**In the UK food industry, distribution vehicles spend just 28 per cent of their time actually running on the road and are empty on nearly 20 per cent of the distance travelled. Putting all journeys together, the average vehicle carries just over half its full potential load.**

We all know Europe's packaged goods industry could make significant improvements to the efficiency of its freight transport operations. Two ECR-Europe studies have already pointed to these opportunities[1].

However, the questions for companies are, just how much more efficient could we be? And how does our current performance compare with our peers and competitors?

New research conducted for the UK's Department of Transport is beginning to provide some useful answers to these questions.

Assessing the potential for transport cost savings can be difficult for individual firms. Judging the actual loading of vehicles against their maximum technical or legal carrying capacity usually sets fleet managers an unrealistically high target, for example.

A more practical yardstick is the range of average load factors achieved by companies engaged in similar distribution operations. This requires benchmarking against a standard set of key performance indicators (KPIs), preferably over the

# Running on empty?

RESEARCH

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Everyone knows retailers and manufacturers could improve their transport efficiency. But what is a realistic target? New research in the UK provides some useful benchmarks

ILLUSTRATION BY CHRISTOPH FISCHER

same time period and employing an identical method of data collection.

This is what has now been achieved on two occasions in the UK as a result of a pioneering initiative run jointly by the Cold Storage and Distribution Federation and the Logistics Research Centre at Heriot-Watt University, funded by the UK Department for Transport.

The first major benchmarking survey was undertaken over two days in October 1998[2]. Feedback from the participating companies was very positive and most indicated a desire to take part in future surveys.

The exercise was repeated in May and October 2002 with a much larger and more diverse sample of fleets and vehicles in the food sector. This paper summarises the main findings of the 2002 survey.

Regrettably, the aggregate results of this survey cannot be directly compared with those of the earlier one as the sample of companies and fleets was significantly different. However, individual companies which took part in both surveys have been able to compare their KPI results and monitor changes in performance over the past four years.

## Objectives and indicators

The main objectives of the survey were to:

- enable companies to benchmark the efficiency of their road transport operations
- estimate average levels of efficiency at both sectoral and sub-sectoral levels
- assess the potential for improving the efficiency of delivery operations.

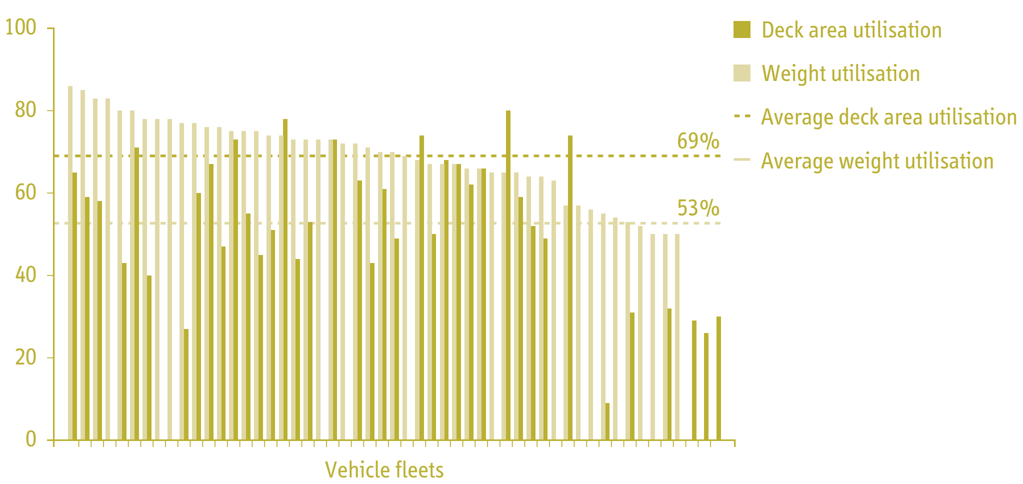
To achieve these objectives, it was essential that companies measured efficiency on a consistent basis. They did this by collecting data over the same 48-hour period and recording data in specially constructed Excel workbooks. Companies were issued with manuals which defined the survey parameters and explained in detail how the data was to be collected. Several workshops were held with staff responsible for compiling the data to provide additional advice and encouragement.

