviewed journals, technical reports, or theses in the context of Thailand
- Source 4: Databases available in LCA software
- Source 5: Industrial databases and databases specific to individual country
- Source 6: Publications from international organizations (e.g., The Intergovernmental Panel on Climate Change (IPCC), The United Nations (UN), The Food and Agriculture Organization of the United Nations (FAO), etc.)

In case of upcycling more than 1 time, the summation of avoided GHG emissions form each time of upcycling must be added up.

For the calculation of life cycle GHG emissions of upcycled materials or products, seven Kyoto gases shall be included in the carbon footprint calculation. The gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorcarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). The unit of analysis shall be defined as the mass of upcycled material or product per piece.

All sources shall be included, except for the acquisition of wastes/scraps. If the GHG emissions from research and development activities are significant it shall be included in the calculation. Capital goods are referred to the buildings, machines, equipment that has the life span for more than 1 year and shall be excluded.

The unit of analysis shall be defined as the mass of upcycled material or product per piece. The calculation method of the life cycle GHG emissions of upcycled materials or products shall be based on the prototype production (1 piece, at least) or 3 batches of production. Once there is a mass production by the industry, there shall be data verification activities at the production site to ensure the accuracy and representativeness of data.

All data used for the calculation of life cycle GHG emissions of upcycled materials or products shall be properly recorded for re-verification within 2 years (at least) or over the life span of upcycled materials or products when using UPCYCLE Carbon Footprint labels in the market.

When comparing between two upcycled materials or products, it is necessary to take into account the quality, performance and lifespan of such upcycled materials or products. Related technical aspects shall be defined, such as upcycling technology or processes to be taken into consideration when comparing between two upcycled materials or products that perform the same functions.

The required data for carbon footprint assessment are:

(i) Activity data

Input data are the inputs required for upcycling processes, which are raw materials, energy, chemicals, water and others. Output data are the outputs from upcycling processes, which are main product, co-product, wastes and emission to environment.

Activity data shall be collected from the primary data if they are direct activities and accessible (such as suppliers who supply wastes/scraps to upcyclers or designers). In case there is no data access, then the secondary data can be used based on these following sources, in decreasing order of preferences (similar as above).

For activity data, the required inventory data are:

1) Amount of scraps and wastes including other raw materials

2) Amount of inputs and outputs associated with packaging production. The primary data for packaging of the product will be required. In the case where this data is not available, secondary data can be used. In the case where the carbon footprint of the packaging of a product is less than 5% of the total carbon footprint of the product, it is considered neglectgible and can be excluded.

3) Amount of energy used for preparation of wastes/scraps. The GHG emissions from fuels shall include:

3.1) Emissions from the production of fuel

3.2) Emissions from fuel use (e.g., kgCO_2e/kg fuel, kgCO_2e/MJ electricity or heat) based on the source of energy used

3.2.1) Emissions at site of energy use (e.g., coal and gas combustion)

3.2.2) Emissions from energy carrier acquisition

3.2.3) Emissions from fuel use in transport

3.2.4) Upstream GHG emissions (mining, transport of fuel to electricity production site) including biomass acquisition for using as fuel

3.2.5) Downstream emissions from waste treatment and management from energy conversion

In terms of distribution and transport, the required data for road transport are the type of vehicle, type of fuel, distance, loading rate, return trip. The distance shall be based on the Department of Highway's website (http://map-server.doh.go.th). For the sea transport, the required data are the type of vessel, name of port in Thailand and port overseas. The distance between two ports shall be based on the International container shipping's website (http://searates.com).

For activity data associated with the use of upcycled materials or products (including installment, use, and maintenance during use), the required data shall come from these following sources:

- Source 1: the product's application shall be based on published technical papers, such as its ISO 14025 or PCRs
- Source 2: the product's application shall be based on the instruction recommended by manufacturers (including installment, use, and maintenance during use)
- Source 3: the product's application shall be based on the typical use method of general consumers, which is a set of rules that describe a product's operations and certain assumptions about the product.

For the final disposal stage, the required inventory data are the amount of wastes after reaching its life span. Transport of wastes to dispose by landfilling shall be based on the transportation by 10-wheel, 16-ton truck over a distance of 40 km (normal roads) with an empty return trip.

