TOWARDS AN ENVIRONMENTALLY-SUSTAINABLE FREIGHT TRANSPORT SYSTEM:
SETTING THE SCENE

by

Mr. Alan McKinnon
Professor and Head of Logistics
Kühne Logistics University (KLU), Hamburg

14 October 2015

This expert paper is reproduced by the UNCTAD secretariat in the form and language in which it has been received. The views expressed are those of the author and do not necessarily reflect the view of the United Nations.
Towards an Environmentally-Sustainable Freight Transport System:

Setting the Scene

Professor Alan McKinnon

Kuehne Logistics University

Sustainable Freight Transport Systems Meeting
UNCTAD

Geneva
October 2015
Climate Challenge for the Freight Transport Sector

5th Assessment Report of the IPCC

**Transport:**

- **2010:** 7 billion tonnes of CO₂
- **2050:** 12 billion tonnes of CO₂

2050 limit on CO₂ emissions from all activity: **20 billion tonnes**

To retain its 14% share transport must reduce CO₂ emissions to **2.8 billion tonnes by 2050**

**freight transport = one of the hardest sectors to decarbonise**

On a BAU basis, freight share of total carbon emissions likely to rise from **7% (2010)** to **16% (2050)**
Potential for Decarbonising Freight Transport in 15 Countries: 2010 - 2050

- Decoupling of freight tonne-km from GDP
- Decoupling energy use from freight t-km
- Decoupling freight energy use from related emissions

<table>
<thead>
<tr>
<th>Country</th>
<th>2010 t-km/$</th>
<th>2010 toe/thousands of t-km</th>
<th>2010 tCO₂/toe</th>
<th>2050 t-km/$</th>
<th>2050 toe/thousands of t-km</th>
<th>2050 tCO₂/toe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>n.c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>n.c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>n.c.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other Freight Transport Pollutants

Average Exposure to PM10 in 1600 Urban Areas (2008-2013)

* The mean annual concentration of fine suspended particles of less than 10 microns in diameters is a common measure of air pollution. The mean is an urban population – weighted average from cities with available air pollution measures.

Transfer of Green Freight best practice from developed to developing countries?
International Variations in Green Freight Parameters

- **Sulphur content in Diesel Fuel (2014)**
  - Source: www.transportpolicy.net (ICCT / Dieselnet)

- **National emissions standards for diesel trucks (2014)**
  - Source: www.transportpolicy.net (ICCT / Dieselnet)

- **Average age of national truck fleet**

- **Index of road infrastructure quality**
  - WEF Global Competitiveness Report 2014-15

- **Truck design and capacity**

- **Tyres**
Forecast growth of global truck market: 2014-2024

Source: Deloittes – ‘Truck Market 2024’
Scope of a Green Logistics Programme

- Supply Chain Structure
- Logistics System Design
- Vehicle Routing and Scheduling
- Vehicle Loading
- Driving
- Vehicle Maintenance
- Vehicle Technology

emissions per vehicle-km

total emissions

total vehicle-kms

emissions per vehicle-km

total vehicle-kms
Analytical Framework for Green Logistics

Relationship between economic output and logistics-related externalities

- Weight of goods produced / consumed
- Weight of goods transported by road
  - Road tonnes-lifted
  - Road tonne-kms
- Total vehicle-kms
  - split of vehicle-kms by vehicle size, age, weight and type
- Timing of deliveries
  - spatial pattern of delivery
- Energy efficiency
  - emissions per unit of energy
    - greenhouse gases
    - other noxious gases

Logistics-related

- modal split
- average handling factor
- average length of haul
- average load on laden trips
- average % empty running

vehicle / technology-specific

- supply chain structure
- efficiency of vehicle routing
- vehicle carrying capacity by weight / volume
- vehicle utilisation on laden trips
- level of backhaulage

Driving behaviour
- Vehicle technology
- Vehicle maintenance
- Vehicle purchasing

ENERGY CONSUMPTION IN WAREHOUSING AND TERMINALS

ENERGY CONSUMPTION IN FREIGHT TRANSPORT

ENVIRONMENTAL IMPACT OF LOGISTICS OPERATIONS
Scoping of Logistics Interventions

logistics ≠ transport

delimiting the boundary around logistics initiatives

transport
- fleet management
- delivery scheduling
- modal split
- backloading
- control tower

logistics
- network design
- cross-docking
- port-centric logistics
- primary consolidation
- vertical collaboration
- horizontal collaboration

related operations
- order processing
- materials handling
- procurement
- vertical collaboration
- horizontal collaboration

business
- recycling
- packaging
- sales and operations planning
- outsourcing
- sourcing
- vendor managed inventory

single company
multi-business
Plotting a greener logistics development pathway

- Economic development
  - Improvements to transport infrastructure – mainly road
    - Centralisation
    - Increased length of haul
  - Increased freight transport intensity: ratio of tonne-km to output
    - Growth in output
  - New industrial / warehousing development not rail-connected
    - Industrialisation
  - Change in commodity mix
    - New patterns of consumption
    - Increasing length of haul
    - Increased freight transport intensity: ratio of tonne-km to output
    - Growth in output
    - New industrial / warehousing development not rail-connected
    - Industrialisation
    - Change in commodity mix
    - New patterns of consumption
  - Decline in rail freight
    - Stronger just-in-time pressures
    - Poorer utilisation of vehicle capacity
  - In less full vehicles
  - By less green mode
  - Higher externalities per unit of freight moved
    - Greater environmental degradation

