



# Implementation status of Taiwan carbon footprint (CFP) system and a case study of the Taiwan High Speed Rail Corporation



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## ARTICLE INFO

### Keywords:

Carbon footprint  
CFP-labeling  
Certification process  
High-speed rail system

## ABSTRACT

The transportation sector in Taiwan has made a significant contribution to reducing atmospheric pollution such as lowering greenhouse gas (GHGs) emissions, by adopting the carbon footprint (CFP) label. GHGs are a major cause of global warming. This paper analyzes the carbon footprint (CFP) system and its application to high-speed railways in Taiwan over the decade 2003–2013. Carbon dioxide (CO<sub>2</sub>) emissions per capita in Taiwan increased slightly from 10.3 to 10.7 t between 2003 and 2013. However, overall energy intensity has improved gradually, falling from 10.0 liters of oil equivalent (LOE)/10<sup>3</sup>\$NT in 2003 to 7.8 LOE/10<sup>3</sup>\$NT in 2013 due to some high energy efficiency and low carbon emission measures implemented by the Taiwan government such as the combined heat and power and green transportation policy updated. This paper describes the analysis of GHG emission trends, two central regulations (i.e., the Basic Environment Act and the Greenhouse Gas Reduction and Management Act) for promoting the CFP-label system and the system's implementation status in Taiwan over the past 10 years. Finally, a case study of the Taiwan High Speed Rail Corporation demonstrates the successful implementation of the green transportation CFP-labeling service, the first such certified railway system in Asia. The certified CFP label is printed on the ticket with 38 g CO<sub>2</sub> equivalent per person-km, which is equivalent to one-third of the carbon emission by a passenger car.

## 1. Introduction

The World Commission on Environment and Development (WCED) addressed the concept of “Sustainable Development” in 1987 (WCED, 1987). Thereafter, the reduction of emissions of carbon dioxide (CO<sub>2</sub>), one of the most important greenhouse gases (GHG), was considered as a vital goal to mitigate global warming under the United Nations Framework Convention on Climate Change (UNFCCC), and this emphasis has continued in the past two decades (1997–2016). In recent years, the number of certified eco-labeled products and the implementation of the green consumption concept was gradually increased in both public and government sectors, which has reduced natural resource depletion and GHG emissions, and led to switching to low-carbon consumption and production approaches (Staniskis, Arbaciauskas, & Varzinskas, 2012). In this regard, the carbon footprint (CFP) system has been developed to disclose GHG emissions as an assessment tool for quantifying the environmental burdens of products or services (Sanye-Mengual, Lozano, Farreny, Oliver-Sola, Gasol, & Rieradevall, 2014). In general, a CFP can

be simply defined as the total GHG emissions produced by a product, people, or service (Wright, Kemp, & Williams, 2011). The CFP can be used to estimate the contribution to carbon emissions at different stages of a product or service lifecycle. Thus, the purpose of the CFP-label is to encourage the production and consumption of products or services with low carbon emissions in order to move towards a low-carbon economy and environment-friendly society. In addition, the CFP system encourages manufacturers and service companies to use these labels for their total carbon emissions (for the entire life cycle of each product or service), and to seek opportunities for carbon emission reduction through supply chains. This will, in turn, encourage consumers to change consumption patterns based on quantitative information and to buy green products or take green behaviors.

Taiwan is known for its economic development in electronic products and convenient transportation (e.g., high-speed railway), but is constantly facing the problem of heavy environmental loading due to dense population and limited natural resources. A particular challenge is that over 98% of Taiwan's energy supply is imported. Also, the

*Abbreviations:* BOT, build-operate-transfer; BEA, Basic Environment Act; CFP, carbon footprint; CO<sub>2</sub>, carbon dioxide; EPA, Environmental Protection Administration; ETC, electronic toll collection; GDP, gross domestic product; GGRMA, Greenhouse Gas Reduction and Management Act; GHG, greenhouse gas; HSR, high-speed railway; ICT, information and communication technology; IEA, International Energy Agency; IPCC, Intergovernmental Panel on Climate Change; KLOE, kiloliters of oil equivalent; LUCF, land-use change and forestry; MOTC, Ministry of Transportation and Communications; MRT, mass rapid transit; PPP, purchasing power parity; TEPMA, Taiwan Environmental Management Association; THSRC, Taiwan High Speed Rail Corporation; WCED, World Commission on Environment and Development; UNFCCC, United Nations Framework Convention on Climate Change