(ii) Emission Factors (EF)

EFs are referred to the amount of GHG emissions associated with the production of main materials, minor materials, energy, chemicals, or transport by various types of vehicles, etc.

In the case where EFs of some inputs are not available, the EFs of substances having similar physical and chemical properties shall be used as the substitutes. If no such substitute data is available, the highest EF of the inputs in the particular life cycle stage shall be used as the substitute.

The calculation of GHG emissions, i.e., carbon footprint, of upcycled materials or products must be based on these following steps:

(i) Converting the primary and secondary data of inputs/outputs to EFs by multiplying their loads with respective emission factors.

(ii) Converting GHG emissions into CO_2e by multiplying the individual EF by the relevant GWP (Global Warming Potential).

(iii) Finalizing the carbon footprint result, expressed in terms of CO_2e per product unit.

Items that contribute lesser than 1% of the total carbon footprint can be omitted. However, the total omissions cannot exceed 5% of the anticipated GHG emissions. In case of an omission, the assessed emissions shall be scaled up to represent 100% of the EFs associated with the defined product unit.

It should be noted that the UPCYCLE Carbon Footprint toolkit, based on the national guideline of carbon footprint of products, will be used to calculate carbon footprints to ensure that the avoided GHG emissions of upcycled materials or products are higher than theirs' life cycle GHG emissions.

The symbol of UPCYCLE Carbon Footprint (Figure 1) is consisted of:

(i) UPCYCLE in the symbol indicates that this materials or products are upcycled by using scraps and wastes for production.

(ii) CO_2 in the symbol indicates that this upcycled materials or products have the avoided GHG emissions higher than theirs life cycle GHG emissions.

Fig. 1: The symbol of UPCYCLE Carbon Footprint

Using of the symbol of UPCYCLE Carbon Footprint shall be based on these following rules [6]:

1. The symbol of UPCYCLE Carbon Footprint shall not be used in the way that will lead to misunderstanding or causing any damage.
2. The symbol of UPCYCLE Carbon Footprint shall not be used as a part of trade mark, trade name, co-marking, or others that is not related to the verification scope of UPCYCLE Carbon Footprint.
3. The symbol of UPCYCLE Carbon Footprint, as shown in the figure, shall be used in any colour that is appropriate and suits the packaging material. The label can be put on packaging (or website, product catalogue, display shelve, etc.) at a readable size to ensure effective communication with consumers.
4. The symbol of UPCYCLE Carbon Footprint can be used for 2 years [5]. There will be a renewal notice in advance, at least 5 months before the license expiry date. The symbol of UPCYCLE Carbon Footprint can be used after expiry date for only 3 months.
5. The license of UPCYCLE Carbon Footprint shall be renewed by applying for verification and certification again.

It is worth mentioning here that the revision of requirements will take place every 2 years to ensure that the requirements are up-to-date with the actual practice.

4 CASE STUDY

To demonstrate the implementation of UPCYCLE Carbon Footprint certification scheme, a case study of glass tiles (under the brand "Granite Glass®") was performed.

4.1 Product description

Granite Glass® was made from discarded glass bottles (Figure 2), which were post-consumer wastes.

Fig. 2: Granite Glass® made from wasted glasses

4.2 UPCYCLE carbon footprint compliance

4.2.1 Scraps and wastes

The proportion of discarded glass bottles in Granite Glass® was 98%. The discarded glass bottles were collected from local sources, within the radius of 40 km from the factory, and transported to the factory by 10-wheel trucks. The preparation of discarded glass bottles was kept minimal by sorting and washing them with water without chemical use.

4.2.2 Upcycling

The upcycling processes started with grinding glass bottles in two steps: rough and fine grinding, by using grinding machines. The grinded pelltes were passed through sives to ensure homogeneous sizes. Pigments and glue were added with grinded pellets and then formed into a square shape (W98xL98xH9 mm). Firing them at the temperature of 900ºC for 4 hours. They are then packed into corrugated boxes for sales.

