Development of a Freight Decarbonization Tool:

Evaluation of Measures for Reducing Freight Transport Emissions in the UK

Professor Alan McKinnon

Kühne Logistics University, Hamburg

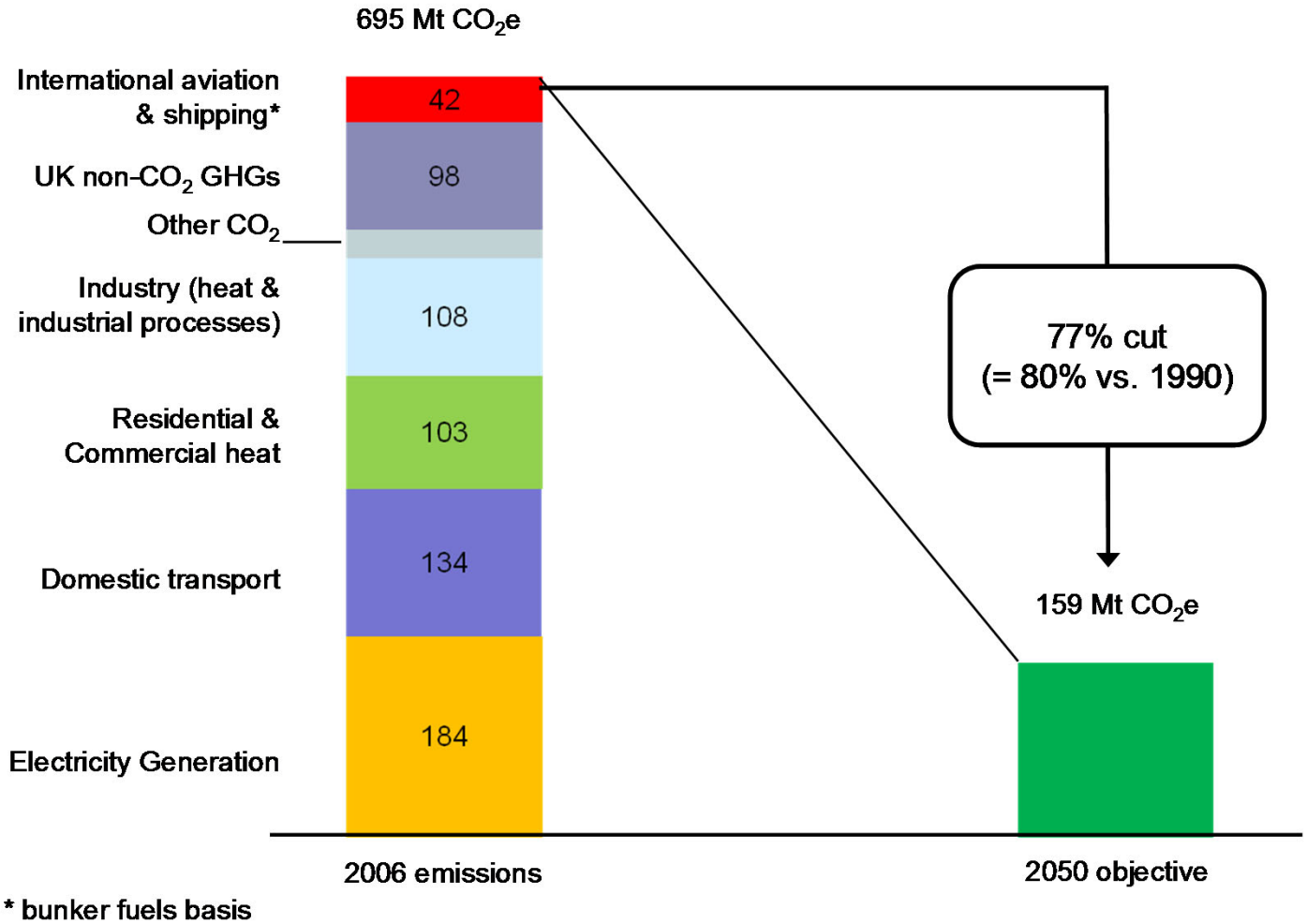
Workshop 175
TRB Annual Meeting 2013

Washington
13th January 2013

Downloaded from amonline.trb.org

UK Climate Change Act (2008)

