URBAN FREIGHT TRANSPORT ECO-EFFICIENCY AND SUSTAINABILITY: POLICIES AND INDICATORS

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ABSTRACT

This paper focuses on two issues: what Governments can do to promote more eco-efficient and sustainable transport; and how the progress in this endeavour can be measured.

There are a number of 'attack points' on which Governments can focus in order to achieve the required improvements and a range of instruments that they can employ in order to influence the outcomes on each of these points. The paper identifies a range of policies that are available to Governments and suggests some specific measures that could be undertaken in implementing these policies. It also develops a framework for prioritizing policy actions to ensure that the best possible return is obtained on the political capital that should be used in achieving positive change.

INTRODUCTION

This paper documents work undertaken as part of a project called “Eco-efficient and Sustainable Urban Infrastructure Development in Asia and Latin America”, sponsored by the United Nations Development Account. The overall objective of the project is to promote the application of eco-efficiency in sustainable infrastructure development. The paper is the result of an effort to assist the ESCAP secretariat in developing a set of indicators for eco-efficient and sustainable urban freight transport.

Although the clear focus of this work is on urban freight movement, from a policy perspective it is not always helpful to separate urban from non-urban freight. The majority of inter-urban freight movements, for example, involve some travel through urban areas. Policies, designed to encourage the use of rail for inter-urban movement, will have an effect on both urban and non-urban freight; and measures, created to capture the success of such policies, will not generally separate the effect on urban freight from that of on non-urban freight. Moreover, some data that are generally available at the national or regional level are not necessarily available at the urban level (for instance, the number of freight truck registrations).

The paper, therefore, is not strictly confined to measures that could be implemented at the city level; nor is it confined to measures that are affected solely by urban freight movements. Rather, it takes a broad view of the relevant domain, and deals with measures of sustainability and eco-efficiency that are likely to be affected by developments in urban freight transport; and with policies that are likely to have an effect on the urban freight transport task or the way this task is undertaken.

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I. ECO-EFFICIENCY INDICATORS AND SUSTAINABILITY INDICATORS

Eco-efficiency is closely related to sustainability and sustainable development, but is conceptually distinct from both of these concepts.

Sustainability is about the relationship between the environmental burden imposed by human activity and the constraint imposed by the capacity of the environment to support that burden. **Sustainable development** is about the ability to more completely meet human needs without breaching that constraint. **Eco-efficiency** is about the ways and means by which the environmental burden, imposed in meeting these needs, can be minimized. Perhaps the simplest and most elegant definition is that offered by Nam (2008):

> Eco-efficiency is simply defined as "creating more economic value with less environmental impact".

Eco-efficiency indicators focus on the process of the transformation of environmental inputs into the means of fulfilling human needs. Eco-efficiency measures are essentially ratios, relating output to input (see, for instance BASF, 2009; City of Oslo, 2005; ESCAP, 2008b; Ness, 2009; OECD, 1997). A separate but related set of indicators - sustainability indicators - measure the aggregate environmental burden, that results from the attempt to satisfy these needs at the current level, using existing transformative processes. In contrast to eco-efficiency indicators, sustainability measures are absolute measures.

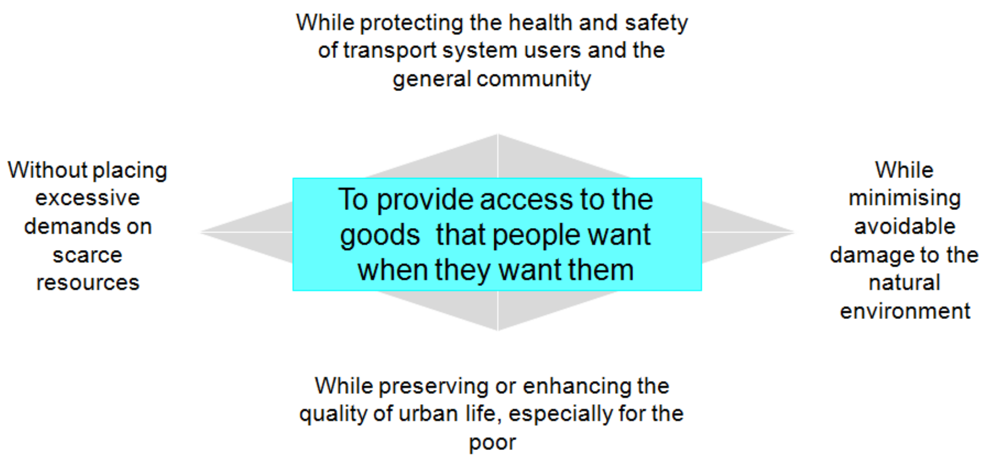
An improvement in eco-efficiency is likely to lead to an improvement in sustainability, but it will not necessarily do so. The possibility that an increase in eco-efficiency will not lead to an improvement in sustainability or environmental quality provides a strong argument for monitoring performance both in terms of sustainability and in terms of eco-efficiency.

II. FRAMEWORK FOR SUSTAINABLE URBAN FREIGHT POLICY

A. The urban freight policy challenge

The challenge for urban freight transport is to meet an economic need subject to a number of social and environmental constraints. The principal dimensions of this challenge are represented schematically in figure 1 below.

Figure 1. The urban freight policy challenge



The demand for urban freight transport is a derived demand. It arises because the locations of production and consumption are different; because the inputs to production are sourced from a number of different locations, none of which may coincide with the location of production; and, increasingly, because the process of production itself takes place in stages, with each stage taking place at a different location.

For most goods and services, a reduction in the level of consumption (unless brought about by a change in tastes) implies a sacrifice of the economic welfare associated with that consumption[1]. But no-one particularly "consumes" urban freight transport; it is, at best, a necessary evil. This opens up a space for potential "win-win" solutions: if the same goods can be delivered to the same consumers, in ways, which reduce the level of freight transport, and do not increase the costs of production, then both the environmental and economic gains become unambiguous.