The KPIs fell into five categories:

1. *Vehicle loading* This was measured by payload weight, pallet numbers and average pallet height. The vast majority of loads were unitised either on wooden pallets or in roll cages. Where products were carried in non-unitised form, conversion factors were used to translate the load data into a pallet-equivalent measure.

2. *Empty running* The distance the vehicle travelled empty. This excluded the return movement of empty handling equipment, packaging and unsold product where this prevented the collection of a backload. Such movements of "returns" were separately recorded.

**Exhibit 1:** Deck area and weight utilisation by vehicle fleet

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3. *Vehicle time utilisation* This was classified into seven activities – running on the road, being loaded/unloaded, pre-loaded awaiting departure, awaiting loading/unloading, undergoing maintenance/repair, driver daily rest period, and idle (ie, empty and stationary).

4. *Deviations from schedule* Delays were attributed to various causes, including problems at supplier and customer premises, internal company actions, traffic congestion and vehicle break-downs. This KPI was included because instability in transport schedules can have a bearing on vehicle utilisation as it makes it more difficult for companies to plan backhauls and more complex multiple collection/delivery rounds.

5. *Fuel consumption* For both motive power and refrigeration equipment.

The survey covered the *primary* distribution of food from factories to regional distribution centres (RDCs), either directly or via primary consolidation centres (PCCs), *secondary* distribution trips from RDCs to shops, and *tertiary* distribution from wholesale depots to independent retailers and catering outlets.

A total of 27 companies participated in the survey. They operated – or contracted – 53 separate vehicle fleets, comprising 3,088 trailers, 1,446 tractor units and 546 rigid vehicles.

All consignments were converted into industry standard pallet-loads (1,000mm by 1,200mm) to establish a common denominator for the analysis of vehicle utilisation. The equivalent of just under one-quarter of a million pallet-loads was distributed by sample vehicles over the 48-hour period. During this time they travelled almost 1.5 million kilometres.

**Utilisation of vehicle capacity on loaded trips**

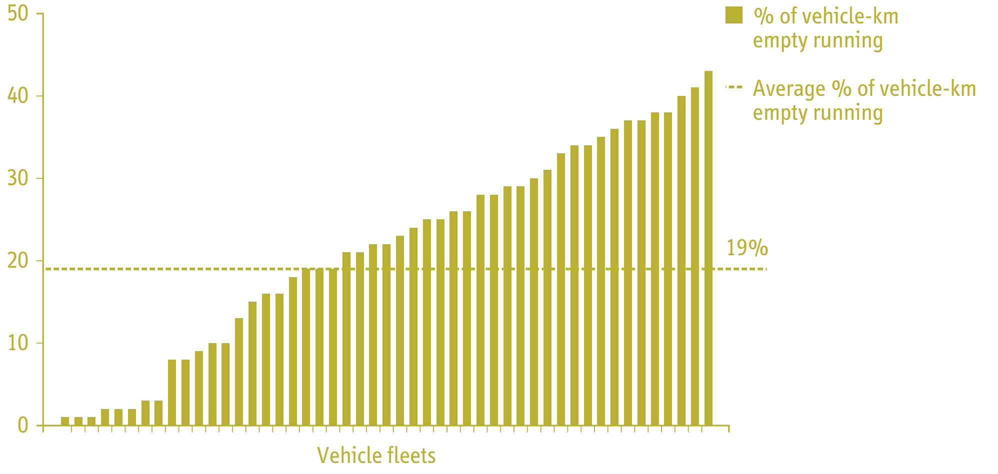
Vehicle fill was measured primarily in terms of pallet numbers. The actual number of pallets carried was expressed as a percentage of the maximum number that could have been carried.

