

Evaluating a supply chain's carbon footprint

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Carbon-to-Serve™ methodology has been developed to generate an end to end supply chain view of the carbon intensity and cost of products of products as they move from source to production. Professor Alan Braithwaite recently presented a paper on the subject to The Chartered Institute of Logistics and Transport's Logistic Research Network Conference. This is an adaptation of the paper.

The world is now sensitised to global warming and the effect of carbon and other emissions. The national target is to reduce emissions by 60% by 2050. Business and political leaders talk about 'Plan A because there is no Plan B'. But the unanswered question is: what is Plan A? It will consist of a range of energy-saving and effectiveness measures from technology and operations through to structural changes in the supply chain coming from product design, sourcing and network.

The challenge in defining Plan A is to be able to generate a reliable estimate of the carbon intensity of different end-to-end chains and to be able to model the potential from achieving best in class performance and structural changes from different scenarios. In addition to understanding the carbon impacts of different scenarios, it is important to understand in parallel the cost impacts; sound business will generally be about measures that improve both carbon and cost.

The Carbon-to-Serve™ methodology has been developed to generate an end-to-end supply chain view of the carbon intensity and cost of products as they move from source to consumption. Building on our existing Cost-to-Serve®, it provides high levels of transparency across supply chain boundaries, enabling parties along the chain to co-operate in making changes that will drive to national targets in a way that is not available by other published methods. While standards are still forming in this area, we believe that our approach is compliant with PAS 2050 from the BSI and adds value by providing a practical toolkit.

Global carbon reduction imperative

The environmental impact of energy consumption by the global economy has attracted increasing commentary over the last five years. The scale of the public interest is remarkable and can be illustrated by the following statistics: in one hour, 25 articles were

published on Google News; in one day, 199 articles were published; in one week 1,734 were published. If you Google 'global warming', over 60 million references are returned. The predictions for global warming leave London under water, grapes grown for wine in the UK Midlands and the demise of entire species.

The UK Government has established an Office for Climate Change and has committed to lowering emissions by 60% by the year 2050. The term 'carbon footprint' has become a commonplace expression of the need to be concerned about personal and corporate energy use and the environmental impacts of both production and consumption. Software vendors have got involved in the process of helping companies evaluate their own emissions or model the carbon implications of their transport networks.

The seminal work entitled: An Inconvenient Truth(1) by Al Gore is widely attributed with having raised the perception of global energy consumption and its impact on the ecosystem to the point where it can no longer be ignored. Doubters remain, including the former Chancellor Lord Lawson with his recent book: A Cool Look at Global Warming(2); but they are now in the minority.

The British Government commissioned Stern to review the economic impact of climate change and he concluded that sustainability was still a practical goal. (3) He reported that the choice between being 'rich and dirty' or 'clean and green' was avoidable; we can be 'green and rich enough'. The practicalities of responding to the sustainability agenda in the UK has cascaded out from the newly formed Office of Climate Change, to individual ministries with specific responsibilities for energy, transportation and the environment, inter alia to devise the nation's Plan A.

It appears that consumers may be more prepared to make rapid changes than their leaders, and many companies have moved to exploit this with green products and services. Retailers have started to market their environmental credentials aggressively and consumers are eager for information and guidance on how to change their behaviours. The publicity grabbing measures on plastic bags by introducing charges and encouraging recycling are a case example of small measures proving highly acceptable.

How to start taking practical measures
Policy-makers tend to operate at the macro level and do not contribute substantively to the detail of what needs to change on the ground in order to enable the goals to be met. Efforts in this respect are founded in parallel approaches: measurement and modelling. The Carbon Trust has

to that search and the identification of Plan A. Two proven themes in the supply chain have been the foundation of this development:

First is the ability to visualise a supply chain using mapping and, from that, develop the implications of doing things differently; we have found this is a

Retailers have started to market their environmental credentials aggressively and consumers are eager for information and guidance on how to change their behaviours

been established as an independent government funded organisation to work with companies to reduce their emissions.(4) It has established measurement and labelling of the carbon impact of products as a major initiative.