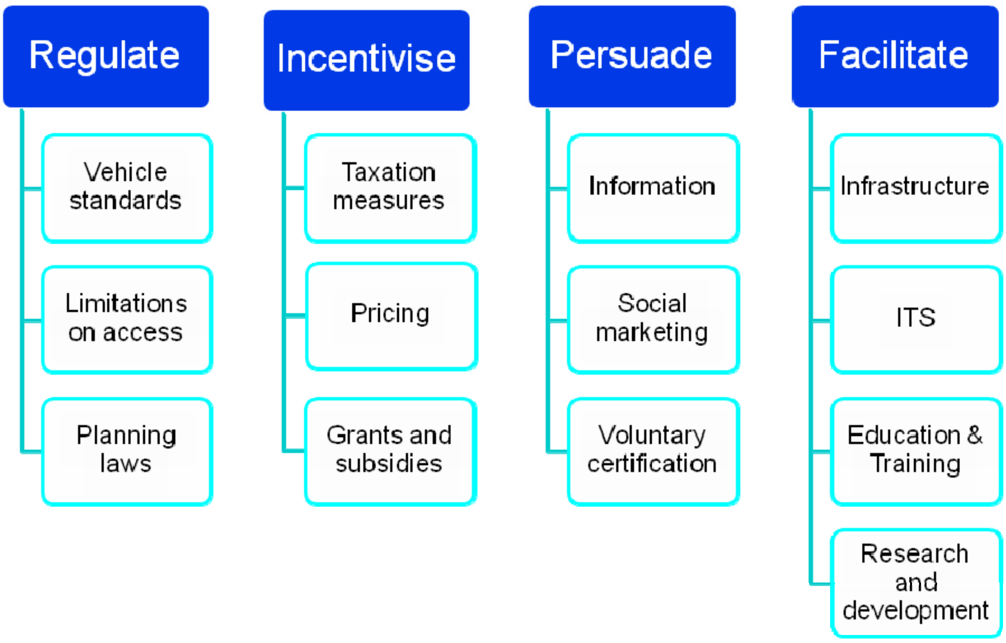
B. Policy instruments and attack points

Policy instruments

There are a number of ways in which the range of policy instruments, available to Governments, can be classified (see, for example, Lidasan, 2010; Min, 2010; Pomlaktong and others, 2010; Wisetjindawat, 2010a).

The classification adopted in this paper groups possible actions under the four headings shown in figure 2 below.

Figure 2. Policy Instruments



Attack points

The concept of 'attack points' is used in Twice the Task (SKM/Meyrick and Associates, 2006) as a way of structuring possible responses to the challenge of

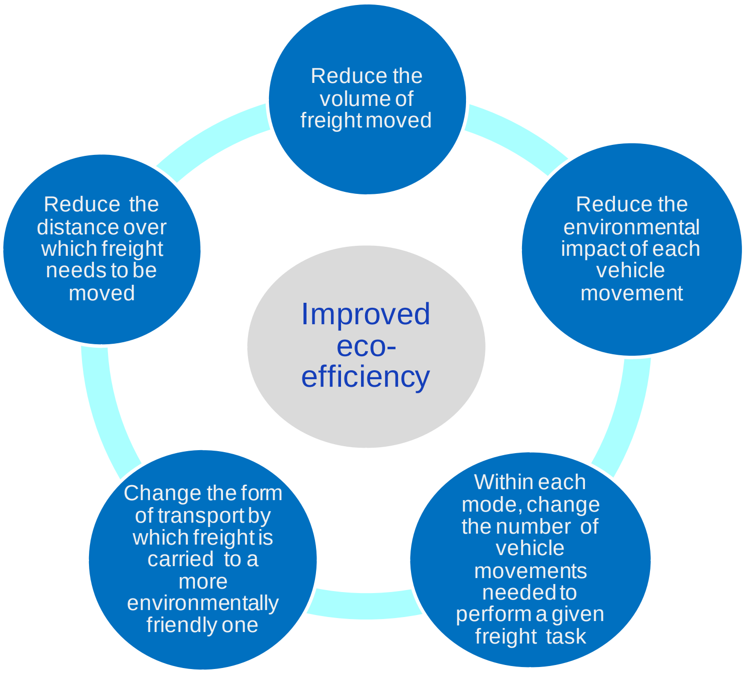
[1] It may well be of course, that the benefit of reducing consumption outweighs the cost. Nevertheless, there is a cost that must be weighed against the benefit.

accommodating a rapidly increasing freight task in a socially and environmentally acceptable way.

A slightly modified version of that framework is summarized in figure 3 below. Five attack points are identified.

Attack point 1: Reduce the volume of freight moved. This is the most fundamental approach to reducing the environmental impact of the urban freight task. It may or may not involve a reduction in overall economic activity, and tends to be the focus of those, who would classify themselves (or are classified by others) as 'deep green'. This is partly because a reduction in the freight task is likely to be closely linked to a decrease in production and consumption of physical goods, which will, in turn, reduce the impact of economic activity on the environment.

Figure 3. Attack points in reducing the environmental impact of urban freight transport



Attack point 2: Reduce the distance over which freight needs to be moved. Freight volume does not directly impact on the environment: the impact comes from the movement of the vehicles that carry the freight. The quantity of this movement is usually measured as the product of two factors: the volume of freight that needs to be moved; and the average distance over which it needs to be moved.

Attack point 3: Change the mode by which freight is carried. There are marked differences in the environmental impact of different modes of transport. At one end of the scale there is air transport, which is not only a very energy-intensive form of transport, but generally releases greenhouse gases at high altitude, where such effect is magnified. At the other end, there are low energy modes such as shipping and pipelines.

Attack point 4: Within each mode, change the number of movements required to perform the freight tasks. Within most transport modes, the environmental impact per ton of freight carried reduces as the scale of the vehicle used increases. This is particularly true for trucking, the predominant mode in urban freight transport. Using fewer larger vehicles would therefore improve environmental performance. But even without changing the fleet composition, gains could be made by ensuring that the average load factor is increased.

Attack point 5: Reduce the environmental impact of each vehicle movement. For any given pattern of vehicle movements, environmental performance can be improved by the operational characteristics of the vehicles operated.

Attack points 4 and 5 tend to be the focus for those who approach the problem of improving environmental performance from the perspective of economics. This is partly because these two attack points do not require a radical transformation of, or significant intervention in the production and consumption choices of businesses; and partly, because it seems likely that at least some initiatives pursued on these attack points could lead to gains in economic efficiency as well as in environmental performance.

III. POLICY OPTIONS

A. Reducing the volume of freight

Decoupling economic growth from material consumption[2]

There has been a considerable interest in the question of whether there is an inherent tendency for the ratio of material consumption to economic activity to decrease once a certain level of income is achieved. So far, not all of the issues associated with this debate have been resolved (see the review article by Stern, 2003). However, the balance of evidence seems to suggest that without positive specific policy action, any inherent tendency in the economy to dematerialize, as income increases, will not be sufficient to contribute significantly to the achievement of sustainability objectives.