This pallet-load measure indicated the proportion of vehicle deck area used. On loaded trips, an average of 69 per cent of available pallet positions were occupied. Exhibit 1 shows the variation in this KPI across the 50 fleets for which deck area utilisation data was provided. Values were spread fairly evenly across the range 32

**Table 1:** Percentage of trips with average pallet height with given ranges

| Height Range | % of trips |
|---|---|
| Less than 0.8 metres | 9 |
| 0.8 metres – 1.5 metres | 9 |
| 1.5 metres - 1.7 metre | 67 |
| Greater than 1.7 metres | 15 |

**Exhibit 2:** Proportion of vehicle-km run empty



per cent to 82 per cent.

The highest floor utilisation was achieved in articulated vehicles engaged in the primary distribution of bulk loads or single-drop secondary distribution from RDCs to supermarkets. The lowest values were recorded by rigid vehicles on multiple drop rounds.

The survey also collected data on the average height of pallet loads (Exhibit 1). It revealed that on 67 per cent of the loaded journey legs, goods were stacked to an average height of 1.5 to 1.7 metres, corresponding to the typical slot height in warehouse racking across the food supply chain.

On nine per cent of the loaded trips, average heights fell below 0.8 metres. Across the full sample of loaded trips, approximately 76 per cent of the "useable" height was actually used. In this calculation, allowance was made for empty space required at the top of refrigerated vehicles for the circulation of cold air.

Multiplying the mean height utilisation figure by the average deck-area coverage yields an estimate of 52 per cent for average cube utilisation of vehicles on loaded trips.

The average weight-based load factor, at 53 per cent, was similar to this average cube-utilisation value, although much lower than the mean deck area coverage (69 per cent). As most loads of grocery products have a relatively low density, they are constrained much more by the available deck area than by the vehicle weight limit.

**Empty Running**

Of the 1.45 million kilometres travelled by the sample vehicles over the 48-hour period, 280,000kms were run empty – approximately 19 per cent of the total. There were, nevertheless, wide variations around the mean value (Exhibit 2).

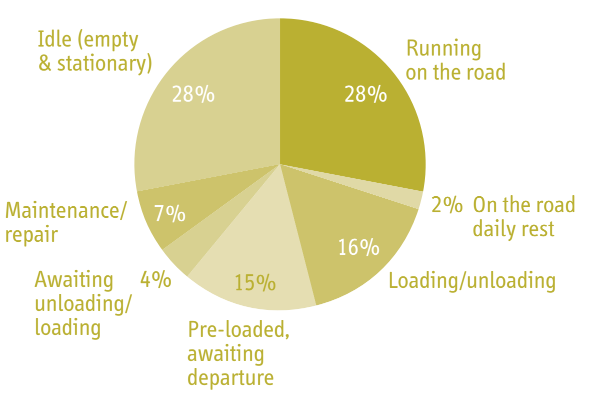
Average figures for empty running are particularly sensitive to the mix of trip types in the sample. Where the sample contains a large proportion of multiple drop trips, the average figure for empty running tends to be lower because on these trips it is usually confined to the final leg in the journey and occurs over a small proportion of the total distance travelled.

This partly explains the wide variation in the proportion of empty running across the 53 fleets surveyed.

Even fleets engaged in a similar pattern of delivery, however, can have markedly different levels of empty running. In some cases, this can be explained by differences in the types of handling equipment used and the manner in which it is returned.

The return of roll cages from supermarkets, for instance, was classed as "running with returns" rather than empty running, since it represented an essential stage in the distribution process

**Exhibit 3:** Time utilisation of the average trailer/rigid vehicle during survey period



and limited the opportunity to pick up a back load. A vehicle carrying only its usual complement of wooden pallets, on the other hand, was deemed to be empty as it could be backloaded with product.

Some fleets achieving very low levels of empty running tended to handle heavy flows of returns. Even once allowance is made for these operational differences, however, there remain significant variations in the level of empty running, suggesting some companies could do more to find back loads.

The survey, like the previous one in 1998, revealed that some companies could release more vehicle capacity for supplier collections by consolidating return loads of empty handing equipment on fewer trips.