This has been recognised by retailers who have adopted the standard and, in the case of Tesco gone further. Sir Terry Leahy in a speech in January 2007 said: 'I can announce this evening that Tesco will take the first step towards developing this by commissioning work from the Environmental Change Institute (ECI) at Oxford University, on identifying and overcoming the carbon pressure points in our own operations and supply chain. This work can best be done in collaboration with our world class suppliers and distributors, and our retail colleagues. To create a mass movement in green consumption we must provide better information. Clear information about the carbon cost of the products we buy will enable customers to make effective green choices. Customers want us to develop ways to take complicated carbon calculations and present them simply. We will therefore begin the search for a universally accepted and commonly understood measure of the carbon footprint of every product we sell – looking at its complete lifecycle from production, through distribution to consumption. If we are to tell our customers the carbon cost of every product, we owe it to them too to minimise that cost.' (5)

As Sir Terry Leahy said, the search is on. We believe that the Carbon-to-Serve™ methodology is a contribution

profoundly valuable way to consider changes by rebalancing the supply chain; the critical skill of supply chain mapping in support of their redesign to increase effectiveness is well established in the literature by both Hines(6) and Christopher(7) Second is the ability to evaluate the cost build-up along the end-to-end chain in order to identify waste and its scale in relation to products, customers and supply chain routings; the Cost-to-Serve® method is now well established as part of the supply chain redesign toolbox(8) The fundamental concept sitting behind Cost-to-Serve® is that the cost of chains is not optimised by adding the lowest possible costs of each of the functions.

These themes apply equally to carbon emissions. A measuring and rebalancing approach is required along the end-to-end chain for carbon and cost. This process has been initiated by a number of companies and the most widely publicised measurement of a total supply chain's carbon impact is that of Walkers Crisps by the Carbon Trust. As a result of this work, we are informed that a packet of crisps weighing 35g has generated 75g of CO2 in its journey from field to shelf, where it puts just 22.5g of carbohydrate into the human frame. Put in that way, it does not seem good value and the key questions include: how could it be different? And are crisps a doomed product?

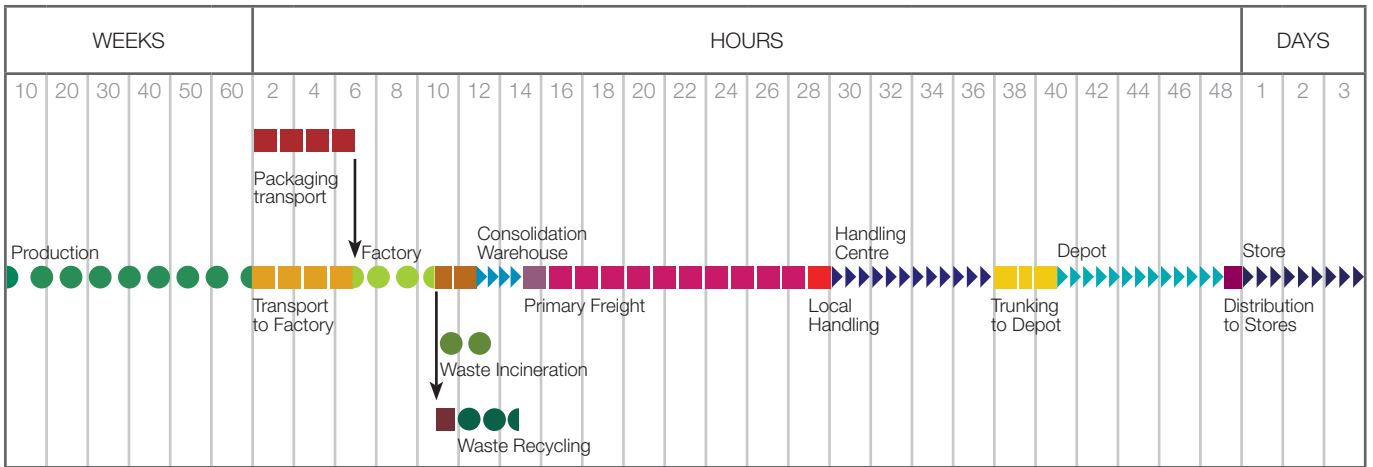
In this case and others, there has been a lack of transparency in the carbon footprinting process in relation to energy effectiveness and the scale or potential for improvement. If consumers and companies are to support radical

KEY

ACTIVITY

MOVEMENT & HANDLING

INVENTORS



Key production ratios

Straw Growing & Harvesting 2				
Quantity per hectare	Unit	Carbon/ unit (kg or km)	Carbon/ 1000 litres kg CO2	Carbon 1000 litres kg CO2
Fertiliser	1000	kg	0.05	0.63
Insecticide	100	kg	0.8	1.00
Weeding	10	km	0.2	0
Picking	10	km	0.2	0.03

Inventory - agent warehouse 3d															
Floor space m2	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Occupancy & Handling	1000	600000	0.43	22.1	700000	0.19	11.4	0.32	0.0	0.27	0.0	0.0	0.21	0.0	0.0

