ANALYSING ENERGY USE IN SUPPLY CHAINS: THE CASE OF FRUITS AND VEGETABLES AND FURNITURE

Michael Browne ¹, Christophe Rizet ², Jacques Leonardi ¹ and Julian Allen ¹. ¹ University of Westminster, Transport Studies Group, London, UK ² INRETS DEST, 2 Av du Gl Malleret-Joinville, 94114 Arcueil, France email: M.Browne@westminster.ac.uk
Supply chain approach

- Tracking the options for carbon reduction along the supply chain, including consumer trip, focusing on transport and logistics
- Complementary with others approaches (vehicle, company, models, urban)
- Energy consumption is estimated at each step of specific chains with the help of operators
- The energy indicators are harmonised (goe)
- Energy use is related to the production (goe/kg)
Influencing options for reducing carbon footprint from transport in the supply chain

- Sourcing and distribution centre locations
- Number of stockholding points in the chain
- Transport modes choice
- Road freight vehicle types and weights
- Vehicle load factors, empty running, and transport distance
- Balance between consumer shopping trips and delivery to the home
Method - Energy intensity:

Energy variables are related to product output

\[
E_{ep} = \frac{(L \times 845) + (E_e \times 226) + (E_g \times 77) + (E_f \times 845)}{M}
\]

- \( L \) = Annual fuel use (diesel) of all vehicles of the fleet in litres
- \( E_e \) = Annual electricity energy use in kWh
- \( E_g \) = Annual use of natural gas energy for heating or mobility in kWh
- \( E_f \) = Annual fuel use for heating in litres
- \( M \) = Annual volume of products sold in kg

- *Conversion coefficients in toe, for each fuel, as used by OECD IEA & National statistics: comparison is possible*
### Method – CO₂ efficiency/intensity calculation

$$\text{CO}_2\,\text{eff} = \frac{L \times \left(\frac{D \times V}{100}\right) \times 2.63}{1000 \times M \times D \times V}$$

where

- $L =$ fuel use in litres/100 km
- $D =$ distance in km
- $V =$ empty running factor
- $M =$ tonnes of loaded trip
- $2.63 =$ emission factor for CO₂ emission per litre diesel fuel

and $\text{CO}_2\,\text{eff}$ is the CO₂ efficiency in gramm of CO₂ per tonnekilometre.

Source: Survey 2007
Method: UK emission factors

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Energy conversion factors</th>
<th>Emission factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>litre</td>
<td>m³</td>
</tr>
<tr>
<td>Diesel</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Petrol</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Heavy fuel oil</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CNG</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Kerosene</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sources Nr</td>
<td>(1)</td>
<td>(2)</td>
</tr>
</tbody>
</table>

Sources: (1) DTI 2007 ; (2) Defra 2005; (3) DTI 2007 and Defra 2005

France, Belgium, New-Zealand and Brazil have different conversion and emission factors.
Method: Data collection and calculation table with typical results

Table 34: Road freight transport in the apple supply chain in UK

<table>
<thead>
<tr>
<th>Step</th>
<th>AB1 import of Sheerness to import storehouse</th>
<th>AB2 import of Felixstowe to import storehouse</th>
<th>BC import storehouse to NDC</th>
<th>CD1 NDC to supermarket in London</th>
<th>CD2 NDC to supermarket in North of UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicators</td>
<td>total tonnage transported</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Trip distance in km</td>
<td>34</td>
<td>160</td>
<td>110</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>Fuel use of vehicles (l/100km)</td>
<td>32</td>
<td>32</td>
<td>28.25</td>
<td>28.25</td>
</tr>
<tr>
<td></td>
<td>Maximum number of pallets per vehicle 100/120</td>
<td>26</td>
<td>26</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Carrying capacity (t)</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Gross Vehicle Weight (t)</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Empty weight of vehicle (t)</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Trip mean load factor (par défaut 57%)</td>
<td>83.33</td>
<td>83.33</td>
<td>62.50</td>
<td>62.50</td>
</tr>
<tr>
<td></td>
<td>% of empty km in total distance</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Distance of empty running (km)</td>
<td>34</td>
<td>160</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Factor of empty running</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Energy efficiency in l/kg</td>
<td>0.00108</td>
<td>0.00512</td>
<td>0.00207</td>
<td>0.00180</td>
</tr>
<tr>
<td></td>
<td>Energy efficiency in goe/kg</td>
<td>0.98</td>
<td>4.64</td>
<td>1.87</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>CO₂ efficiency in g CO₂eq/kg</td>
<td>2.8</td>
<td>13.5</td>
<td>5.4</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Source: Survey 2007
Apple supply chains for superstores