**Time utilisation**

On average, the vehicles spent only 28 per cent of their time running on the road (Exhibit 3). They spent a similar amount of time empty and stationary. Of the 3,128 vehicles included in the hourly audit, an average of 877 were idle during any given hour, representing a substantial under-utilisation of expensive vehicle assets.

The average vehicle also spent around one-fifth of the survey period waiting to be loaded, to depart from the collection point or to be unloaded at its destination. Three-quarters of this waiting time occurred at the collection point, where the vehicles were on average preloaded three and a half hours before their departure.

In the case of temperature-controlled distribution, this practice significantly increases energy consumption since it is much less efficient to refrigerate products in a vehicle than in a cold store.

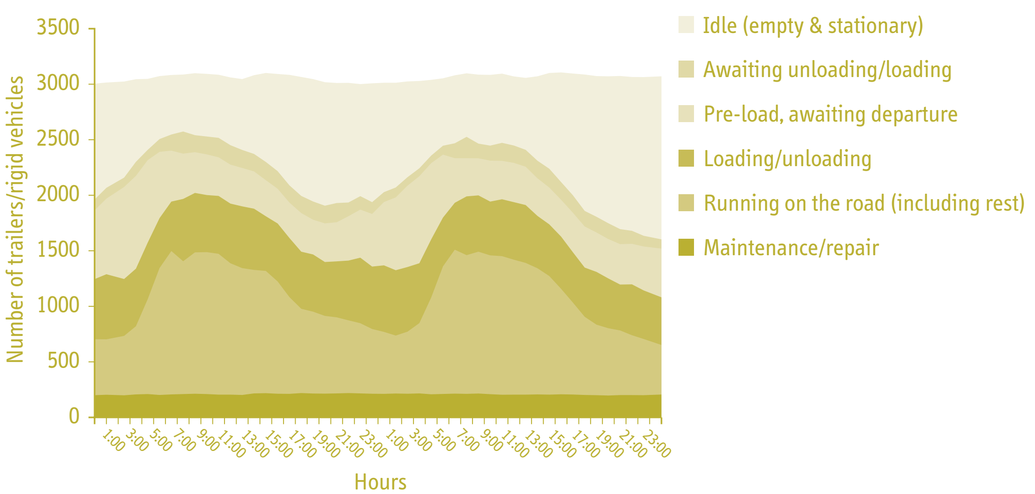
Companies were asked to indicate the dominant activity of vehicles on each hour of the survey period. This data was used to construct a time-utilisation profile for the full sample of vehicles over 48 hours (Exhibit 4).

The proportion of vehicles running on the road rose steeply from 5am, reaching a peak of roughly 50 per cent around 8am. During the nine-hour period between 6am and 3pm, when the road network is at its busiest, an average of 40 per cent of the fleet was on the road at any given time. In contrast, over the 12 hours between 5pm and 5am, an average of only 23 per cent of the fleet was running on the road.

At the secondary level – between RDC and supermarket – there was very pronounced peaking between 6am and 8am, particularly for chilled product (Exhibit 5).

There was then a reasonably steady flow of ambient product into retail outlets between 9am and 10pm. The peaking of primary flows – from factories to RDCs – was less pronounced, but again occurred between 6am and 9am. This coincidence of the delivery "peaks" at secondary and

**Exhibit 4:** Time utilisation profile for sample vehicles over the 48-hour survey period



primary levels during the morning "rush hour" was also observed in the 1998 survey.

While secondary distribution to retail outlets is largely constrained by shop opening hours, there might be less justification for concentrating primary deliveries in the morning peak period. By altering daily delivery cycles, particularly for the movement of supplies into RDCs, it would be possible to integrate primary and secondary operations more effectively to raise vehicle load factors.

The potential benefits of rescheduling primary deliveries to off-peak periods would be even greater today as the level of traffic congestion during the morning peak has increased markedly since 1998.