CO_{2e} Reduction Targets



Source: UK Committee on Climate Change

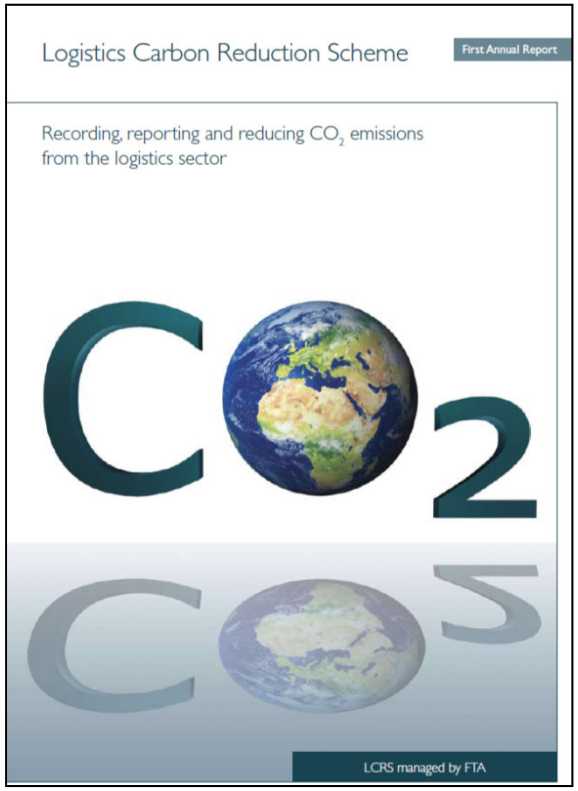
Downloaded from amonline.trb.org

FTA Logistics Carbon Reduction Scheme

Freight Transport Association

Delivering safe, efficient, sustainable logistics

14,000 members operating / using 200,000 trucks (half the UK's total fleet), delivering 90% of rail freight and 70% of exports by sea and air.



Logistics Carbon Reduction Scheme

December 2012: 72 companies operating 60,000 trucks and vans

Agree to report freight-related CO_2 emissions on a quarterly basis

Committed to reducing these emissions relative to turnover, employment and vehicle kilometres

Macro-level modelling:

Constructing freight-CO_2 scenarios

Deriving freight sector targets for CO_2 reduction between 2010 and 2015

Micro-level modelling:

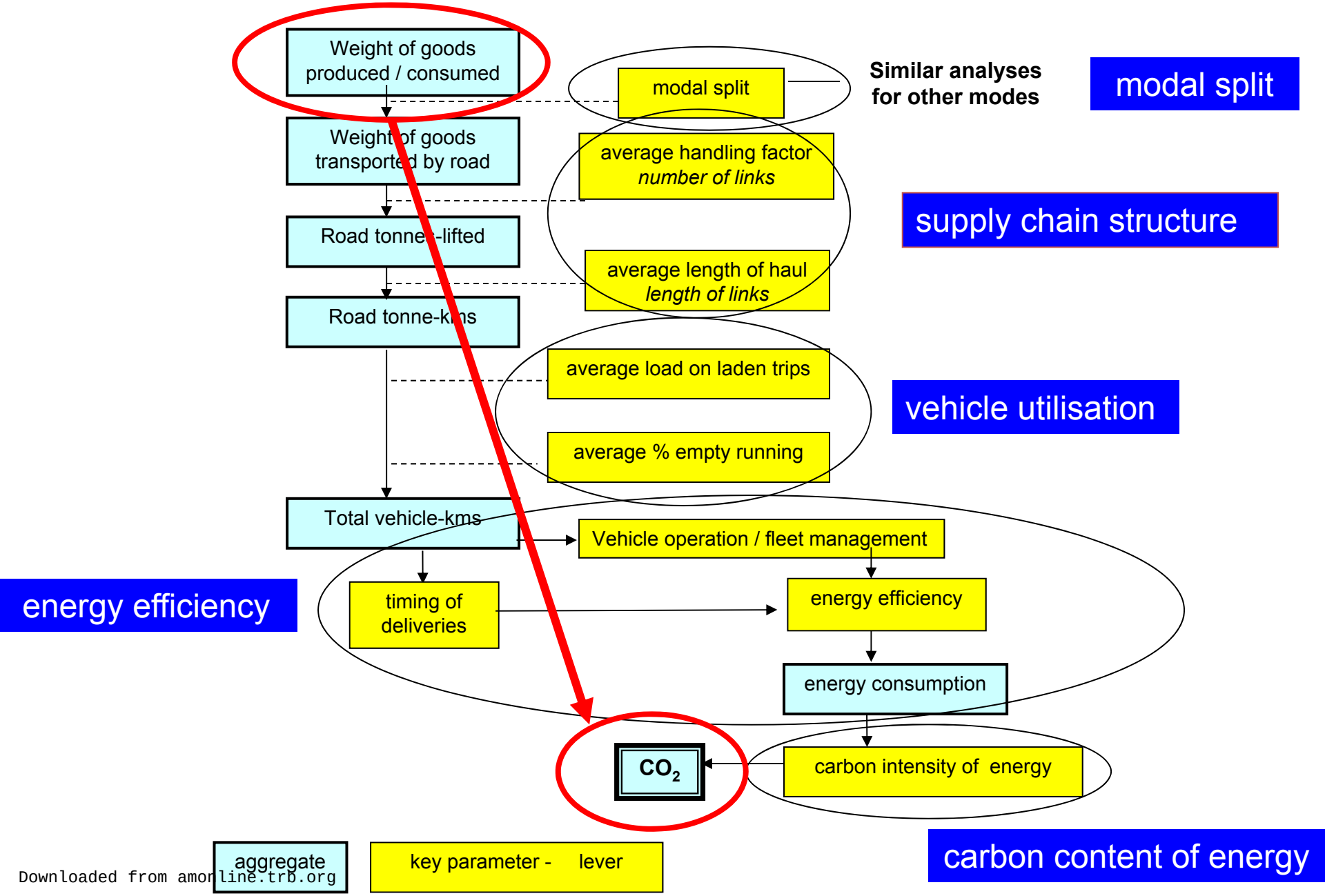
Software tool for companies to estimate the combined impact of a range of CO_2-reducing measures

