Decarbonizing Freight Transport:
A Review of Technical, Managerial and Operational Options

Professor Alan McKinnon

Kühne Logistics University

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Urgency

Scoping

Uncertainty

Transferability
Need to convey new sense of urgency to logistics sector

Forthcoming IPCC report emphasises importance of staying within 1.5°C

For 50% probability of staying within 1.5°C by 2100: *remaining carbon budget 750 Gt CO₂*

At current emission rate (41 Gt/annum) – only 18 years to reach this limit

- *road freight 2.4 Gt of energy-related CO₂ (IEA, 2017)*

Annual emissions need to peak soon and drop sharply: *longer the delay steeper the decline*

Source: Figueres et al, *Nature* June 2017
Meeting EU 2011 Transport White Paper CO₂ Target for 2050

Reduction in carbon intensity need to achieve 60% cut in total freight-related emissions

Source: Smokers et al. (2017). Decarbonising Commercial Road Transport. Delft: TNO.
Leveraging freight decarbonisation parameters to achieve a Factor 6 reduction by 2050

- 30% modal shift road to rail
  
  *Rail improves energy efficiency by 50% and reduces carbon intensity of energy by 50%*

- 20% improvement in routeing efficiency

- 30% increase in loading of laden vehicles

- 30% reduction in empty running

- 50% increase in energy efficiency

- 50% reduction in carbon intensity of the energy

\[\downarrow\]

83% reduction in carbon intensity

**Factor 6**

Achievable in 20-30 years?

- May need to restrain forecast growth in demand for freight transport

- EU wants to avoid ‘curbing mobility’
CO₂ emission reduction profiles for European freight transport

- **peak 2030 steep decline**
- **60% reduction**
- **cumulative emissions 2015-2050: 34% lower**
- **peak 2015 more gradual decline**
- **60% reduction**


Implementation time for logistics decarbonisation options

- physical internet
- substantial modal shift to rail
- new fleet of low carbon vessels
- new fleet of low carbon planes
- new fleet of low carbon locomotives
- electrification of EU motorway network
- hydrogen refueling infrastructure
- truck platooning
- average replacement cycle of truck
- relaxing truck size / weight limits
- Increasing sustainable biofuel blends
- road vehicle retrofits
- computerised routing upgrades
- driver training programme

Contribution of demand-side interventions to UK truck decarbonisation 2015-2035 (Greening et al 2015)

- relax schedules and JIT
- restructure SCs
- urban consolidation
- collaborative synchronisation
- backloading initiatives
- longer/heavier vehicles
- off-peak deliveries
Road freight decarbonisation measures: *abatement – implementation graphs*

**Professor Cebon**

**International Energy Agency**

**Smart Freight Centre**

- **CO₂ abatement potential**
  - Low
  - High

- **Implementation time**
  - Low
  - High

**Technological development**
- Electrified highways
- High capacity transport
- Supply chain collaboration
- Battery-powered vehicles
- Eco-driver training
- Aerodynamic profiling
- Vehicle telematics
- Weighting
- Preventative maintenance
- Low rolling resistance

**Operational/managerial/regulatory development**
- Urban freight consolidation
- Predictive analytics
- On-line load matching
- Delivery rescheduling
- Down-speeding
- Vehicle automation
- Natural gas vehicles
- Platooning
- Hydrogen fuel cells
- Biofuels
- Physical internet

**Ease of implementation**
- Low
- High

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Methods of Decarbonizing Freight Transport

reduce level of freight movement
- relocalize / decentralize
- circular and sharing economy
- digitisation
- 3D printing
- ‘pollution routing’ systems

shift freight to lower carbon modes
- synchronomodality
- intermodal corridor strategies
- infrastructural enhancement
- internalise environmental cost

improve vehicle loading
- logistical collaboration
- relax JIT pressures
- online load matching
- liberalise high capacity transport
- consolidate urban deliveries

increase energy efficiency
- energy-saving technologies
- fuel economy standards
- eco-driving: training / monitoring
- platooning / automation

switch to low carbon energy
- low carbon electrification
- switch to bio-fuels
- electrifying infrastructure
- refuelling / recharging networks

logistics management behaviour regulation technology engineering
Under-estimation of the Logistical Contribution to Road Freight Decarbonisation

- disciplinary bias: *precedence of physical science / technology over social science!*