Recognition of this reality explains the initiatives that have recently been adopted by several ESCAP countries (ESCAP, 2008a). Supportive measures that Governments can take to encourage decoupling include:

- Attitudinal change programmes, including changing the way in which progress is measured, away from the predominance of indicators that show the volume of market transactions, such as GDP or GNI, towards the broader based measures such as the genuine progress indicator (Redefining Progress, undated);
- Industry policies that promote and support services, rather than material goods, as the future engines of economic growth. Governments have at their disposal a range of tools that can be used to this effect, including investment incentives;
- Differential consumption taxes designed to shift consumption from material goods to dematerialized services.

Reduce 'consequential' freight movements

Not all freight movements are directly related to the satisfaction of customer demand. Two elements in particular stand out:

- the movement of the packaging of consumer goods

[2] Some would argue that there is a 'deeper' level of policy that should be considered here: the total rejection of the notion of economic growth as a desirable social objective. The position that has been adopted in this paper is such, that while a defensible argument could be advanced for this approach in developed countries, in countries where absolute poverty remains widespread this would be inappropriate.

- 'reverse logistics' movements — the freight movements required to dispose of waste generated during the entire life cycle of consumer goods.

There is a growing consciousness of the importance of these freight movements:

> "In the past decade, waste management and recycling have become important political key words in many countries. EU policy stresses prevention of waste production and possibilities of recycling of waste". (OECD, 2003)

These movements could eliminate or require a lower level of freight transport activity to support any particular level of consumption. Supportive measures that Governments could implement include:

- Mandating responsibility for reverse logistics. This approach has already been widely adopted in developed countries as far as hazardous waste is concerned;
- Regulation of packaging practice, either by making manufacturers responsible for the disposable of all packaging or by directly intervening through the regulation of packaging practice.

Bottega (2005) provides an analytical study of the use of these measures concluding that the optimal policy consists of a combination of mandated packaging standards and a tax on packaging.

Increase life of products

This policy would face considerable practical difficulties, as it is very difficult to reconcile with commercial interests of producers, which are usually served by encouraging relatively high rates of product turnover and hence increasing sales potential.

Possible supportive measures include:

- Attitudinal change campaigns at the level of both corporations and individual consumer;
- Regulation and enforcement of minimum standards relating to product life-spans, supported by labelling requirements and an alignment of warranty periods with the specified minimum product life;
- Taxation measures, including higher taxes on raw materials and waste and reduced taxes on labour. This would help to discourage built-in obsolescence and reduce the price of repair work compared to the cost of replacement.

These and other measures are discussed in greater detail in the submission by the Centre for Sustainable Consumption (2007) to the United Kingdom of Great Britain and Nothern Ireland House of Lords Science and Technology Committee Enquiry into Waste Reduction.

B. Reducing the distance that freight travels

Collocate production and distribution activities

The typical supply chain consists of a number of distinct movements: input materials to component factory; components to final assembly; movement of the final product to a distribution centre; movement from distribution centre to wholesaler; from wholesaler to retailer; and from retailer to final destination. If some of these movements can be eliminated or reduced in length by the collocation of activities that take place at different stages of the supply chain then the total distance travelled by freight can be reduced.

Supportive measures that could be adopted by Governments include:

- Integration of transport, logistics and production activities within a single industrial park at free trade zones, freight villages, and logistics centres;
- Urban planning and zoning changes to allow activities at different points along the supply chain to grow up in close proximity to one another. Urban planning and zoning play an important part in ensuring that the opportunities for this to occur are preserved;
- Release of public land. Public authorities often control significant areas of land, particularly on the urban periphery. In some instances, as is the case with the Moorebank site in Sydney, Australia (Australian Rail Track Corporation, 2010), this may be the only land in the urban sector that has the potential for development as an integrated logistics hub;
- Applying differential rates of land tax to influence the location decisions of enterprises, and encourage the collocation of production and distribution facilities.

Economic localization

Over the past several decades, international trade has grown much more rapidly than the global economy, and more and more products are shipped long distance between the point of production and the point of consumption. This notion has led a number of stakeholders to advocate localization of production as a means of increasing sustainability.

The strategy, however, is highly contentious. It depends on a presumption that reducing transport distance will, at least on average, lead to a reduction in environmental impact. This may not be the case, as the eco-efficiency of production and of the different modes of transport, involved in product delivery, need also to be taken into account. Localization policies may also be used as a veiled attempt to protect inefficient local industry, and may clash with national obligations under World Trade Organization free trade agreements.

However, if economic localization is judged to be an appropriate way of pursuing sustainability goals, there are a number of supportive measures that Governments can consider:

- As a major consumer in its own right, it can include preferential purchasing clauses in its contracts that favour locally produced product;
- It can sponsor or endorse awareness campaigns that seek to increase economic localization by making consumers more aware of the distance which products travel from the point of production to retail outlet; and, explicitly or implicitly encourage consumers to regard goods that travel further as less environmentally friendly than those that are locally produced. Product labelling plays an important part in such strategies (Leopold Centre, 2003);
- A less direct approach is to sponsor ‘Buy local’ campaigns. These campaigns differ mainly in the directness of the approach. 'Buy local' campaigns do not explicitly focus on the environmental consequences of the consumption decision, but use whatever arguments they can to influence consumer to purchase locally produced product.

Containing urban sprawl

Asian cities use substantially less per capita energy than North American and European cities. This is largely a result of differences in average income, but the higher urban density of Asian cities also plays an important role (Dodman, 2009). However, the average density of Asian cities is falling rapidly (Dodman, 2009; Roberts undated). The relationship between urban density and the energy-efficiency of transportation is well established. While the primary determinant of this relationship is urban passenger transport, the energy-efficiency of urban freight transport is also likely to decline with reducing urban density.

Governments can support the containment of urban sprawl through:

- Land use planning policies that provide the necessary conditions for increasing urban densities. Marcotullio (2001) has argued strongly that these policies would be critical to the maintenance of compact urban forms in Asia as they have been in Europe;
- Encouraging public transport development. Although public transport is rarely used for urban freight transport, urban public transport initiatives foster the eco-efficiency of urban freight transport indirectly, by supporting and encouraging higher urban density.