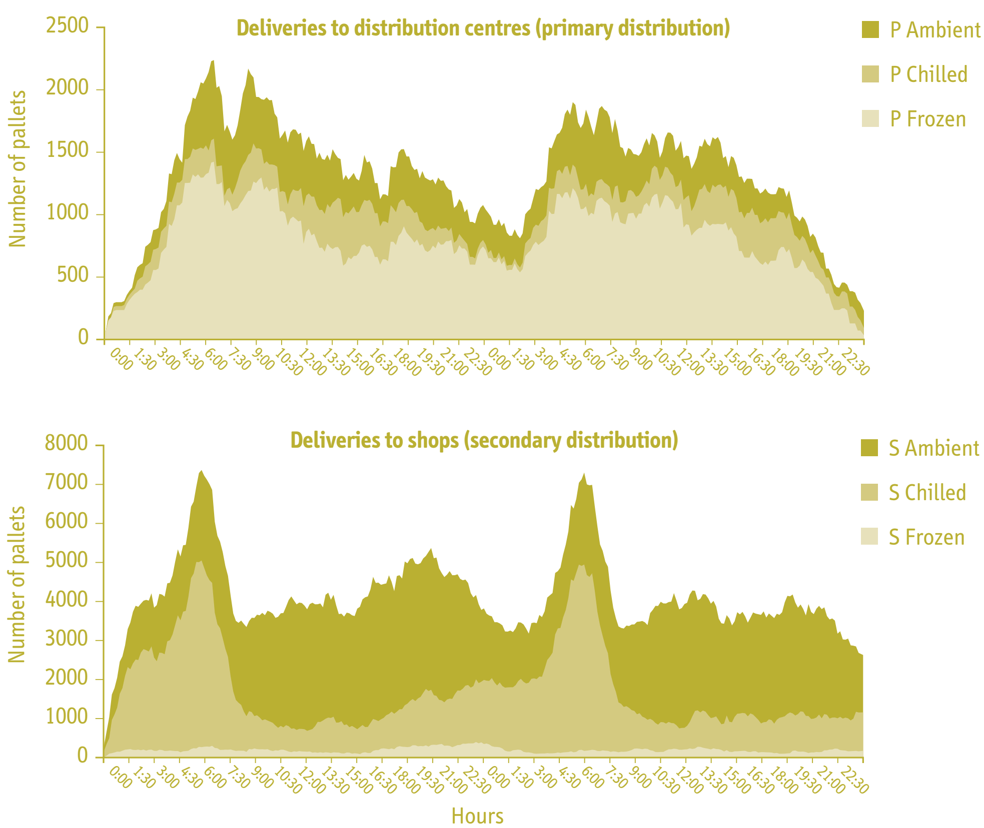
**Deviations from schedule**

Of the sample of 15,252 legs surveyed in 2002 for which sufficient scheduling data was provided, 29 per cent were subject to an "unscheduled delay". Overall, 31 per cent of delays were blamed mainly on traffic congestion (Exhibit 6).

This statistic may under-estimate the true impact of congestion, in two respects. In the first place, many companies will already have allowed for congestion-related delays in their delivery schedules. Second, the causes of delay are inter-related. A vehicle held up on the road could miss its booking-in time at a warehouse and be forced to wait until the next available slot. A delay initially caused by traffic conditions can therefore become cumulative, particularly in the case of multiple collection and delivery rounds.

As in the 1998 survey, most of the deviations from schedule were internal to the logistical system rather than caused by external delays on the road network. In 16 per cent of cases, the company running the vehicles took responsibility for the delay. Thirty-four per cent of delays occurred at collection and delivery points and were blamed on suppliers or customers. It appears that congestion at the reception bays of distribution centres,

**Exhibit 5:** Freight volumes in the delivery system at primary and secondary levels by time of day and product type over 48 hour survey period.



factories and shops disrupts delivery schedules more than traffic congestion.