Downloaded from amonline.trb.org

Members of the Logistics Carbon Reduction Scheme

Downloaded from amonline.trb.org

Decarbonisation Framework for Freight Transport



Downloaded from amonline.trb.org

Development of software tool to help companies devise carbon-reduction strategies

Inventory of Carbon-reduction Measures

Long list: 82 carbon-reducing measures

1. Reduce number of links in the supply chain:	**5. Reduce empty running:**
Dis-intermediation – bypassing agencies / nodes in the supply chain	Use load matching services (online freight exchanges / web-based procurement)
Greater vertical integration of processing – reduce intermediate journeys between processing plants	Promote collaborative initiatives – both vertical and horizontal collaboration
	Explore backloading opportunities during purchasing negotiations
2. Reduce the average length of haul:	Incorporate the planning of backloading into vehicle routing and scheduling software
More localised sourcing of inbound supplies	Use telematics to increase 'visibility' of the fleet and help exploit backloading opportunities
Decentralise processing, storage and distribution operations	Consolidate return of handling equipment (roll-cages / dollies) in a fewer vehicles
Move production / storage / distribution facilities into more 'transport efficient' locations	Maximise use of returning shop delivery vehicles for collection of packaging material
Swap arrangements - to minimise delivery distances	Relax delivery schedules to accommodate more backloads
Improve vehicle routing (e.g. use CVRS) / recalibrate routing packages to minimise fuel consumption	Improve the reliability of loading and off-loading operations to build confidence in backloading schedules
Use telematics (possibly in association with CVRS) to determine most fuel efficient route	Increase the ratio of trailers to tractors (i.e. the 'articulation ratio') to create more flexibility for backloading
3. Promote transfer of freight to lower carbon modes	**6. Reduce exposure to traffic congestion**
Send greater % of freight by rail	Reschedule deliveries to inter-peak periods and evening / night
Send greater % of freight by waterborne services	Extend opening hours of premises for collections and deliveries
Relocate production facilities / warehousing to be adjacent to alternative transport network	Introduce unattended delivery systems for out-of-hours delivery
Invest in rail siding and / or rolling stock	
Apply for government freight facilities grants	**7. Improve fuel efficiency**
Develop / invest in equipment to facilitate intermodal transfers	Development fuel management programme
Reschedule distribution operations to match timetables of the alternative mode	Appoint fuel champion
	Collect and analyse disaggregated fuel consumption data
4. Increase vehicle payloads on laden trips:	Train drivers in the techniques of fuel efficient driving (eco-driving)
Relax just-in-time replenishment schedules to permit greater load consolidation	Use telematics / onboard devices to monitor driving performance
Increase use of primary consolidation (at expense of adding an extra link to the supply chain)	Regularly debrief drivers on fuel performance
Give hauliers / transport departments more advanced warning of traffic demands	Give drivers financial and other incentives to drive more fuel efficiently
Promote collaborative initiatives – both vertical and horizontal collaboration	Reduce the vehicle replacement cycle to accelerate adoption of more fuel efficient vehicles
Shift from dedicated contracts with 3PL to shared-user contracts / network services	Prioritise fuel efficiency as a vehicle purchase criterion
Suppress the 'bullwhip effect' in supply chains	Use vehicle with stop-start system
Adopt 'vendor-managed inventory' (VMI) arrangement with suppliers	Use vehicle with turbocharging
Expand the use of 'nominated day' delivery systems	Reduce vehicle tare weight
Replace the monthly 'order – invoice' cycle with a system of rolling credit	Improve aerodynamic profiling of vehicles
Use more 'space-efficient' handling equipment	Improve vehicle maintenance, wheel-alignment etc.
Minimise the amount of secondary and primary packaging	Adopt vehicles with automatic transmission
Stack loads to greater height (within warehouse slot height constraints)	Ensure effective tyre management / inflation of tyres to fuel efficient level
Reduce the height of rigid vehicles / trailers to match internal load	Use supersingle tyres
Use longer and/or heavier vehicles when justified by load size / weight	Use low 'rolling-resistance' tyres
Make greater use of double-deck vehicles / drawbar trailer combinations.	Set vehicle speed limiters at lower speeds
Switch from powered- to fixed-double deck trailer	Reduce engine idling
Use compartmentalised vehicles to increase load consolidation opportunities	Match vehicle size and weight to the characteristics of the load
Increase storage capacity at delivery points – to permit delivery of larger loads	Adopt more energy efficient forms of refrigeration
Use of online procurement platforms ('freight exchanges') to increase opportunities for load consolidation	Reduce pre-loading time for refrigerated vehicles
Deploy load optimisation software (including agent-based systems)	Power tanker pumps externally rather than from vehicle engine
Use telematics to improve management of the vehicle fleet	
	8. Reduce emissions per litre of fuel consumed:
	Use hybrid vehicles
	Use new electric vehicles
	Use new biogas vehicle
	Use new CNG vehicle
	Use dual-fuel vehicle (biogas or LNG with conventional diesel)
	Increase % blend with environmentally-sustainable biofuel
	Recharge vehicle batteries with low carbon electricity
	Use lower carbon energy in refrigeration equipment
	Minimise refrigerant gas leakage from vehicles