C. Changing modes

There are very significant differences between the energy consumption and emissions performance of different transport modes. The extent of these differences depends on the specific characteristic of the freight task and the transport vehicle used; but top-down analysis, based on total energy consumption and emissions, can provide a robust indication of the relative magnitude. A wide range of studies has confirmed the following general ranking, based on increasing energy efficiency and decreasing emissions: sea, rail, road and air.

Greater use of rail

Although rail is not a viable option for most purely intra-urban freight movements, modal shift can still have an important impact on the eco-efficiency of urban freight transport for two specific movements:

- The movement of freight from urban or peri-urban locations to the city port;
- The movement of inter-urban freight. (Most freight between urban centres spends part of its journey travelling within each of the connected urban centres).

  Greater use of rail for these freight tasks could be encouraged by:

  - Improving rail infrastructure. Several ESCAP countries — including India (ADB, 2008) and Australia (ARTC, 2010) are currently planning or constructing dedicated freight rail links that will pass through urban areas;
  - Intermodal terminal development. The development of efficient intermodal terminals is widely seen as essential to the competitiveness of rail with road for container and general cargo freight. The majority of ESCAP countries are actively engaged in the development of intermodal terminals at key transport nodes, and this has been supported by the Busan Declaration and the Bangkok Declaration on Transport Development in Asia (ESCAP, 2009);

- Increase competition in rail operations. Promoting competition in above-rail services has been advocated by many as a strategy for improving operating efficiency, although the real benefits of this approach continue to be debated (Pittman and others, 2007; Drew, 2006);
- Road pricing. A shift to rail would also be encouraged, if the prices paid by road freight vehicles reflect the full cost of road use, including the congestion costs and externalities, as well as the cost of road provision and road wear. However, several studies have suggested that the scale of the impact of road pricing on freight mode choice may be small (Productivity Commission, 2006).

Increasing use of water transport

For cargoes that transit urban areas to access port facilities, the use of water transport may provide an alternative to road transport. Barges account for a substantial and growing proportion of cargoes delivered to some European ports. Many of the important ports of Asia are located on or near major rivers (for example, Shanghai, Shenzhen, and Ho Chi Minh), and in some cases the delivery of containers by barge already plays a major role (United States Department of Transport, 2008).

In other instances, there is a potential to substitute coastal shipping movements for long road movements that transit major cities: for example, for cargoes produced in Southern Thailand and travelling to Khlong Toey or Laem Chabang ports.

Greater use of sea and river transport could be encouraged by:

- Reducing cargo handling costs. Generally, water transport is very competitive if terminal costs are excluded, but terminal costs tend to be higher than for other modes;
- Improving non-price characteristics of water transport. Reliability of services, and risk of damage to (or loss of) cargo are important considerations for shippers, and water transport often performs poorly in this respects. Improved security at inland points of loading or discharge, provision of customs clearance facilities at these ports, and the improvement of navigational aids on inland waterways can all play a part in improving the non-price characteristics of water transport;
- Providing dedicated port facilities for barges and coastal shipping. Greater use of water transport can also be encouraged by proper facilities are available for use by barges and coastal shipping.

D. Reducing the number of trips

Increase load carrying capacity of individual vehicles

Economies of scale in operation are present in almost all transport modes. The environmental impact per unit of cargo carried also tends to decrease as the scale of the operating unit increases. One Australian study has estimated that the substitutions of B-Doubles[3] for standard articulated vehicles on inter-State trips could lead to a reduction of approximately 33 per cent in the number of urban vehicle movements generated by this freight task (Hassall, 2005).

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[3] B-Doubles mean a combination consisting of a prime mover towing 2 semi-trailers.

Supporting measures that can help to increase the payload per trip include:

- Improved road and rail infrastructure. In the case of road transport, this may require strengthening of bridges and pavements; or widening or other improvements to the road alignment. In the case of rail, it may also require bridge strengthening, the provision of additional passing loops, and the extension of terminal facilities;
- Special limits on designated freight routes. Controls on the mass and dimensions of freight vehicles need not apply equally to every element in the network. Permitting the use of vehicles that exceeds general limits on particular parts of the network, where the negative impact is small and the economic benefit is large, can significantly reduce the number of trips required to perform the freight task;
- Performance-based standards. Traditional dimensional limits are set conservatively, so that regulators can be reasonably confident that, for example, all vehicles that are below the length limit will meet regulatory requirements. Performance-based standards provide greater scope for innovative design that allows vehicles to be larger and carry greater loads while still meeting regulatory requirements designed to protect infrastructure assets and promote safety.

Improve load to capacity ratios

Much of the time, urban freight vehicles run empty. And even when they are carrying loads, the loads that are carried are often much less than the capacity of the vehicle. There are a number of things that can be done to improve load factors (load to capacity ratios), and achieving these improvements will allow the same freight task to be performed with fewer vehicle trips.

Private sector trip planning will be the main mechanism for improving load to capacity ratios. But there are a number of things that Governments can do to encourage and support private sector operators in effecting improvements.

- Developing of urban freight centres. The potential for the development and promotion of urban freight centres to facilitate the consolidation of freight has been explored in detail by Wisetjindawat (2010b) and Min (2010). Consolidation of freight can reduce the number of freight vehicle movements by both permitting the use of larger vehicles and by increasing load factors;
- Access privileges. Another strategy for encouraging freight consolidation is to provide privileged access for freight vehicles operating at high load factors. This approach is most obviously applicable in the case of port-related container traffic transiting urban areas;
- Freight matching. Access to real-time information on freight availability can also provide opportunities to improve truck utilization;
- Encouraging industry consolidation. The trucking industry in most countries is highly fragmented. Coordination and timely exchange of information are particularly difficult in very fragmented industries, and encouraging industry consolidation has been advanced as a possible solution to these problems. However, the advantages of pursuing this direction must be considered in the light of the economic advantages of promoting competition in the road freight industry as well as the social advantages of providing opportunities for SME development.

Change logistics systems that generate excessive vehicle movements

Modern supply chain practices made supply chains more transport-intensive, and in so doing have increased the environmental burden of freight transport (Nathan, 2007).

