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OPPORTUNITIES AND APPROACHES TO REDUCE CARBON FOOTPRINT IN TRANSPORT SECTOR

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Abstract: *The transport sector as a whole is recognized as one of the major contributors to climate change and GHG emissions. Many countries have set up the challenging transport-related emissions reduction targets. In an effort to accomplish these goals, effective measures are of importance from a sustainable perspective, especially under business-as-usual scenario. This present paper discusses in detail the opportunities and approaches to reduce carbon footprint in transport sector, including developing the effective traffic connections, developing the logistic areas and centers, developing renewable energy introduction, and improving passenger and freight transport management. This paper is of benefit to managers and policy makers by providing thorough and inspiring measures to mitigate carbon footprint in transportation.*

Key words: *Climate change, GHG emissions, Carbon footprint, Transport*

1 CLIMATE CHANGE AND GHG EMISSIONS

Today more than ever before, the issues of climate change bound with greenhouse effect are dominating the international agenda. According to the Kyoto Protocol, identified greenhouse gases (GHG) include six contents: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), hydrofluorocarbons (HFC) and perfluorocarbons (PFC). Greenhouse effect caused by human activities like fossil fuel burning and deforestation [7], can result in all kinds of catastrophes to our planet Earth and its inhabitants. One of the evidently exiting problems is that the high number of on-road diesel vehicles implies that emissions from the engines contribute significantly to the atmospheric levels of the most important greenhouse gas, CO_2 and other urban pollutants such as CO, NO_x, unburned hydrocarbons, particulate matters and aromatics [12]. The Inter-governmental Panel on Climate Change (IPCC) have demonstrated that the risk of severe climate change impacts will rise obviously with a temperature increase of 2°C above preindustrial levels [5].

Studies show that if GHG emission continues to intensify, the two-degree limit for temperature rise will be broken during the next couple of decades [5, 10]. If efforts can be made effectively to mitigate climate change through international agreements and GHG

emissions can be decreased at least by half by 2050, the temperature rise can be controlled with 2°C. According to the goals of the Kyoto Protocol, the EU will reduce CO_2 emissions by 8% from 1990 to 2012. In contrast, according to EU's Climate Action and Renewable Energy Package it was decided that CO_2 emissions will be reduced by 20% from the 1990 levels by 2020 in EU [3]. This goal is very challengeable, especially for the transport sector since the tendency of GHG emission from traffic is ascending.

2 CARBON FOOTPRINT IN TRANSPORT

A carbon footprint is the total set of GHG emissions through transport, land clearance, and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, buildings, and services. It contains two parts, the direct and indirect footprint. The direct footprint is a reflection of our direct GHG emissions from the combustion of fossil fuels including domestic energy consumption and transportation (e.g. car, diesel train and plane), while the indirect footprint is a reflection of the indirect GHG emissions from the whole lifecycle of products like electricity power and services we use [11]. There are several carbon footprint calculation models or methods provided by a range of organizations including government agencies, non-governmental organizations (NGOs) and private companies, and they are widely available on the Internet. McKinnon and Piecyk [9] compared four approaches to estimate CO_2 emission and found that different methods have some different calculation results. No matter which methods they are, the most important parameters influenced the emission factor are load factor, share of empty running, energy efficiency of the vehicle, carbon intensity of the energy source, and so forth [2].

In the EU-15 member countries GHG emissions from transport have increased by 20% between 1990 and 2008, accounting for 21% of the total EU-15 GHG emissions in 2008 [4]. Road transport is the largest contributor to these EU-15 emissions, arriving at 93% in 2008 [4]. CO_2 emission contributes 93–95% of total GHG emissions in transport sector and about one third of total GHG emissions are from freight transport [2]. The percentage of transport emissions is ever-increasing year after year and it is predicted that it could arrive at over 30% of all EU GHG emissions by year 2020 unless any effective measures is taken. In this regard, it is of pretty importance to explore effective opportunities and approaches to reduce carbon footprint in transport sector. In this paper several measures will be discussed in detail in an amttempt to mitigate GHG emissions to a great extent.