38 measured modelled

Measures to Reduce Energy Consumption
1. Vehicle design and settings
1.1 Adopt vehicles with automatic (manual) transmission
1.2 Set vehicle speed limiters at lower speed
1.3 Install anti-idling device
1.4 Switch from powered to fixed-deck trailers (for double-decks)
1.5 Reduce vehicle tare weight
Aerodynamic profiling:
1.6 Install cab-roof fairing
1.7 Install body / trailer side panels
1.8 Use trailers with sloping front roof (double-deck / high-cube vehicles)
1.9 Use tear-drop trailer
1.10 Reduce height of vehicle
Tyres
1.11 More regular tyre inflation checks
1.12 Fit low rolling resistance tyres
1.13 Fit super singles
1.14 Automatic tyre pressure adjustment
2. Fuel type:
2.1 Use fuel additive
2.2 Use low-friction oil / lubricant
3. Driver training and monitoring
3.1 Give drivers training in fuel efficiency
3.2 Monitor and manage driver fuel performance (including telematics)
4. Delivery operations
4.1 Increase proportion of evening / night-time delivery
4.2 Use of telematics to optimise vehicle routing
4.3 Accelerate turnaround times at collection and delivery points
Measures to Reduce the Carbon Content of Energy Used
5. Use of alternative fuels / energy sources
5.1 Increase use of hybrid vehicles
5.2 Increase use of electric vehicles
5.3 Increase use of biodiesel
5.4 Increase use of biomethane / CNG
Measures to Reduce Distance Travelled by Road Vehicles
6. Improve vehicle loading
Increase vehicle carrying capacity
6.1 Make greater use of double-deck / high-cube vehicles
6.2 Make greater use of longer and / or heavier vehicles
6.3 Reduce vehicle tare weight
6.4 Switch from powered to fixed-deck trailers (for double-decks)
Make better use of available carrying capacity
6.5 Reduce empty running / increase backloading
6.6 Improve vehicle fill on laden trips (by weight and / or volume)
6.6 Use more space-efficient handling equipment
6.7 Rationalise the return of empty handling equipment
7. Improve vehicle routing
7.1 Introduce computerised vehicle routing and scheduling
7.2 Zone deliveries on a 'nominated day' basis
8. Shift freight to alternative modes
8.1 Send a greater % of freight by rail
8.2 Send a greater % of freight sea or waterway
9. Reconfigure the logistics system
9.1 Reposition inventory within the existing system
9.2 Relocate distribution facilities

- Reducing energy consumption (relative to distance travelled)
- Reduce carbon content of the energy consumed
- Reduce distance that vehicles travel