These delays cause companies to build extra slack into their delivery systems and make it harder for them to arrange backloads. The average vehicle spent 43 minutes per day on unscheduled delays at loading and unloading points. Given mean vehicle standing charges, daily trip rates and annual activity levels, this wasted time would be worth approximately £1,280 per vehicle per annum, and this figure excludes any allowance for losses in operating efficiency due to unreliability.

**Fuel efficiency**

As in the 1998 survey, it was found that average kms-per-litre varied much more widely across the rigid vehicle fleet than for articulated vehicles (Table 2). The greater variability of fuel efficiency values among rigid vehicles can be partly attributed to wider differences in the nature of the delivery work they undertake.

Analysis of the benchmark data at sub-sectoral and individual company levels, however, indicates that this provides only a partial explanation and that some operators could do more to run their rigid fleets more fuel efficiently. Eighty-five per cent of fleets containing articulated vehicles with gross weights of 38 tonnes or more had an average fuel efficiency for this class of vehicle within the range 2.8 to 3.5 km per litre. The difference between the highest and lowest fuel efficiency value for this class of truck, however, was 1.5 km per litre.

For a typical articulated vehicle of this type, running around 100,000 kms per annum, this difference in fuel efficiency would correspond to an extra 19,800 litres of diesel consumed annually, worth approximately £12,400 at current UK prices (excluding VAT).

Companies which achieve high kms-per-litre figures do not necessarily have the most energy-efficient distribution operations.

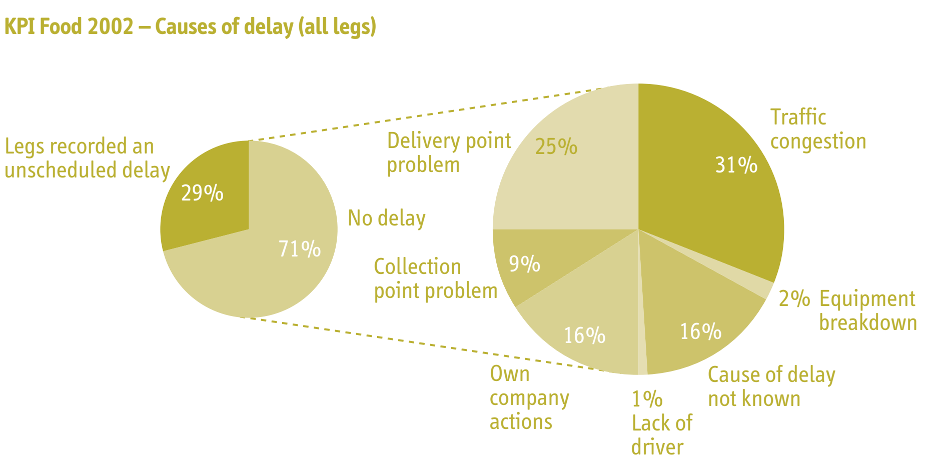
High fuel efficiency can be offset by poor utilisation of vehicle capacity. Energy efficiency (or "energy intensity") is therefore best measured by a composite index which expresses fuel consumption on a pallet-km rather than vehicle-km basis.

Across the 46 fleets for which this calculation could be carried out, energy-intensity values varied by a factor of seven and a half, from 8ml of fuel per loaded pallet-km to around 61ml. (These energy-intensity calculations excluded fuel consumed by refrigeration units).

Much of this variation can be attributed to differences in the size and type of vehicle used, the nature of the distribution operation, and geography of the delivery area.

To help standardise the comparison, the fleets were divided into five categories:

**Exhibit 6:** Frequency of delays by main cause



- primary distribution of temperature-controlled products (all articulated vehicles) (P1)
- primary distribution of ambient temperature products (all articulated vehicles) (P2)
- secondary distribution to supermarkets and superstores (mainly articulated vehicles) (S)
- tertiary distribution to small shops and catering outlets (mainly rigid vehicles) (T)
- mixed distribution to large and small outlets (involving both articulated and rigid vehicles) (M).

The colour coding of these different categories of fleet in Exhibit 7 confirms that variations in energy intensity are largely associated with differences in the nature of the distribution operation.