3 APPROACHES TO REDUCE CARBON FOOTPRINT

3.1 Developing the effective traffic connections

It is important to develop an integrated and effective system combining all modes of transport, with an emphasis on the synergies between the transport modes. However, some design of routine is not sensible and justified. For example, some of them overlap quite a lot, and at the same time the traffic service is so frequent (empty or half-empty running). Consequently, it will give rise to unexpected and unnecessary emissions. In this regard, it is meaningful if effective traffic connections can be developed, with the prerequisite of ensuring the ability to provide the services required by customers, in an economic and efficient manner.

3.2 Developing the logistic areas and centers

The importance of logistic areas and centers are growing in product distribution process. Focused on reducing costs, increasing customer satisfaction, and optimizing supply chain to resources, suppliers and customers, manufacturers are paying much more attention to the location and number of distribution centers and the functions they perform in supply chain. The development of logistics centers and their networking will continue to have an impact on improving communication links, spatial planning practices and approaches, logistics chain development and the promotion of sustainable transport modes. Logistic areas and centers (warehouses) differ greatly, depending on the geographic region served, space required, type and functions of operations. The location goal of most logistics centers should provide the lowest transportation costs with the easiest access to the greatest number of customers, taking into consideration the importance of just-in-time. The warehouse site selection should consider the following factors (but are not limited to): market trends, proximity to existing and new customers, access to suppliers and vendors, transportation services and cost, telecom infrastructure, labor availability and cost, building and site acquisition and cost, quality educational institutions and training facilities, and regulatory factors, such as inventory valuation [1].

3.3 Developing renewable energy introduction

The increasing use of fossil fuel can cause the risks of the exponential rise of greenhouse effect, which can result in all kinds of catastrophes to our planet Earth and its inhabitants. To confront the global climate changes, the current subsidy and steering systems should be rendered more effectively, and structures need to be changed relatively [6]. Renewable and alternative energy should be developed and being put into practice, including wind power, solar energy, geothermal energy, and biofuels. The percentage of electricity generation from renewable sources should be increased, which can decrease indirect emissions. Currently, biofuels derived from biomass have huge potential to replace the use of fossil fuels. The term covers solid biomass, liquid fuels (e.g. bioethanol and biodiesel), and various biogases. In constructing the energy system, the plants that do not emit greenhouse gases or ones with low emissions, should be prioritized, such as renewable fuel based power and heat cogeneration plants, and hydro and wind power plants. Furthermore, nuclear power can be constructed after scientific assessment.

3.4 Improving passenger and freight transport management

3.4.1 Passenger Transportation Demand Management

(1) Higher fossil fuel taxes

Decrease current taxes on income and business activities and increase more taxes on vehicles and vehicle fuels. Meanwhile, encourage energy efficiency, technological innovation, and renewable fuel development.

(2) Traffic jams pricing

Motorist should pay a fee for driving private automobiles in its central area during weekdays or peak periods to reduce traffic congestion. This has been well exercised in London since February 2003 [8]. Consequently, it has significantly reduced traffic jams, improved bus and taxi service, generated substantial revenues and thus raised public acceptance. Its success suggests that congestion pricing may become more politically feasible elsewhere.

(3) Parking pricing and subsidy

Charge motorists directly for using parking facilities based on the amount of time they have parked. Another measure is to offer vehicle owners a choice between parking subsidies and their cash equivalent. For instance, employees can choose between a free parking space and €50 cash per month, considering it is fair to give non-drivers benefits.

(4) Distance-based fees

Except insurance, registration, taxes and leases, motorists should also pay a fee based directly on the vehicle's annual mileage. The methods can give consumers a new opportunity to save money when they reduce their vehicle mileage. This assignment can be undertaken by local service station to periodically check the vehicle odometer and record its mileage.

(5) Public transport improvement

Measures can include lower fares, more convenient payment options, increased service frequency, improved comfort, improved user information, marketing programs, transit-oriented development, improved security, and special services such as express commuter buses.

(6) Ridesharing

People live nearby or have the same travel direction or destination can share their vehicles to save the costs and reduce emissions.

(7) Walking and biking

People can walk or ride their bike especially for short distance travelling. Walking and biking provide unique benefits like mobility for non-drivers, public fitness and health, safety, and community livability. Ways to improve walking and biking, include better facilities (sidewalks, crosswalks, paths and bicycle parking), traffic calming (speed limit for vehicles), road lamp establishment, and more mixed land use to make activities are closer.

(8) Smart communities

Smart communities have centralized district where shopping center, entertainment lots, kindergarten, etc. are available, the travel distances are shorter, and destinations are not disperse. Citizens have more travel options, including on foot and by bike.