Supply chain decisions are overwhelming made by private sector actors in response to market signals, including the cost of alternative distribution strategies. However, measures that change the balance of incentives with which they are faced can re-shape these decisions. These measures could include:

- Road pricing. In many jurisdictions the prices paid for use of the road system often do not reflect the full cost of road use (Pomlaktong and others, 2010). Adjusting road prices will increase the cost of transportation relative to the cost of inventories, and may induce a reconsideration of the intercity transport of logistics practices.
- Increasing fuel taxes. Sustainability considerations may include lower transport intensity of logistics operations beyond the point that would be ideal if only economic considerations were of concern. In this case, higher fuel taxes will increase incentives to reconsider logistics practices.

E. Reducing the impact of each trip

Switch to more environmentally friendly energy sources

The range of alternative fuel options for urban freight transport extends for incremental improvements such as the addition of ethanol to fossil fuel and the use of bio-diesel through to the use of fully electric vehicles (GTZ 2005). Battery-powered trucks with capacities of up to 12 ton are a proven commercial proposition.

Governments can support the switch to the use of more environment friendly fuels in urban freight transport by:

- Subsidies/tax concessions for electric or hybrid vehicles. Production costs of electric vehicle still exceed those of internal combustion engines. While this cost disadvantage will be overcome by large scale electric vehicle production, in the short to medium term some fiscal support, preferably in the form of research and development, may be necessary. (Freedonia, 2009);
- Infrastructure support. One of the obstacles to the widespread use of alternative fuels is the lack of an adequate energy supply infrastructure (Wisetjindawat, 2010b). Both regulatory and incentive policies can be used to support the development of adequate infrastructure;
- Differential levels of fuel taxation. Many countries, including Australia, Japan and the Republic of Korea, use differential rates of fuel tax to encourage the use of fuels that are considered to be less environmentally damaging;
- Access privileges. Localized problems, caused by emissions from motor vehicles - including freight vehicles, can be particularly intense in specific urban areas, for example, in and near the central business district. Restricting access to these areas to any but low- or zero-emission vehicles, either completely or during particular periods, can help to promote the adoption of environmentally friendly technologies;
- Public sector purchasing policies. A number of Governments have adopted or are considering purchasing policies that require that a certain percentage of the

government fleet consist of hybrid or other low emission vehicles (see, for example, Commissioner for Environmental Sustainability, 2006).

Improved vehicle design and maintenance

Choices that are made in vehicle design and maintenance can have a material effect on the environmental performance of urban freight transport, both through increasing fuel efficiency and through ensuring that each litre of fuel burned produces the lowest possible quantity of pollutants. A recent report undertaken by the United States of America Transportation Research Board identifies potential fuel consumption savings from various initiatives, ranging from 11 to 35 per cent (Transportation Research Board, 2010).

Possible government actions to encourage improved vehicle design and maintenance include:

- Improved Design rules/registration requirements. While some ESCAP countries, such as, Japan, already have in place very strict design requirements for new heavy vehicle, the Clean Air Initiative has shown that most countries' standards lag well behind what might be regarded as 'best practice' (ADB/CAI-Asia, 2006);
- Differential road pricing. Ideally, road user changes should vary with the environmental performance of freight vehicles. The principles of price setting, according to European Directive 1999/62/EG, make differentiation on the grounds of environmental performance a mandatory feature of road pricing schemes in Europe (Rottengatter and Doll, 2002);
- Stricter enforcement of emissions standards. The adoption of strict environmental standards for motor vehicles will only be effective if it is backed up by effective enforcement of such standards;
- Education on good vehicle maintenance practice and minor design changes. Many of the vehicle maintenance practices and minor design changes that would result in improved environmental performance also reduce fuel consumption. Fabian (2010) reported a pilot project in Guangzhou that focuses on the minor design improvements to an existing truck fleet which has resulted in a reduction of fuel consumption of 12 per cent and a payback period of 1.8 years for the required investment.

Improved driving practices

According to the Victorian Transport Association, a "driver's level of skill can effect fuel use by up to and in excess of 35 per cent" (VTA, 2009). Although savings of this magnitude are likely to be rare, it is clear that driver behaviour can have a significant effect on the environmental impact of freight vehicles operations. The United States Environmental Protection Agency (USEPA) cites a Canadian study which estimates that many fleets could achieve a 10 percent fuel economy improvement through driver training and monitoring. (USEPA, undated).

Moreover, driver behaviour is one aspect of the freight transport system that can be changed quickly and at little cost. Most of the techniques required to improve fuel efficiency are simple:

- Sponsorship of/support for driver training programmes;
- Supporting the introduction of real time performance monitoring technologies. Continued application of the lessons learned in driver training courses will be

encouraged by the presence of in-cab real-time performance monitoring equipment that provides continuous feedback on fuel consumption performance.

Create better operating conditions

The environmental performance of freight transport can also be improved by improving the conditions in which freight vehicles operate. Operating on poorly designed or poorly maintained infrastructure, or in congested conditions, increases fuel consumption per ton-kilometre carried, and consequently the GHG emissions and pollution associated with carrying the freight task increases. These factors lower vehicle productivity, which in turn requires greater number of vehicles to perform the task, increasing the demand on material resources consumed in the manufacture of these vehicles. Additionally, they may also increase other environmental impacts.

There is a choice of interventions that Governments could make to create better operating conditions for urban freight transport:

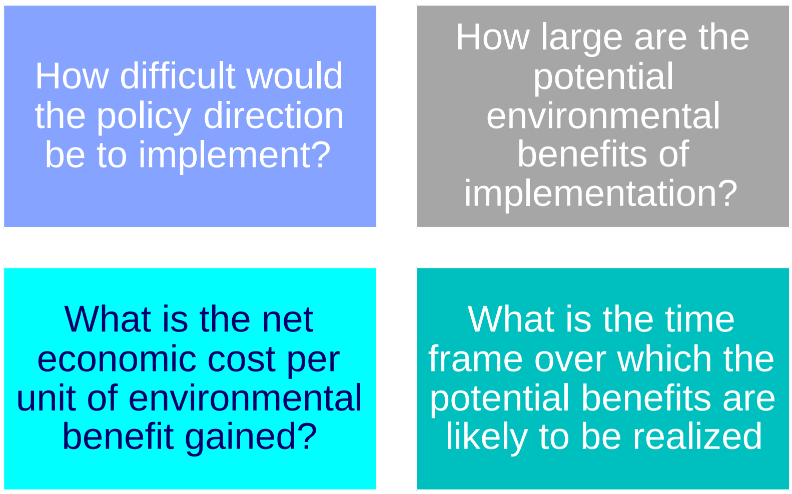
- Infrastructure investment. For both road and rail transport, fuel consumption and noxious emissions can be reduced if smooth operating conditions are maintained throughout the journey. This may require the elimination of steep grades, at-grade crossing and tight horizontal curves; the provision of smoother road surfaces and more stable rail tracks will also help;
- Introduction of intelligent transport systems. Improving the quality of the information available to truck drivers can also make a contribution. In particular, detailed real-time information on traffic conditions can lead to better decisions on which route to take, and may also, to a lesser extent, influence decisions on when to travel;
- Time of day pricing. Charging different road, or terminal access, prices at different times can reduce congestion and improve operating conditions.