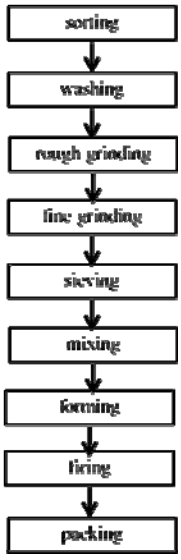

Fig. 3: Upcycling processes of granite glass tiles

4.2.3 Quality

To ensure the quality of Granite Glass®, they were tested for water absorption, breaking strength and young modulus according to the Thailand Industry Standard Institute (TISI) for tiles. The results confirmed the quality was in compliance with the standard.

4.2.4 Creative design

Using discarded glass bottles to make Granite Glass® offers a creative way for waste management. Upcycling discarded glass bottles into Granite Glass® was captured and disseminated by the media widely (Figure 4).

Fig. 4: Example of Granite Glass® in the media

4.2.5 Carbon Footprint (CF)

4.2.5.1 GHG emissions of virgin material production

If the discarded glass bottles were not used for making Granite Glass®, then there will be a need to produce Granite Glass® from virgin material. Upcycling, thus, helps avoid 26.0 $kgCO_2e$ per m^2 of Granite Glass® [7].

4.2.5.2 GHG emissions of waste disposal

If the discarded glass bottles were not used for making Granite Glass®, then there will be a need to dispose emptied glass bottles (after use) by landfilling. Upcycling, thus, helps avoid 0.0778 $kgCO_2e$ per m^2 of Granite Glass® [4].

4.2.5.3 GHG emissions of Granite Glass® from discarded glass bottles

The calculation of life cycle GHG emissions, i.e., carbon footprint, was referred to the national guideline of carbon footprint of products [3]. The required inventory data associated with each sub-process were identified and collected from the company's recording systems. The emission factors of electricity and water, including transport, were sourced from the national databases. Other inputs (e.g., pigment and lubricant) were gathered from international databases.

It was found that 25 kg of discarded glass bottles, 1.59 kWh of electricity, 5.2 kg of LPG (Liquified Petroleum Gas), and 0.5 kg of pigment were required to produce 1 m^2 of Granite Glass®. The carbon footprint value of upcycled Granite Glass® was 23.5 $kgCO_2e$ per m^2 of Granite Glass®. The key hot spot was linked to the use of LPG in the firing process.

5 RESULTS AND DISCUSSIONS

Discarded glass bottles from post-consumption were upcycled to make Granite Glass®. This has offered a new way of waste management through creative design. At least 98% of discarded glass bottles was used and the preparation of pellets did not require intensive processes. The results of quality test have proven that Granite Glass® is fit for use.

The avoided GHG emissions from the production of virgin materials and the disposal of wastes from upcycling discarded glass bottles for Granite Glass® was 26.1 $kgCO_2e$ per m2 of Granite Glass®, which was higher than the CF value of Granite Glass® (Figure 5). As a result, the upcycled Granite Glass® is in compliance with the carbon footprint criterion of UPCYCLE Carbon Footprint certification scheme.

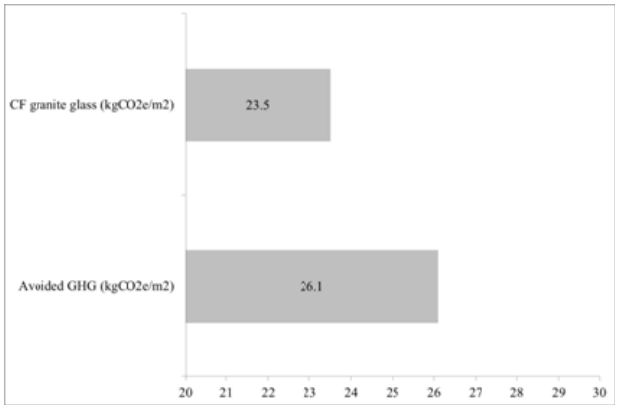

Fig. 5: Carbon footprint of upcycled granite glass compared to the avoided GHG emissions

6 OUTLOOK

At present, there are various upcycled products available in Thailand and growing around the world. It is expected that the UPCYCLE Carbon Footprint certification scheme will be an effective green practice and marketing tool for manufacturers to promote more upcycling activities and producing more upcycled products into mainstream markets. Simultaneously, upcycling help stimulate innovative ideas for waste management and GHG reduction. With the increase of customer confidence in and appreciation of creative eco-products, UPCYCLE Carbon Footprint certification scheme can support the move toward sustainable consumption and production and will contribute to the low-carbon society.

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