Transport - Growers to Wineries 6					Transport - Chemical agents inventory to Wineries 0				
Vehicle Type	Distance per journey (return) km	Carbon/ km kgCO2/km	Carbon/ 1000 litre kgCO2	linked distance to ratios so only need to multiply CO2 factor by key ratio x2 for return journey	Vehicle Type	Distance per journey (return) km	Carbon/ km kgCO2/km	Carbon/ 1000 litre kgCO2	REMOVE THE SECTION NEEDS CALCUS
Road	Lorry Diesel Rigid	340	1.07	6.1	Road	Lorry Diesel Rigid	0	1.07	0.0

Wineries 25																
Production	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Total Carbon / litre kgCO2
Production	12002		25.8	100000		9.5	0		0.0	0		0.0	0		0.0	35.3
of which																
Occupancy & Handling	50000	0.43	10.8	100000	0.19	9.5	0	0.32	0.0	0.27	0.0	0.0	0	0.21	0	20.3
Pressing	70000	0.43	15.1		0.19	0.0		0.32	0.0	0.27	0.0	0.0		0.21	0.0	15.1
Fermentation	1	0.43	0.0		0.19	0.0		0.32	0.0	0.27	0.0	0.0		0.21	0.0	0.0
Filtering	1	0.43	0.0		0.19	0.0		0.32	0.0	0.27	0.0	0.0		0.21	0.0	0.0

Bottling parts manufacture 1456															
Sub-process if required	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Bottle		0.43	0	100000	0.19	10	0	0.32	0	10000000	0.27	1350	700000	0.21	75
Label	50000	0.43	11		0.19	0		0.32	0		0.27	0		0.21	0
Bottle top	50000	0.43	11		0.19	0		0.32	0		0.27	0		0.21	0
Packaging		0.43	0		0.19	0		0.32	0		0.27	0		0.21	0

Transport - Winery to Bottling / Parts to Bottling 3				
Vehicle Type	Distance per journey km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Wine - Tanker small	Shipping - Tanker small	500	0.04	0.25
Parts import - Road	Lorry - Diesel Rigid	200	1.07	2.68
Parts import - Shipping	Lorry - Diesel Rigid		1.07	0

Packaging & Bottling 108															
Floor space m2	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Bottling	500000		107.5			0.0			0.0			0.0			0.0
of which															
Occupancy	50000	0.43	107.5		0.19	0.0		0.32	0.0	0.27	0.0	0.0		0.21	0.0
Load empty bottles															
Filling process															
Corking machine															
Labeling															
Packing															
Palleting															

Transport - Bottling to Consolidation Centre 3				
Vehicle Type	Distance per journey (return) km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Road	Lorry - Diesel Rigid	300	1.07	4.0

Inventory - Consolidation Centre 24															
Floor space m2	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Occupancy & Handling	45000	2500000	0.43	20.5	2500000	0.19	9.1	0.32	0.0	0.27	0.0	0.0	0.21	0.0	0.0

Transport - Consolidation Centre to National DC 132				
Vehicle Type	Distance per journey (return) km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Shipping	Shipping - Tanker small	132.3	0.04	132.3

Transport - Consolidation Centre to Regional DC 132				
Vehicle Type	Distance per journey (return) km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Shipping	Shipping - Tanker small	132.3	0.04	132.3

Inventory - National DC 24															
Floor space m2	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Occupancy & Handling	30000	2000000	0.43	16.4	2000000	0.19	7.2	0.32	0.0	0.27	0.0	0.0	0.21	0.0	0.0

Transport - National DC to Regional DCs 47				
Vehicle Type	Distance per journey (return) km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Road	Lorry - Diesel Rigid	200	1.07	47.3

Transport - National DC to Stores 47				
Vehicle Type	Distance per journey (return) km	Carbon / km kgCO2/km	Carbon / 1000 litre kgCO2	
Road	Lorry - Diesel Rigid	200	1.07	47.3

Inventory - Regional DC 19															
Floor space m2	Electricity used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Gas used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Coal used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	Oil used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2	LPG used per year kWh	Carbon/ kWh kgCO2/kWh	Carbon/ 1000 litre kgCO2
Occupancy & Handling	30000	2000000	0.43	13.1	2000000	0.19	5.8	0.32	0.0	0.27	0.0	0.0	0.21	0.0	0.0

change through their buying behaviour or supply chain organisation, it requires that stakeholders have good visibility of the relative merits of the options that can be exercised to support the national targets. Notwithstanding this requirement, there is a competitive element to the whole process and the recent Publicly Available Specification (PAS) 2050 is designed to ensure that standards in carbon foot-printing are followed and transparency is achieved. However, the PAS is about defining what to do rather than how to do it. Actually doing the work presents significant challenges in a number of areas. For example, the experience of the authors is that there are many data sources on carbon emissions with a significant lack of expert agreement on the true emissions for different elements of the chain. The fact that the experts do not agree and that there is no standard library of emissions rates is a concern as it allows doubters to question the outputs of any analysis. However, it also points to the fact that there are considerable local differences that may allow an organisation to select one figure over another.