Downloaded from amonline.trb.org

Sources of Data for Model Calibration

Secondary data

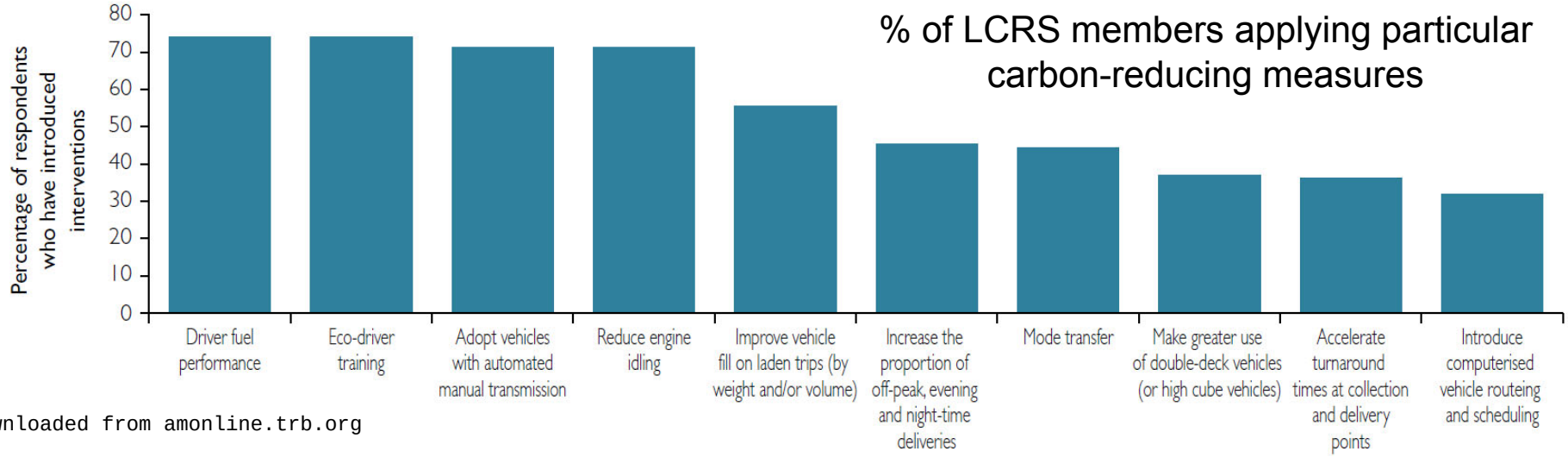
- UK government 'Freight Best Practice' programme
- Consultancy reports on Low Carbon Truck Technologies
- UK government study on reducing externalities from food distribution in UK
- Manufacturers' literature and websites
- Academic research

Primary data

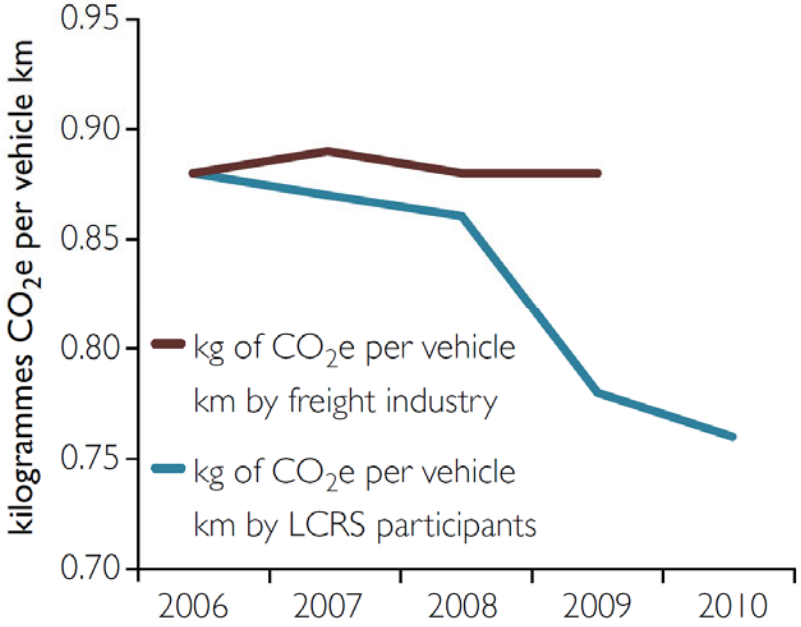
15 participating companies including DHL, TNT, Wincanton, Arla Foods and John Lewis.