The mean energy intensity varies from 12.2 ml per pallet-km for primary trunking of ambient product (P2) to 37.3 ml per pallet-km for local deliveries to small outlets (T). Even within these more homogeneous sub-sectors, energy-intensity values for individual fleets can still diverge by a significant margin. The greatest variability was found in tertiary distribution.

Differences in average energy-intensity values within sub-sectors often occur for good reason. The classification of fleets is, after all, fairly crude and even within sub-sectors, there is seldom an exact match of distribution operations.

Particular circumstances can justifiably cause a company's energy-intensity value to deviate from the average of its benchmark group. By exposing these differences, however, the benchmarking exercise can encourage logistics managers to explain why their index is above the sub-sectoral average.

It therefore prompts further analysis which might reveal sources of inefficiency in areas such as vehicle design and maintenance, driving behaviour, nature of the handling equipment, load-building procedures and backhauling.

As in the 1998 survey, it was found there was only a weak correlation between average fuel consumption (measured in km per litre) and average energy intensity (measured in ml per pallet km).

This is illustrated by the fairly random scatter of points in Exhibit 8. The points represent fleets and have been differentiated by vehicle type. They show companies operating the same type of vehicle at similar levels of fuel efficiency can require widely varying amounts of energy to move a pallet-load one kilometre.

This demonstrates that total energy consumption is also critically dependent on the utilisation of vehicle carrying capacity.

The KPI data was used to estimate by how much energy consumption might be reduced if companies whose energy-

**Table 2:** Average fuel efficiency estimates by vehicle class (kilometres per litre)

| Vehicle class | Average | Range |
|---|---|---|
| Small rigid (2 axles) < 7.5 tonnes | 4.0 | 2.3 ~ 5.2 |
| Medium rigid (2 axles) 7.5 - 18 tonnes | 3.6 | 1.7 ~ 5.0 |
| Large rigid (> 2 axles) > 18 tonnes | 3.1 | 1.7 ~ 4.4 |
| Drawbar combination | 3.1 | 2.8 ~ 3.4 |
| City semi-trailer (3 axle) | 3.2 | 2.8 ~ 3.8 |
| 32 tonne articulated vehicle (4 axles) | 3.2 | 2.1 ~ 3.7 |

intensity value was above the average for their sub-sector could bring it down to this mean. This would cut the amount of fuel consumed by five per cent, reducing annual fuel costs for the average vehicle by £1,115 and annual emissions of $CO_2$ by 3.9 tonnes per vehicle.

If the target energy-intensity value was lowered even further to the mean of the one-third of companies with the lowest ml per pallet-km values, energy savings of 19 per cent could be achieved.

However, one must be careful in interpreting these figures because as explained above, some of the variation in energy-intensity values will reflect justifiable differences in the nature of the distribution operation and composition of the vehicle fleet within each sub-sector.

**So, what's next?**

Benchmarking of transport efficiency in the food supply chain against a standard set of KPIs has revealed wide variations in vehicle utilisation, delivery reliability and energy intensity. Some of this variation is due to differences in the nature of the product and pattern of delivery.

More detailed analysis of the data at sub-sectoral and intra-company levels suggests, however, that some of the variation is the result of differences in operating performance. The purpose of the benchmarking exercise is to highlight these differences and give managers an incentive to raise operating performance to that of the most efficient fleets in their particular sub-sector.

This will not only cut distribution costs – by reducing vehicle kilometres and energy consumption – it will also yield wider environmental benefits.