F. Assessing policy priorities

There is a wide range of policies available that would increase the sustainability and improve the eco-efficiency of urban freight transport. Deciding what policies to implement, and in what order, is a complex and difficult question; the answer to that is likely to vary from country to country and from time to time.

Figure 4 suggests a framework that could be adopted for assessing priorities amongst policies to improve the sustainability and eco-efficiency of urban freight transport.

Figure 4. Proposed criteria for a preliminary assessment of policy priorities



IV. METRICS FOR SUSTAINABILITY AND ECO-INDICATORS

A. ESCAP Eco-efficiency indicators

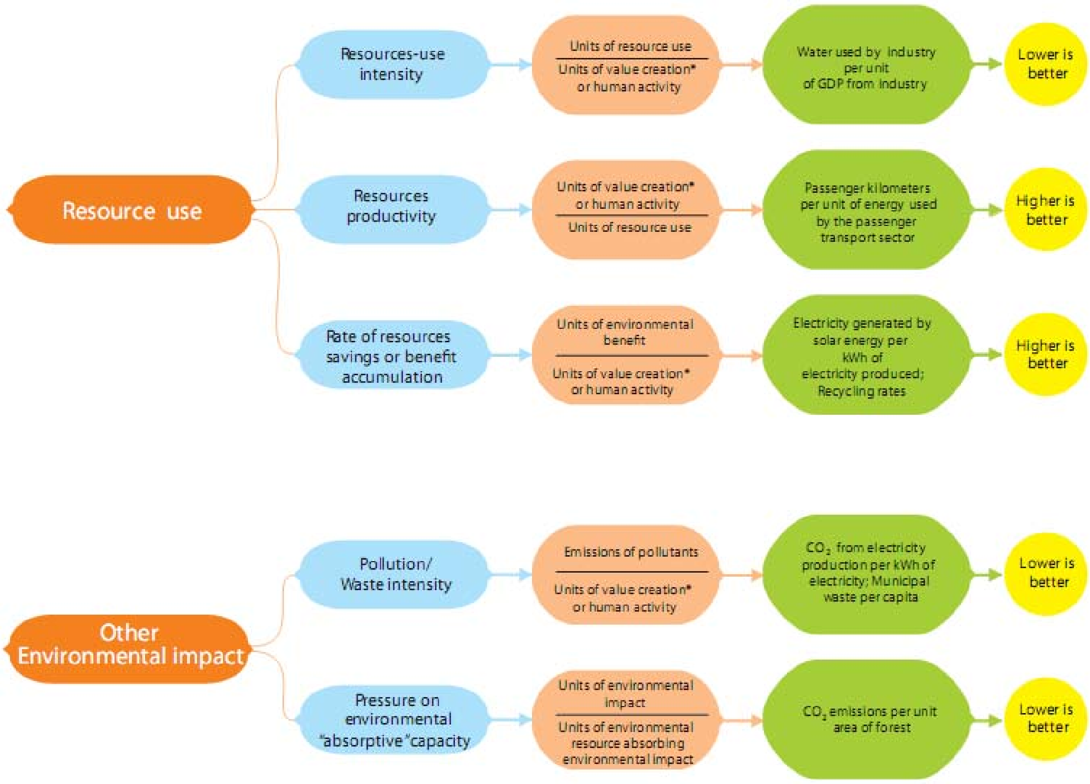
General approach

The ESCAP "State of the Environment in Asia and the Pacific 2005: Economic Growth and Sustainability" report directly addresses the challenge of scaling up a concept designed for use at the level of the firm to a concept that can be applied at the city, regional or national level:

> "However, the types of eco-efficiency measure used at the firm level cannot reflect the wide range of human activities that comprise any economy and that impact on natural resource use, produce waste or pollution or change landscapes. Scaling up eco-efficiency concepts and applying them at the national level, therefore, requires the examination of a wide range of economic driving forces, reflecting production and consumption activity, as well as the basic human activities that contribute to economic growth and increased human welfare." (ESCAP, 2006, pp.143-144).

The report, therefore, adopts a "back to basics" approach that centres on a clear flow of ideas from the identification of domains of environmental impacts, such as resource use, other environment impact) through to the specification of a relevant eco-efficiency indicator. This process is summarized in figure 4 below.

Figure 5. A coherent framework for potential eco-efficiency measures



Source: ESCAP, 2006

The report also makes some general comments on the design and use of eco-efficiency indicators that are very pertinent to the current discussion. The report suggests:

> "To serve as useful indicators of environmental sustainability, eco-efficiency measures should:
>
> 1. Not be interpreted as measuring total levels of pressure on the environment...
> 2. Be appropriate for the context. In particular, they should be used with caution in situations of resource scarcity...
> 3. Be used to monitor changes over time...
> 4. Facilitate comparisons between economic sectors. Economy-wide eco-efficiency measures ...are strongly influenced by economic structures and can be far less policy-relevant...
> 5. Not be constructed in a way that can send mixed signals.
> 6. Be chosen carefully to ensure their relevance to the societies and countries concerned…" (ESCAP, 2006).

Transport indicators

The framework shown in figure 5 is attractive. It is coherent and pitched at the appropriate level to serve as a general guide to policy formulation. However, the report stops short of full articulation of a suitable set of indicators by industry.

In a later paper, Nam (2008) goes some way towards supplying this deficiency by proposing key indicators for major industry sectors (see table 1).