- Opportunities for deviating from the conventional pathway
  - Land use planning policies for logistics
  - Supply chain IT and analytics to optimise flows

- Economic development
  - Much more freight being moved
  - By less green mode
  - In less full vehicles
  - Growth in output
  - New patterns of consumption
  - Higher externalities per unit of freight moved
  - Greater environmental degradation

- Establish multi-modal logistics hubs
  - Upgrade rail infrastructure and services

- Internalise environmental cost – rebalance logistical cost trade-offs
  - Online freight exchanges to maximise backloading
  - Promote supply chain collaboration

- IBM supply chain maturity model (2005)
Logistics interventions: challenges and constraints

- capital investment
- internal business process
- external links
- infrastructure
- regulation

increasing difficulty

- property
  - IT
  - vehicles
  - materials handling

- congestion
- capacity
- connectivity
- inter-operability

- competition law
- vehicle regulation
- land use controls
- corruption

trade-offs with other company activities and functions

transactional outsourcing collaborative

'low-hanging fruit'
Future economics of greening logistics activities?

How does the shape of the curve vary with a country’s level of economic development?

- harvesting low hanging fruit
- investment in low emission technologies
- internalisation of environmental costs

Future economics of greening logistics activities?

Adapted from Tavasszy (2014)
Company targets to reduce the carbon intensity of logistics

<table>
<thead>
<tr>
<th>company</th>
<th>normaliser</th>
<th>time period</th>
<th>% carbon reduction target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutsche Post / DHL</td>
<td>‘every letter and parcel delivered, every tonne of cargo transported and every sq.m. of warehouse space’</td>
<td>2007-2020</td>
<td>30%</td>
</tr>
<tr>
<td>DB-Schenker</td>
<td>Tonne-km</td>
<td>2006-2020</td>
<td>At least 20%</td>
</tr>
<tr>
<td>UPS</td>
<td>UPS Transportation Index</td>
<td>2010-2017</td>
<td>5%</td>
</tr>
<tr>
<td>UPS Airlines –Global</td>
<td>Pounds of CO₂ emitted for every ton of capacity transported on nautical mile</td>
<td>2005-2020</td>
<td>20%</td>
</tr>
<tr>
<td>Fedex (aircraft)</td>
<td>available ton mile (ATM)</td>
<td>2005-2020</td>
<td>20%</td>
</tr>
<tr>
<td>TNT (Mail and Express)</td>
<td>not specified</td>
<td>2007-2020</td>
<td>45%</td>
</tr>
<tr>
<td>Maersk Line</td>
<td>not specified</td>
<td>2007-2020</td>
<td>25%</td>
</tr>
<tr>
<td>NYK</td>
<td>‘unit of transportation from vessels’</td>
<td>2006-2013</td>
<td>10%</td>
</tr>
</tbody>
</table>

Source: McKinnon and Piecyk, 2012

40% improvement in carbon intensity of global logistics between 2010 and 2020

Reconciling corporate carbon intensity targets with absolute targets of governments

EU 2011 Transport White Paper target: 60% reduction in TOTAL CO₂ from transport by 2050
Assessing the effect of **external** factors on the decarbonisation of logistics

**TIMBER framework**

categories of external factor

- Technology
- Infrastructure
- Market
- Behaviour
- Energy
- Regulation
Assessing the effect of external factors on the decarbonisation of logistics

TIMBER framework

categories of external factor

Technology  Modal split
Infrastructure
Market
Behaviour
Fuel efficiency
Energy
Energy mix
Regulation
Assessment of the Influence of External Factors on Logistics Decarbonisation

Europe: Germany / Austria / Switzerland, UK, Netherlands, France, Italy
North America: US, Mexico
Asia: China, India, Indonesia
Africa: South Africa

Publication of final report in November 2015
Professor Alan McKinnon

Kühne Logistics University – the KLU
Wissenschaftliche Hochschule für Logistik und Unternehmensführung
Grosser Grasbrook 17
20457 Hamburg

tel.: +49 40 328707–271
fax: +49 40 328707–109

e–mail: Alan.McKinnon@the-klu.org
website: www.the-klu.org
Examples of General Recommendations to Companies

TECHNOLOGY (T1-8)