France

- New Zealand
  - Port of Nelson (NZ)
    - Antwerp (Belgium)
      - Importer Rungis
        - RDC France Ile de France
          - Hypermarket Ile de France
            - Ile de france
  - Limousin
    - Port of Nelson (NZ)
      - Antwerp (Belgium)
        - Importer Rungis
          - RDC France South-West
            - Hypermarket Limousin
              - Limousin
          - RDC Limousin
            - Limousin

UK

- New Zealand
  - Port of Nelson (NZ)
  - Port of Nelson (NZ)
  - Port of Nelson (NZ)
    - Port UK Felixstowe
      - Importer UK
        - NDC near London
          - Supermarket London
            - Londres
          - Supermarket Aberdeen
            - Aberdeen
          - Supermarket Sheerness
          - Supermarket Aberdeen
            - Aberdeen
          - Supermarket London
            - Londres
          - Supermarket Aberdeen
            - Aberdeen
          - Supermarket Wallonie
            - Wallonie

Belgium

- New Zealand
  - Port of Nelson (NZ)
    - Port Uk
      - Importer UK
        - Rungis
          - RDC France Ile de France
            - Hypermarket Ile de France
              - Ile de France
          - NDC near London
            - Supermarket London
              - Londres
            - Supermarket Aberdeen
              - Aberdeen
            - Supermarket Wallonie
              - Wallonie

Source: Survey 2008
Apple supply chains distributed in large superstores - energy intensity in goe/kg

Source: Survey 2008
Apple supply chains distributed in large superstores - CO₂ intensity in gCO₂eq/kg

Source: Survey 2008
Maritime transport for France and UK import: container vessel with a shipping line and charter of a conventional vessel

Source: Survey 2007
Apple production and transport for export in New-Zealand

Tasman Fruitpacker Ltd, Nelson

Source: Survey 2007
Apple production and transport in UK

Farmshop near London

Source: Survey 2007
Comparison of different logistics and production types for tomatoes in Limousin

Note: energy assessment is for transport only, not production

Source: Survey 2007
Apple supply chain results for UK:
Consumer trip sensitivity to load distance and type of delivery for Greater London area and Aberdeen (with London km x 2)

Source: Survey 2007
Bookcase supply chain results for UK:
Consumer trip sensitivity to load distance and type of delivery for Greater London area and North of UK

goe/kg

Source: Survey 2007
Jeans supply chain
UK and France comparison

Source: Survey 2005
Discussion and limitations

• Actual active discussion on carbon footprint
• Limited original data collection work on “transport in the supply chain” or “freight in LCA” so far
• Special case and general cases: “standard” supply chains were identified first
• Little amount of data and few efforts from companies gathering the information (1.5 hours interview with main freight responsible are required, + few follow up mails)
• Willingness of companies upstream of the first contact partner is difficult to obtain (point of failure for each 2\textsuperscript{nd} chain)
Conclusion:
Advantages and limitations of the supply chain approach

- Approach chosen is efficient in terms of amount of work for data collection
- It focuses on goe per kg product and transport (storage proved to have far less impact)
- Thus the carbon balance of a whole company or even a group is not necessary
- Focus on maritime and consumer legs as the two most energy intensive
- Online shopping practice is not always positive