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<http://dx.doi.org/10.1016/j.scs.2017.08.021>

Received 7 June 2016; Received in revised form 26 July 2017; Accepted 15 August 2017

Available online 21 August 2017

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domestic energy consumption reached a total of 115.3 million kiloliters of oil equivalent (KLOE) in 2014, in contrast to 62.8 and 103.2 million KLOE in 1994 and 2004, respectively (MOEA, 2015). On average, the annual growth rate is about 3.09% during the period. However, the annual growth rates of total CO<sub>2</sub> emissions and energy consumption in the past decade (2004–2014) were relatively lower than those in the years of 1994–2004 due in part to policies promoting carbon reduction, energy saving and renewable energy development (Tsai, 2010, 2014). When classified by final consumption sector, the energy consumption for each sector in 2014 was: energy sector (own use) 6.71%, industrial sector 37.73%, transportation sector 11.63%, agriculture, forestry and fishery sectors 0.89%, services sector 10.92%, residential sector 10.78%, and non-energy use 21.33%.

In order to foster green consumption patterns on green-mark products, the central competent authorities of Taiwan, especially the Environmental Protection Administration (EPA), jointly began to promulgate central regulations and promotional measures in the 1990s. For this reason, the Legislative Yuan (Taiwan's Congress equivalent) passed a significant environmental law (the Basic Environment Act) in 2002. All levels of central and local government organizations have taken necessary measures to promote the procurement of renewable resources and other green-mark or environment-friendly materials, products or services that have a lesser or reduced impact on the environment and/or human health over their life cycles. In December 2009, the EPA further initiated CFP labeling of products in Taiwan. Taiwan thus became the eleventh nation worldwide to start carbon labeling for consumer products. The other countries that started to develop or implement CFP labeling (standards or programs) prior to 2010 include UK, France, Germany, Switzerland, Japan, South Korea, Thailand, Australia, Canada, and USA.

The objective of this paper is to present an in-depth analysis of the success of CFP labeling efforts through legal systems and innovative measures by Taiwan's EPA in recent years. This paper also includes a case study of the sustainable intercity transport service provided by the Taiwan High Speed Rail Corporation, the only transportation company to adopt CFP-labeling in Taiwan and also the first railway service to do so in Asia. In brief, the main subjects covered in this paper include the following key elements:

- Carbon emissions status in Taiwan.
- Central regulations and subsidiary measures for promoting carbon footprint labeling in Taiwan.
- Implementation status of carbon footprint system in Taiwan.
- Case Study: the Taiwan High-Speed Railway Corporation.

## 2. Carbon emissions status in Taiwan

It is well known that the most important anthropogenic GHG is CO<sub>2</sub> because it is closely related to the widespread use of fossil fuels (i.e., coal, petroleum and natural gas) in the combustion process. The increasing CO<sub>2</sub> concentration in the atmospheric environment could trigger global warming and thus cause adverse impacts on climate change. The anthropogenic emissions of CO<sub>2</sub> from the combustion processes are the primary sources of GHG in industrialized countries. With respect to the national inventories of carbon (i.e., CO<sub>2</sub>) emissions from anthropogenic sources in Taiwan, the central competent authority (i.e., EPA) has published the “National Greenhouse Gas Emissions Inventory”, presenting the first edition of National Communications in 2002 even though Taiwan is not a signatory of the UNFCCC. In 2016, Taiwan EPA updated the report as “2015 Taiwan Greenhouse Gas Inventory” (Taiwan EPA, 2016). As listed in Table 1, the total CO<sub>2</sub> emissions without land-use change and forestry (LUCF) in Taiwan increased from 122,419 kt in 1990–269,627 kt in 2013, an increase of 120.25% at an average annual growth rate of 3.16%. Regarding the CO<sub>2</sub> emissions in 2013, the energy sector accounted for 92.39%, industrial processes and product use sector 7.59%, agriculture sector 0.02%, and

waste sector 0.002%.