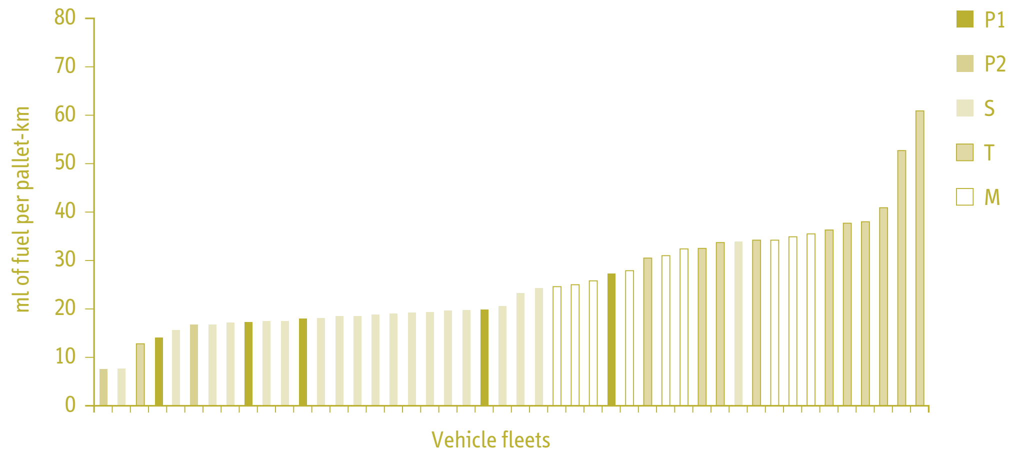
One limitation of this exercise, like most benchmarking surveys, is that it sheds little light on the causes of the observed differences in KPI values. This would require in-depth analysis of the operations of the 53 fleets.

In addition to being extremely labour-intensive, this would require a high level of co-operation from participating companies. If the necessary resources and assistance were secured, future KPI surveys could examine the relationship between transport and other logistical variables.

Apparent under-performance on some transport KPIs, for example, could be the result of a deliberate, and perfectly rational, trade-off against greater efficiency in warehousing or in-store handling.

For example, a company might give greater priority to the utilisation of reception facilities and staff productivity at RDCs than to the backloading of delivery vehicles. Return legs could be so tightly scheduled that the opportunities for picking up a backload were severely constrained.

**Exhibit 7:** Fleet energy intensity values differentiated by sub-sector (see text for definition of subsectors)



The use of roll-cages in secondary distribution – rather than wooden pallets – is another example of companies sacrificing vehicle cube utilisation, in this case, for quicker and more efficiency handling of goods at both the RDC and the shop.

The use of roll-cages, however, also permits faster loading/unloading of vehicles and results in more intensive utilisation of the vehicle over the 24-hour cycle. This illustrates how the transport KPIs themselves can be inversely related, with better performance on some measures being achieved at the expense of poorer performance on others.

On the basis of the available data, however, it seems there are several ways in which transport efficiency can be improved:

- while the average deck area utilisation of 71 per cent is relatively high for the mix delivery operations surveyed, some companies fall well short of this figure and could do more to consolidate loads
- the average level of empty running is low by comparison with other sectors, although again, some companies perform poorly against this KPI and could probably put more effort into finding backloads
- there could be greater consolidation of returns in fewer trips to release vehicles to collect orders from suppliers
- by spreading deliveries more evenly over the daily cycle and reducing the proportion of vehicle-kms run during the morning peak – particularly in primary distribution – companies could reduce transport costs, vehicle emissions and transit-time variability
- greater adherence to schedules at collection and delivery points would improve the utilisation of vehicle assets and establish a more stable environment for route planning and back loading
- the widespread practice of pre-loading refrigerated vehicles well ahead of the departure time needs to be reassessed in the light of current concerns about fuel efficiency and emissions
- energy-intensity should be more widely adopted as a distribution KPI as it makes companies more aware of the combined effect of fuel efficiency and vehicle loading on energy consumption.

**Acknowledgement**
The UK Department for Transport funded this project as part of the TransportEnergy Best Practice initiative. Further details can be found at www.transportenergy.org.uk/bestpractice

1. A T Kearney (1997) *The Efficient Unit Loads Report* and University of St Gallen (2000) *The Transport Optimisation Report*.

The full report of this earlier survey can be found at www.som.hw.ac.uk/logistics

**Exhibit 8:** **Relationship between fuel efficiency (km per litre) and energy intensity (ml per pallet-km) for the sample of fleets**