1. Review available data (in main report) on potential carbon savings from truck technologies, future trajectories, uptake rates and cost effectiveness
2. Assess client expectations of future level of carbon emissions from their logistics operations and willingness to pay for low carbon technologies (LCTs)
3. Regularly recalibrate carbon modelling tools to reflect impact of LCTs, especially in countries with tightening fuel economy standards
4. Take advantage of any government schemes for vehicle scrappage and/or incentivising the purchase of lower CO₂ vehicles
5. Partner with vehicle and equipment manufacturers to pilot new LCTs in logistics
6. Exchange information with shippers / clients on new logistics-related LCTs, either directly or through green freight organisations
7. Establish joint initiatives with larger shippers / clients to develop/trial of new LCTs
8. Assess options for switching to alternative fuels: systematic reviews of the cost, quality, availability and carbon intensity of alternative fuels

INFRASTRUCTURE (I 1-6)

1. Review available data (in main report) on infrastructural trends and developments and their likely impact on carbon intensity
2. Take full account of planned road improvements in the planning of DC locations and delimitation of their service areas
3. Assess the effect of planned changes in rail/water-borne/intermodal infrastructures on the relative attractiveness of a shift to lower CO₂ modes
4. Ensure that vehicle routing systems are sensitive to changes in the quality/reliability of road and rail networks
5. Take account of fuel consumption and CO₂ emissions when planning vehicle routes and schedules
6. Work with shippers / clients to find ways of rescheduling deliveries into off-peak periods to minimise impact of congestion on CO₂ emissions
Rating of TIMBER recommendations by ease of implementation and potential CO$_2$ saving
TIMBER Scenario 1: OPTIMISTIC

**Technology**
- Rate of technology advance and uptake in the logistics sector at upper end of projections
- More rapid diffusion of low carbon technologies (LCTs) to developing countries / emerging markets
- IT advances (e.g. analytics, big data and cloud computing) translate into much greater CO₂ efficiency

**Infrastructure**
- Congestion minimised by capacity increases, improved infrastructure management and road pricing
- Prioritised investment in rail, inland waterways and ports promotes significant shift to these alternative modes
- Extensive gas refuelling and battery-recharging networks in place

**Energy**
- Rate of decarbonisation of grid electricity at upper end of projections
- 2nd and 3rd generation biofuels shown to yield significant net GHG savings at affordable cost
- Extensive use of micro-generation at logistics facilities where climatic conditions are favourable

**Behaviour**
- Eco-driving is standardised by compulsory training
- Electronic monitoring of driver behaviour becomes universal
- In-cab guidance systems, smart cruise control and ultimately automation over-ride deficiencies in driver behaviour

**Market**
- Large increase in horizontal and vertical collaboration in FMCG supply chains
- Full harmonization of carbon auditing and reporting by logistics providers and carriers
- Load fill and minimization of transport CO₂ prioritised over inventory reductions
- Competitiveness of rail-freight services enhanced by liberalization / privatization and corridor planning

**Regulation**
- Truck size and weight limits are relaxed with measures to minimise adverse effect on rail’s market share
- More governments introduce vehicle scrappage schemes to accelerate adoption of LCT across the truck fleet
- Proliferation and harmonization of national fuel economy standards for trucks
TIMBER Scenario 2: PESSIMISTIC

**Technology**
- Rate of technology advance and uptake in the logistics sector at the lower end of projections
- Diffusion of low carbon technologies (LCTs) to emerging markets restricted by cost factors, import controls etc
- Business practices and corporate governance prevent IT innovations from being fully exploited

**Infrastructure**
- Traffic growth exceeds additional infrastructural capacity increasing congestion and related CO$_2$ emissions
- Limited improvement to rail and water-borne infrastructures as investment in passenger rail, highways and aviation are prioritised
- Gas refuelling and battery-recharging networks are slow and expensive to develop

**Energy**
- Rate of decarbonisation of grid electricity at the lower end of projections
- Transport usage of biofuels remains low due to concerns about net GHG impacts, land use effects etc
- Low ‘feed-in’ tariffs and poor rates of return discourage micro-generation at logistics facilities

**Behaviour**
- Eco-driving remains patchy, particularly in the developing world
- Adoption electronic monitoring of driver behaviour proceeds at a slow rate
- Use of technology to control vehicle operation is resisted by trade unions and owner drivers in many countries.

**Market**
- Collaborative initiatives in the FMCG sector stabilise at a low level because of corporate inertia, managerial scepticism, legal constraints etc
- Comparing the carbon / environmental performance of carriers remains inconsistent and difficult
- JIT pressures intensify in the FMCG sector forcing reductions in load fill and transport-CO$_2$ increases
- Modal shift to rail continues to be inhibited by a lack of competitiveness in the rail / intermodal sectors

**Regulation**
- Strong resistance from the railways and environmental organisations discourages governments and EU from relaxing truck size and weight limits
- Governments are reluctant to commit the large sums requires to rejuvenate national truck fleets
- National fuel economy standards for trucks remain confined to the US, China and Japan