The largest source of CO<sub>2</sub> emissions was the energy sector, accounting for about 90%, which can sequentially include energy industry, manufacturing industry & construction, transportation, and other sectors (i.e., commerce, residential and agriculture), as shown in Table 2. It is obvious that the contribution of the energy industry to CO<sub>2</sub> emissions indicates an increasing trend from 44.84% in 1990 to over 64% in 2013. In contrast, the CO<sub>2</sub> emission from the sub-sector of agriculture, forestry, fishery, and husbandry decreased significantly over the past two decades. It should also be noted that CO<sub>2</sub> emissions from the sub-sectors of manufacturing industry & construction, transportation, and residential in Taiwan have shown a stable trend since 2000, indicating that the decoupling of economic development from energy consumption has approached sustainability in recent years (Tsai, 2014). For example, the Taiwan government promoted the establishment of “high energy efficiency” and “low carbon emissions” in green transportation, including high-speed railway, mass rapid transit (MRT), E-bus & IC card integration (electronic ticketing), city-bicycle service, and an electronic toll collection (ETC) system for highways.

In order to compare the energy sustainability indicators of Taiwan with other developed countries, the Reference Approach of the Intergovernmental Panel on Climate Change (IPCC) method and the International Energy Agency (IEA) reporting form were adopted to estimate CO<sub>2</sub> emission factors from fossil fuel consumption, using national statistics. Thus, apparent consumption of primary fuels (including coals, crude oil, natural gas, and natural gas liquids) can be obtained by subtracting the consumption of non-energy use from the domestic energy consumption. Next, apparent consumption of primary fuels needed to be converted to a common energy unit (e.g., TJ) using a conversion factor (i.e., 1 l of oil equivalent = 9000 kcal = 37,674 J). Once apparent consumption was estimated, the calculation was made using effective fuel-specific CO<sub>2</sub> emission factor like t CO<sub>2</sub>/toe (i.e., tonnes of oil equivalent, abbreviated as toe). Table 3 summarizes the results for Taiwan and several developed countries in reporting CO<sub>2</sub> emissions and their factors per energy consumption per capita, gross domestic product (GDP) and purchasing power parity (PPP) from the combustion of fossil fuels in 2013 (IEA, 2015). Taking the example of China, this country would rank first for CO<sub>2</sub> emission per GDP because motorization has driven the rampant expansion of roads and the fast increase of fossil energy use in recent years. CO<sub>2</sub> emissions per capita in China are still lower than those in the developed countries like USA, Japan and Germany; however, China's total CO<sub>2</sub> emissions are increasing significantly as compared to these countries (IEA, 2015). The analysis also reveals that the CO<sub>2</sub> emissions per capita in Taiwan was consistent in proportion to the increase in the domestic energy consumption: 9.67 metric tons per capita in 2000, 11.73 metric tons per capita in 2007 and 10.63 metric tons per capita in 2013. Although the financial crisis in 2008 was a vital factor for CO<sub>2</sub> emission mitigation, the governmental promotion of GHG emissions mitigation has obtained significant benefits in recent years (Tsai, 2014). For example, the Taiwan government legally established a green procurement system in the late 1990s for green-mark products (including eco-labeled products, energy-saving products, water-saving products, and green building materials) to be preferentially obtained in the official and private organizations, in order to encourage the domestic market to trend towards a green economy (Lin, Persada, Nadlifatin, Tsai, & Chu, 2015).

## 3. Central regulations and subsidiary measures for promoting carbon footprint labeling in Taiwan

Regarding the central regulations for promoting CFP in Taiwan, they include the Basic Environment Act (BEA) and the Greenhouse Gas Reduction and Management Act (GGRMA), which are described below.

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