Use of the software tool to capture company data on carbon savings for individual measures : *replacing default values with company-specific figures*

Initial distribution of beta version of software to members of the FTA LCRS

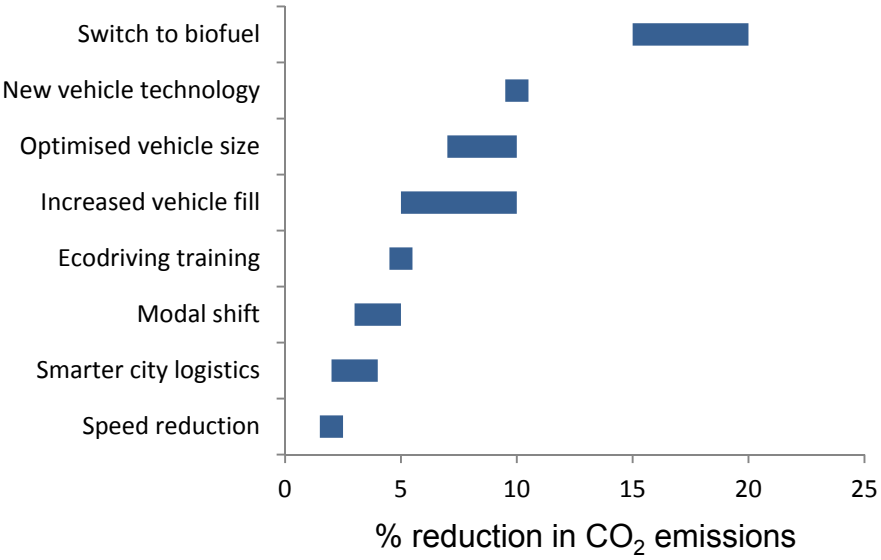


Downloaded from amonline.trb.org

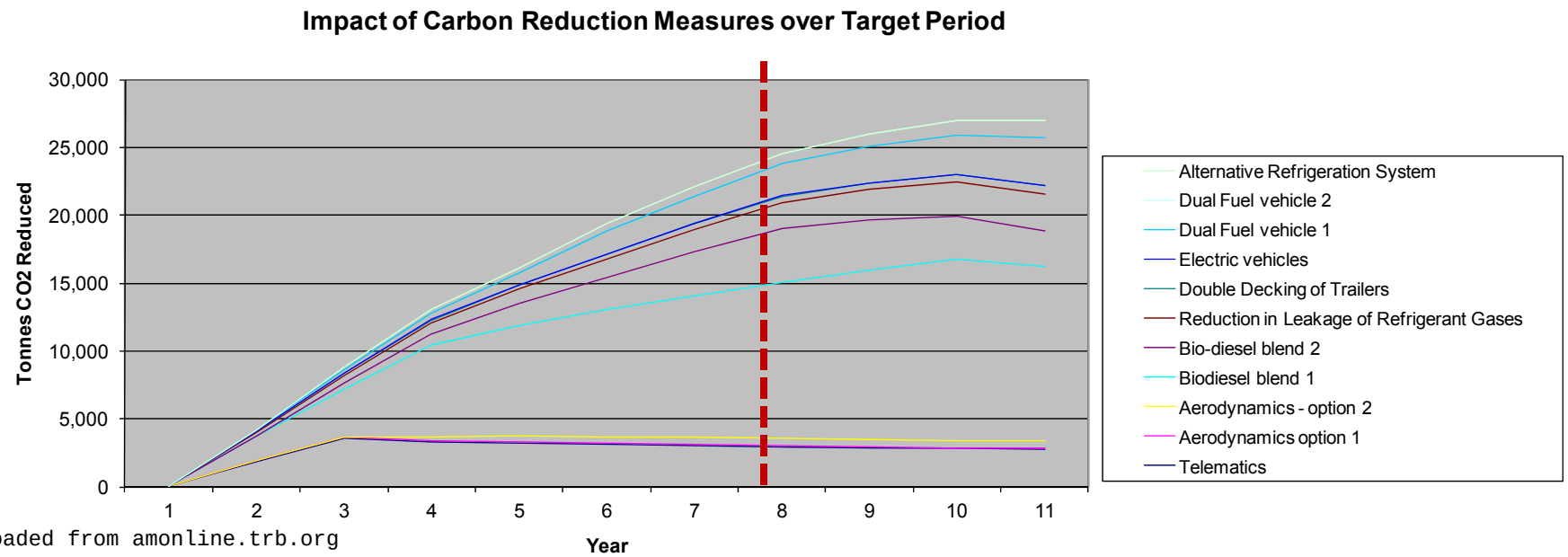


Estimated CO_2 Savings from Various Sources 2006-2020

DB Schenker's Land Division (Sweden)