- difficult to quantify potential carbon savings from logistical options
  
  - lack of macro-level data: *especially on empty running and loading*
  
  - uncertainty about baseline conditions and rate of behavioural change

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Macro-level Truck Utilisation Statistics: *available data in EU*
Under-estimation of the Logistical Contribution to Road Freight Decarbonisation

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- difficult to quantify potential carbon savings from logistical options
  - lack of macro-level data: *especially on empty running and loading*
  - uncertainty about baseline conditions and rate of behavioural change
- past experience discouraging:

**empty running**

% of EU truck kms run empty: *only declined from 25% to 23% between 2005 and 2015*

despite online load matching, relaxation of cabotage regulations, growth of reverse logistics

**supply chain collaboration**

much discussed and heavily promoted – *but still the exception rather than the rule*
Under-estimation of the Logistical Contribution to Road Freight Decarbonisation

- disciplinary divide: *social science vs physical science / technology*

- difficult to quantify potential carbon savings from logistical options
  - lack of macro-level data: *especially on empty running and loading*
  - uncertainty about baseline conditions and rate of behavioural change

- past experience discouraging:

  modal shift to rail and water

*based on analysis by Tavasszy and van Meijeren (2011)

2030 modal shares if EU 2011 White Paper target is achieved*

- loss of fossil fuel tonne-kms from rail – will be difficult to replace
- rail may struggle to maintain current share
- narrowing carbon intensity gap between long haul road and rail freight
A regulatory quick win? Raise truck size and weight limits

2 truck for 3 substitution: load consolidation → reduced energy use and emissions per tonne-km

% reduction in carbon intensity against baseline vehicle

- 25.5 m truck – variable maximum weight limit

- Assumed modal and cross-modal price elasticities?

Conflict between freight decarbonisation strategies
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Uncertainties / Disagreements in Road Freight Decarbonisation Community

**past energy efficiency improvements in new European trucks**

**Daimler**
- 15% improvement in fuel efficiency between 2003 and 2016

**ICCT / T&E**
- Minimal improvement in fuel efficiency in 13 years to 2015

**weight, size, recharging time and cost of HDV batteries**

**Sripad & Visvanathan, McKinsey etc**
- 10-12 tonnes for US Class 8 truck
- 400 kW per hour charging time

**Tesla, ETC etc**
- 4-6 tonnes for US Class 8 truck
- 1600 kW per hour (Tesla)

**practicality and cost-effectiveness of hydrogen fuel cells in HDVs**

**IDDRI, ETC etc**
- Despite high energy losses, potentially viable decarbonisation option

**Bossel, Cebon et al**
- Energy losses so high never likely to be viable option

Anheuser-Busch to buy up to 800 Nikola hydrogen-electric trucks

<table>
<thead>
<tr>
<th>Low-carbon electricity pathway</th>
<th>WTW energy efficiency</th>
<th>Euro cent per truck-km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrified road systems</td>
<td>77%</td>
<td>19</td>
</tr>
<tr>
<td>Battery</td>
<td>62%</td>
<td>20</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>29%</td>
<td>55</td>
</tr>
</tbody>
</table>

Source: German Ministry of Environment
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Transferability
Transferability of Road Freight Decarbonisation Strategies

Developed country (OECD) bias in research, technology and strategy development

Much of the future growth of road freight in emerging markets

Relatively slow diffusion of truck technology to developing countries

Average age of the truck fleet

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>5</td>
</tr>
<tr>
<td>US</td>
<td>10</td>
</tr>
<tr>
<td>EU (average)</td>
<td>15</td>
</tr>
<tr>
<td>Chile</td>
<td>20</td>
</tr>
<tr>
<td>South Africa</td>
<td>10</td>
</tr>
<tr>
<td>Indonesia</td>
<td>15</td>
</tr>
<tr>
<td>Brazil</td>
<td>5</td>
</tr>
<tr>
<td>Latin America (average)</td>
<td>15</td>
</tr>
<tr>
<td>Mexico</td>
<td>20</td>
</tr>
</tbody>
</table>

Deficiencies in global market for second-hand trucks

In many emerging markets carbon intensity of electricity is high and only slowly declining

Limited resources for investment in highway electrification and recharging facilities

Need different road freight decarbonisation strategies and pathways for less developed countries?
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
www.alanmckinnon.co.uk

@alancmckinnon