Table 1. Eco-efficiency indicators by industry sector

	Resource use intensity	Environmental Impact Intensity
Transport	Energy intensity of passenger kilometre	Carbon intensity per passenger kilometre
Energy (production)	Share of renewable energy	Carbon intensity of electricity
Manufacturing	- Water intensity of GDP - Energy intensity of GDP	- Carbon intensity of GDP - Air and water pollution per GDP
Commercial building	Energy use per unit area	Share of energy consumption
Household/Residential	- Water consumption per dollar of household expenditure - Energy consumption per dollar of household expenditure	Non-recyclable domestic waste production per dollar of household expenditure

Source: Nam, 2008

However, the focus of the indicators suggested by Nam is on passenger rather than freight transport.

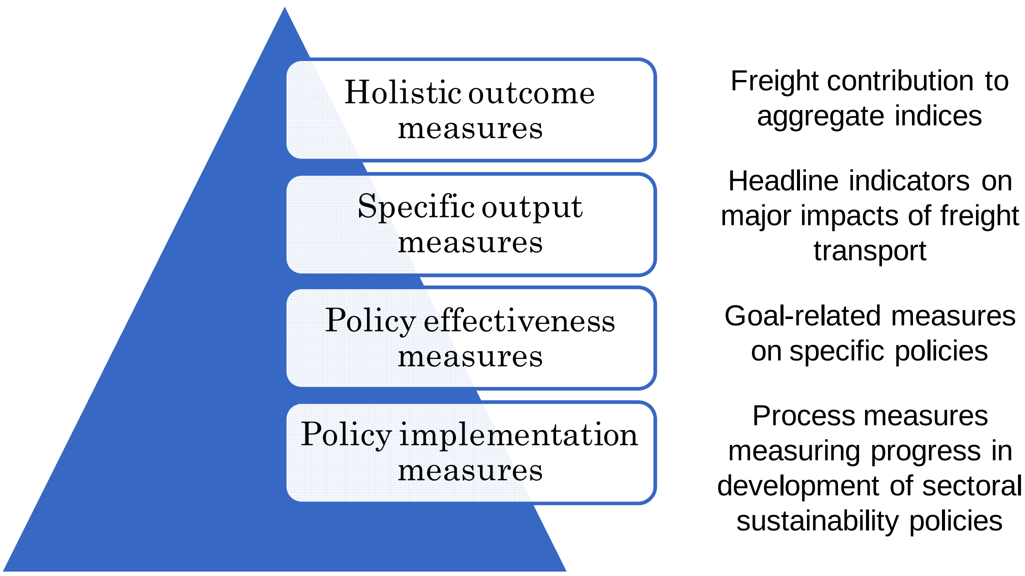
B. A framework for urban freight transport

In this section, therefore, an attempt has been made to construct a framework, designed to meet the specific needs of the urban freight sector. The framework is generally consistent with that of the ESCAP "State of the Environment in Asia and the Pacific 2005" report but also incorporates from a range of other reports (in particular, Global Reporting Initiative, 2006; OECD, 2003; OECD, 2006). However, the framework is not specifically modelled on any one of these.

A hierarchical approach

The proposed framework, summarized in figure 6, uses a hierarchical approach to defining sustainability and eco-efficiency indicators.

Figure 6. A hierarchical approach to measuring sustainability and eco-efficiency



At the top level of the hierarchy are outcome measures, designed to measure the contribution that freight transport makes to consolidated indicators of the impact of a society's activities on the natural environment. These are intended both to track the impact of freight transport on reaching the ultimate objective of achieving more with less, and to allow the assessment of progress in the freight transport relative to progress in other industry sectors. At this level, sustainability and eco-efficiency measure are separately defined.

The second level indicators are the core indicators which focus the specific impacts of the freight industry. At this level, outcomes on the specific dimensions of environmental impact are separated out, and individual measures developed to track the progress that is being made along each dimension. Once again, at this level, sustainability and eco-efficiency measure are separately defined.

The third level focuses on the measurement of the success of policies designed to improve environmental performance, rather than on directly measuring the improvements themselves. Inclusion of this level of measurement allows policy makers to monitor where a specific policy instrument is working in the way in which it is intended. At this level, the distinction between measuring sustainability and measuring eco-efficiency disappears.

At the fourth level are process measures. These measures, which now play a very large part in the Global Reporting Initiative (GRI) Framework[4], monitor the development and implementation of green policy measures. Including these measures allows the level three measures to be more accurately interpreted. For example, it allows the policy maker to gauge whether the failure of a policy to meet its intended goals is due to defects in the policy itself, or to defects in the way in which it is implemented. More directly, it can also provide a measure of the level of practical commitment to the pursuit of sustainability and eco-efficiency improvements.

Outcome measures (Level 1)

(a) Core dimension of environment impact

The proposed outcome measures would focus on the two core dimensions of environmental performance identified in the cited earlier ESCAP report. In that work, these dimensions are identified as: 'resource use' and 'other environment impact'. The second descriptor is not specific enough to provide, by itself, much guidance on the content of this dimension, but an examination of figure 5 suggests that it is concerned with what is known as 'environmental stress': the deleterious impact on the environment of human activity.

The fundamental distinction between these two dimensions of environmental impact is that our concern with resource depletion is ultimately an economic one, whereas our concern with environmental stress transcends economics. Resource depletion matters, because excessive consumption of resources today means that these resources are not available for the future consumption, and this may mean lower living standards for future generations. If a cheaper renewable substitute for crude oil in all its uses miraculously became available tomorrow, we would no longer be concerned about the rate at which we are using up our oil reserves. However, we should still be concerned of the rate at which we are consuming crude oil not because it may one day be all gone, but because in the process of consuming, it emits GHGs and other pollutants that put stress on the environment.

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4 The Global Reporting Initiative (GRI) Framework provides the sustainability reporting guidelines that are the worldwide standard for corporate reporting on social and environmental performance. The Framework was developed through an international multi-stakeholder process, and adopted by major corporations. The Framework's comprehensive guidelines include principles for ensuring report content and quality, and define 49 core performance indicators along with 30 additional indicators and sector supplements.

As the example above shows, the two dimensions of environmental impact may be intertwined. Nevertheless, they are conceptually distinct, and from a policy perspective it is best to maintain this distinction.

(b) Practical considerations

From a practical perspective, devising outcome measures is by far the most difficult task. This is mainly because they will necessarily rely on the use of composite indicators of environmental impact, and developing credible composite indicators is extremely difficult. But it is also because, even after the way in which the composite index will be constructed is agreed, gathering all of the data required to calculate it is likely to be a major task.