So, the gap in carbon measurement and reporting appears to be the lack of a methodology to actually do the footprinting to the standard so that organisations, supply chain members and consumers can draw their own conclusions and plan step changes in the way they do business – even if the data is not perfect. It is this gap that the Carbon-to-Serve™ has tried to start to fill.

Potential for change

Over the years, we have devoted considerable effort to creating a standard framework for supply chain visualisation using mapping. The value in this approach, using time as the base, has been proven through a wide range of projects for its ability to create the discussion necessary to identify co-operative step changes in overall performance.

The starting point for this approach is that it should cover the end-to-end chain extending from customers back to suppliers where appropriate and include recycling and recovery. The second key principle is that supply chains are fundamentally simple and contain only three types of activity: inventory, movement and conversion.

All chains can be broken down into their unique DNA sequence of these elements, which may involve, within just one function, all three types. For

example, in a plant or warehouse there may be inventory in more than one location and several internal processing and transportation events. The first step in mapping a chain is to draw out the chain scaled to time along the bottom axis and representing each of the three types of event in their sequence of occurrence. In Figure 1, this is represented in standard convention of an inverted triangle for inventory, a block arrow for conversion and an arrow for transport. We have automated the production of these diagrams to support regular revisions and the map may be non-linear to compress the diagram to a chart that can be viewed on a single page. A scaled map could be measured at more than 10m, so a level of pragmatism is required in the way in which the chart is prepared. Figure 1 represents a simplified version of a global supply chain for the purpose of illustrating this paper. It is a charted on a constant time base.

Combined Cost and Carbon-to-Serve picture

The core feature of the methodology is to be able to bring together on to this map the carbon and cost build-up of all the activities in the chain into an accumulated estimate of the cost and carbon-to-serve for the chain. The model to achieve this is constructed in Microsoft Excel and is built in three steps.

Step 1 is to construct the best possible picture of the supply chain on a time base as described and shown in Figure 1. The supply chain needs to be represented as parallel supply side tracks that combine at different points in the chain; this enables all the associated activities of packaging, and production to be represented as shown for the manufacturer illustration.

Step 2 is to extract and normalise the data on energy consumption and emission. This is important because the ratios of usage and coverage vary for the activities along the chain.

The process of normalisation is the calculation that brings all of the supply chain components back from their standard local measure to the equivalent carbon to produce, based on a per kg, per litre or whatever measure is relevant to the product. It is at this point that allocations of shared resources need to be made by the appropriate driver. This normalisation process is difficult and results in a complex table that is illustrated, but not readable – see Figure over

Step 3 is the mapping of the carbon-to-serve of the chain, which the model does automatically based on the time taken for the process and the progressive summation of the elements of the chain normalised to the output standard. The model automatically draws the carbon build-up as the striated shaded area on the timescales for the chain shows in Figure 3. This is an example for manufacturing industry and not a validated case.

The principle advantages of this methodology are that it can:

- Be repeated quickly for different scenarios to show their reduction potential
- Hold and test a range of emissions standards and be used to build a library of benchmark information
- Be aligned to the cost-to-serve to support business decision-making.

As the world gets used to the carbon issue, the Carbon-to-Serve™ methodology can form a platform for refining the inputs and discussion of the conclusions and implications between the parties in the supply chain. Radical supply chain redesign of the type that will be needed to meet national goals will depend on the parties in the chain viewing the same consistent information.

Over the past six months, we have mapped the carbon footprints of several international supply chains and have built up a database of emissions factors. One of the key findings from our work is that supply chain costs and carbon emissions do not necessarily align. This makes it even more imperative for organisations to be able to visualise the impact of potential supply chain initiatives on their carbon footprint before making any changes. We believe that without this understanding there is a danger that organisations may make costly interventions that do not deliver corporate benefits. At a time when many companies are struggling to survive, our view is that the most effective way of approaching carbon management is to apply business principles to the environment, not environmental principles to business. ▀

About the authors

Professor Alan Braithwaite and Daniel Knivett Note. Registration of the methodology Carbon-to-Serve has been applied for by LCP Consulting. Cost-to-Serve® is a registered methodology of LCP Consulting Ltd. (with 3 figs and 2 pics) Article courtesy of The Chartered Institute of Logistics & Transport (CILT). For more information see website: www.ciltuk.org.uk