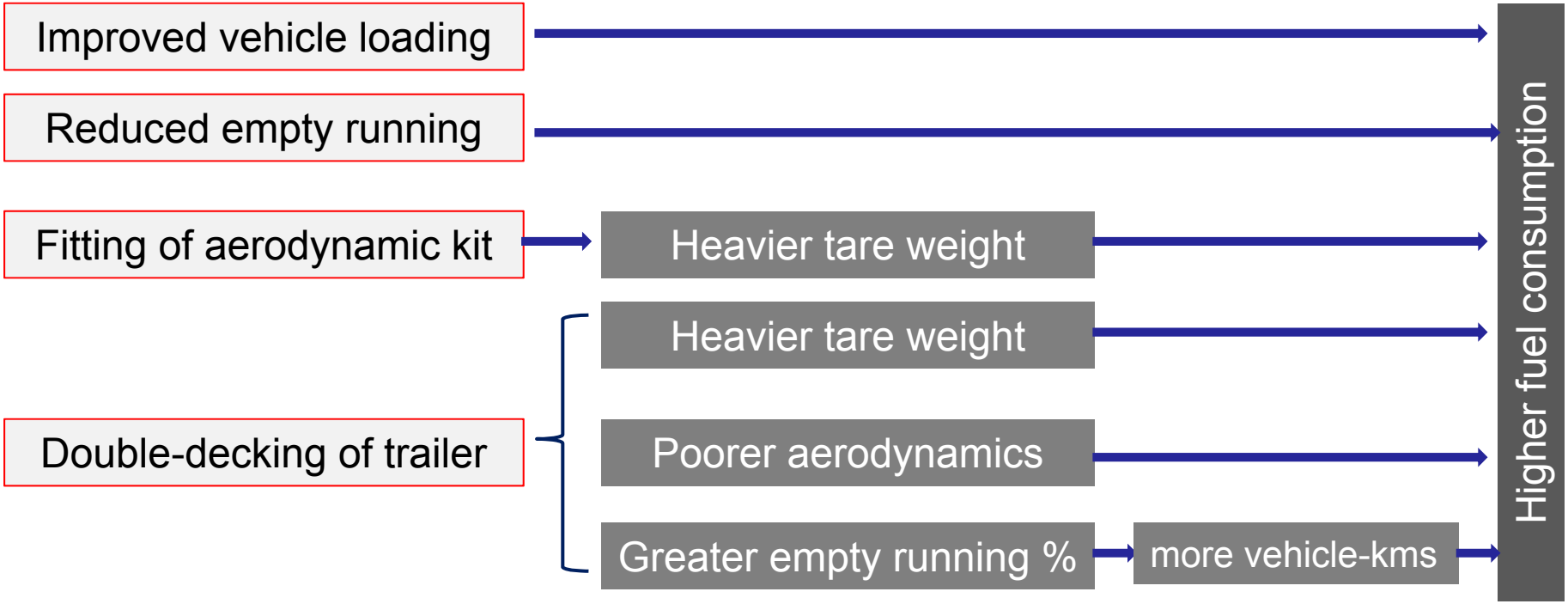


Carbon Reduction Trajectory for Large UK Road Freight Fleet



Downloaded from amonline.trb.org

Modelling Inter-dependences



No allowance for second-order / rebound effects from efficiency improvements

No financial calculations / estimates of relative cost-effectiveness

Downloaded from amonline.trb.org

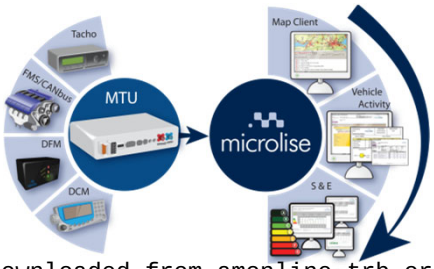
Company Feedback on the Decarbonisation Tool

Reasons for limited company feedback on typical carbon savings:

- No experience of the action
- Measure implemented to cut cost rather than carbon – *carbon impact not assessed*
- Measure introduced many years previously – *no retrospective data*
- Difficult to determine the baseline – *especially where introduction was phased*
- Several measures implemented simultaneously – *difficult to separate their effects*
- Special circumstances of company / market make its experience atypical

Wide variations in estimated CO_2 savings from interventions

Teardrop trailer
claims: 1 – 12% fuel saving per vehicle-km
Main saving from extra cube at top of trailer for certain products
e.g. hanging garments ?



Vehicle telematics – fuel efficiency score-card
claims: 5 – 17% fuel efficiency improvements

Depends on the nature of the delivery operation
and baseline conditions

Downloaded from amonline.trb.org

Microsoft Excel non-commercial use - Decarbonisation Prediction Model Ver 1 7

Freight Transport Association
Delivering safe, efficient, sustainable logistics

Decarbonisation Model - Main Menu

HERIOT WATT UNIVERSITY

Carbon intervention modelling tool

This tool can model current and future CO_2 emissions from a company's freight transport operation. These emissions can be reduced by the application of a range of technologies and management practices. A total of 36 carbon-reducing measures have been identified on the basis of previous research and company experience. By modelling the effects of these measures individually and in various combinations, the tool allows you to conduct what-if analyses and thus help you to develop a 'decarbonisation strategy' for freight transport.