3.4.2 Freight Transport Management

(1) Modal shift

Shift transport operations to "greener" modes of transport which emit the least CO2 per ton-kilometer. For example, switch road transport to train transport, and to road/train-short sea-road/train transport whereby the goods are transported over the major part of the distance by sea (ferry, barge, ship).

(2) Supply chain management

Total tonne-kms can be reduced through improved supply chain management. Measures include: a. Product exchange: in order to avoid a long distance transport, manufacturer can deliver the same product to each other's customers located in the area close to the respective manufacturing sites; b. Maximize direct deliveries: in order to reduce the handling process in warehouse and cutting the total tonne-kms, deliver products directly from plant to customers; c. Logistics network optimization: the optimization of route through intermodal terminals, warehouses and tank cleaning stations, and on the road and rail networks can reduce unnecessary tonne-kms.

(3) Empty running minimization

Empty running can be minimized by: a. Horizontal cooperation between different logistics service providers (LSPs) at variable places to deliver their own goods; b. Horizontal cooperation between shippers to build co-load opportunities; c. Vertical cooperation between shippers and their LSPs to streamline delivery; d. Tank cleaning stations accessible at the unloading point, so that vehicles do not need to go to other places to do some cleaning.

(4) Load factor maximization

Load factor can be maximized by increasing storage capacity within the weight permit, like building or extending additional storage.

(5) Fuel efficiency improvement

Two measures can improve fuel efficiency: a. Improve vehicle design and maintenance (engine, tyre, axle, etc.); b. Optimize driving style (appropriate speed) by training programs.

(6) Carbon intensity reduction

Introduce alternative fuels, like biodiesel, bioethanol, and biogas, can yield net reductions in carbon emissions. If trains are able to source electricity from different energy providers, for instance, nuclear power or renewable fuels who have low carbon intensity, it may significantly reduce carbon footprint of train journeys.

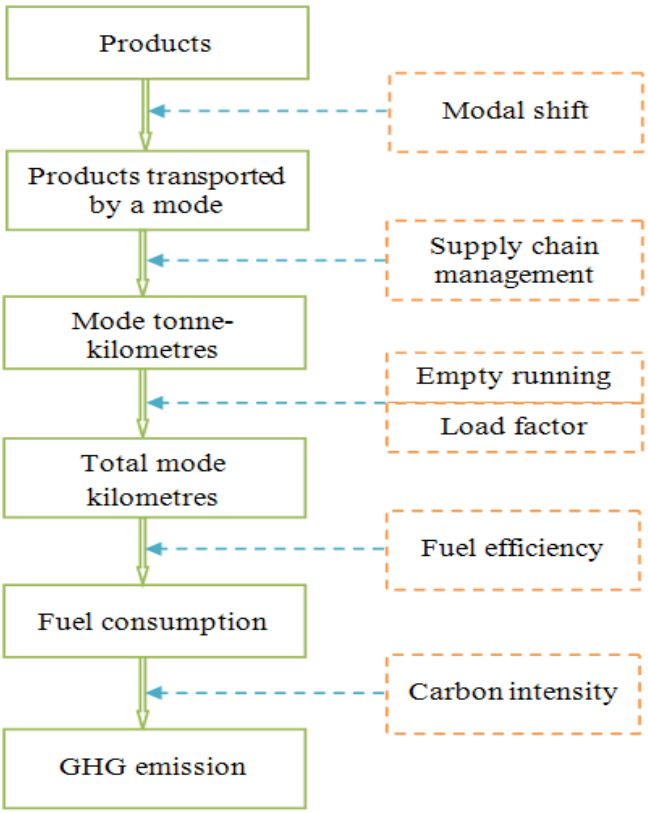

Fig.1 *Decarbonisation framework for freight transport*

4 CONCLUSIONS

This paper provides a generic overview of opportunities and approaches for managers or policy makers from governments or companies to reduce CO_2 emissions associated with transport operations. In very broad terms, opportunities to reduce carbon footprint from transport sector can include: developing the effective traffic connections, developing the logistic areas and centers, developing renewable energy introduction, and improving passenger and freight transport management. These measures may be used as some kind of checklist, judging the potential related to each opportunity, going through the considerations for implementation and applying these to their specific associated transport operations in practice.

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