Some measurement frameworks make use of measures of total material resource consumption. However, all must face the challenge of how to combine different types of resources, for example, should one kilogram of uranium be regarded as the same as one kilogram of iron ore; and of where the boundaries of relevant measurement lie.

Similar concerns arise in the definition of the environmental stress caused by freight transport. One established candidate is the use of 'ecological footprint'. However, the construction of this indicator remains contentious, and in any event it incorporates both environmental stress and resource depletion elements.

In the absence of adequate composite measures, and given the difficulty of assembling the relevant data, it may be desirable to defer the articulation and implementation of these measures, and focus on the other three levels of the hierarchy. An alternative would be to construct a relatively simple proxy that could act as an interim substitute for both of these measures. This could be done by constructing an index based on the weighted average ton-kilometres of travel by freight vehicles where:

C_1 is the average freight capacity, in tons, of vehicles of type 'i' (basing the index on available freight-capacity rather than actual freight carried allows the index to capture the effect of improvements in vehicle utilization)

K_1 is the total kilometres of travel by vehicles of type 'i'.

W_1 is the weight assigned to vehicles of type 'i'.

The number of vehicle classes used in constructing the index could be varied depending on the quality of available data. Ideally, it would include at least two or three categories of truck as well as (where relevant) at least one train and barge. The sophistication with which the weights to be assigned to each vehicle type are derived will also vary depending on the quality of available data. Generic (internationally derived) values for relative fuel consumption for vehicles of different types could serve as default values, with gradual refinement as a greater understanding of the total environmental impact of various vehicle types in a particular environment becomes better understood. Weights could also be adjusted over time as improvements in vehicle technology or emission standards reduce the impact per vehicle-kilometre travelled.

(c) Proposed outcome measures

The proposed outcome measures, both ideal and interim proxy, are set out in table 2 below.

Table 2. Proposed outcome measures

IDEAL: Ecological stress caused by freight transport activities	Ecological stress caused by freight moved per unit of GDP
IDEAL: Total material requirement from freight transport activities	IDEAL: Total material requirement per ton-km per unit of GDP
PROXY: Weighted ton-km of travel by freight vehicles	PROXY: Weighted ton-km of freight moved per unit of GDP

Headline indicators of major impacts (Level 2)

Freight transport, and particular urban freight transport, affects the environment in a number of ways. It is tempting to strive for comprehensiveness and include a wide range of indicators to reflect all of these impacts. However, using fewer, more clearly targeted indicators will help to ensure consistency and clarity of interpretation.

There appears to be an implicit consensus in the relevant literature that the three critical issues for freight transport are:

- Resource depletion: the consumption of fossil fuels
- Environmental stress: GHG emissions
- Environmental stress: Air pollution

The proposed headline indicators set out in table 3 below therefore focus exclusively on these three key issues.

Table 3. Headline indicators for the impact of freight transport

Petroleum fuel consumption by freight transport	Fuel consumed per ton-km of freight carried
Aggregate GHG emissions for freight transport	GHG emissions per ton-km of freight carried
Composite measure of emissions [5]	Composite emissions per ton-km of freight carried

Policy effectiveness measures (Level 3)

The level 1 and level 2 measures discussed focus directly on the outcomes that green policies on freight transport are seeking to achieve: increasing the efficiency of fossil fuel use in freight transport and reducing the environment stress resulting from freight transport operation.

But in order to achieve these outcomes, governments seek to change behaviour in various ways, and it is important to track these behavioural changes themselves as well as the environmental outcomes that they are intended to achieve. The information gathered in this process can be used to change or refine policy directions.

[5] One possible approach to developing a composite measure emission is to use the weights assigned to each type of emission in the computation of the air quality index.

In section II (B), the concept of 'attack points' was introduced, and these attack points were used as a way of categorising the various policies that a Government may wish to pursue.

Level 3 measures are designed to measure progress on these attack points. Suitable measures for each attack point are set out in table 4 below. It may be noted that these measures are not eco-efficiency indicators, but simply provide guidance on whether policies to improve eco-efficiency are working.

Table 4. Policy effectiveness measures for each attack point

Reduce the volume of freight moved	Freight tons/unit of GDP
Reduce the distance over which freight is moved	Freight ton-kilometres/freight tons
Change mode of transport	Modal shares of freight transport (ton-km)
Reduce number of vehicle movements	Ton-km per vehicle (veh)-km for each mode
Reduce impact of each vehicle movement	Fossil fuel consumption per veh-km by mode Pollution emissions be veh-km by mode

Measures of policy implementation (Level 4)

The measures proposed for levels 1 to 3 are strictly quantitative. By contrast, level 4 measures are concerned with the development and implementation of policies to achieve improvements in the environmental performance of freight transport. They are essentially process measures, and not amenable to quantification.

In this sense, process measures are closely akin to many of the measures that are now included in the GRI reporting framework. Many of these measures require respondents to document what they are doing to promote improved performance again a particular goal, as well as measure progress against the goal. In cases where measuring progress against the goal is very difficult, process measures are to be used instead of progress measures.

Section II discusses a large number of policy options from which a Government may choose in an endeavour to improve the environmental performance of freight transport. The scope of the level 4 indicators will vary depending on which policy a Government chooses to pursue.

A fully developed set of level four indicators would include:

- Clear articulation of the policy directions that a Government intends to pursue in order to improve environmental performance, for example, to encourage a switch to more environmentally friendly energy sources;
- Details of the supporting measures that will be used to implement this policy, for example, in the case of encouraging the use of greener energy sources; encouraging research and development on new fuel sources; differential taxation of various energy sources; privileged access to certain infrastructure for vehicles meeting certain environmental performance standards; subsidies for electric or hybrid vehicles; and public sector purchasing policies to encourage the purchase of environmentally friendly motor vehicles;
- An implementation programme for each of these supporting measures, including commitment dates for legislative, regulatory and contractual changes; and, where relevant, proposed budgetary allocations;

- A checklist, allowing ready comparison of performance against the documented implementation programme.

IV. Summary

To measure the progress in achieving the desired policy outcomes, the paper recommends maintaining a tight focus on the most important dimensions of performance. It recommends the development of a hierarchy of performance measures for tracking at the top level of the hierarchy. These are outcome measures, designed to measure the contribution that freight transport makes on the natural environment. The second level indicators are the core indicators which focus on the specific impacts of freight industry. The third level focuses on the measurement of the success of policies designed to improve environmental performance and the fourth level consists of process measures.

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