The first step is to click the 'Input Data' button. This opens a table in which you should insert information about your current vehicle fleet. You can specify the fleet in various ways. At the most aggregated level, you can treat it as a single entity and enter only one row of values. If your fleet comprises one type of vehicle undertaking very similar delivery operations this might be a sensible option. If, however, you operate a mixed fleet engaged in different types of distribution, it would be advisable to differentiate the various classes of vehicle and / or distribution operation assigning each a different row in the table. If you operate a small fleet, you may even wish to enter data for individual vehicles, each getting a separate row. Clicking on each cell opens a window providing advice on the information required.

Having specified your vehicle fleet and indicated the anticipated change in total vehicle-kms between now and 2013 and 2015, you can proceed to the 'Select Measures' screen by clicking the appropriate button. This lists the 36 carbon-reducing measures under three general headings:

1. Measures which reduce energy consumption (relative to distance travelled)
2. Measures which reduce the carbon content of the energy used
3. Measures which reduce the distance travelled by road vehicles

As some measures can reduce both fuel use and vehicle-kms they appear under both headings.

Clicking on the measure opens a window containing background information and a default value indicating the % reduction in energy consumption, carbon content or distance travelled that you might expect to achieve from applying this intervention. It is possible to alter this default value by moving the slider within the pre-defined range. You can also indicate to what % of your vehicle fleet the measure is currently applied and will be applied in 2013 and 2015. Separate estimates are required for each of the categories of vehicle / distribution operation that you specified earlier. In the case of several of the measures that reduce distance travelled, there will be an adverse effect on fuel efficiency. This is indicated in red and a default value has been inserted to allow for this offsetting effect. Again you can substitute an alternative value for the default figure.

Once you have decided on a suitable range of carbon-saving measures for your fleet and indicated the % uptakes for today, 2013 and 2015, you can get the results presented in either tabular or graphical form by clicking on the appropriate button. The table is divided into three sections. The first shows the baseline position, estimating the current level of CO_2 emissions for each category of vehicle / distribution operation and the total for the fleet as a whole. There are also baseline projections of the change in this carbon footprint by 2013 and 2015 assuming that no carbon-saving measures are applied. The second section forecasts the level of CO_2 emissions in 2013 after the specified carbon-saving measures have been applied. Clicking on the 'vehicle type' cells opens a window containing a summary of the selected measures and level of adoption. An indication is given of the predicted changes in carbon emissions in 2013 relative both to the current level and the baseline projections for 2013. The third section provides the same output for 2015. All these

Input Data

Select Measures

Display Results in Tabular Form

Display Results in Graphical Form

Close Model

http://www.fta.co.uk/policy_and_compliance/environment/decarbonisation_tool.html

Downloaded from amonline.com

Microsoft Excel non-commercial use - Decarbonisation Prediction Model Ver 1 7

Freight Transport Association
Delivering safe, efficient, sustainable logistics

Decarbonisation Model - Input Data

HERIOT WATT UNIVERSITY

Save | Main Menu | Select Measures | Tabular Results | Graphical Results | Clear Contents

	Vehicle Type	Field for User Description	Trailer Type	Fuel Consumed per Year (Litres)	Litres per 100km Average Vehicle Fuel Consumption	Fuel Type	If Bio Enter the % Blend	Total Kilometres this Year	% increase over total km/year 2013	2015
1	7.5 to 18 tonne rigids	urban distribution	Standard		29	Bio Diesel	5%	245000	5%	10%
2	Over 18 tonne rigids	special loads	Standard		32	Diesel or Hybrid		563000	5%	10%
3	Over 32 tonne artics	primary trunking	Standard		35	Diesel or Hybrid		1400000	5%	10%
4	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
5	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
6	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
7	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
8	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
9	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
10	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
11	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				
12	-- No Vehicle Type Selected --		Standard			Diesel or Hybrid				

22:58
12/05/2011

Downloaded from amonline.trb.org

Microsoft Excel non-commercial use - Decarbonisation Prediction Model Ver 1 7

Freight Transport Association
Delivering safe, efficient, sustainable logistics

Decarbonisation Model - Select Measures

HERIOT WATT UNIVERSITY

Save | Main Menu | Input Data | Tabular Results | Graphical Results | Reset Interventions

	Carbon-saving Measure (Double click on measure to enter values)	Measure Applied		
		This Year	2013	2015
	Measures to Reduce Energy Consumption			
1	**Vehicle Design and Settings**			
1.1	Adopt vehicles with automated manual transmission	No	Yes	Yes
1.2	Set vehicle speed limiters at lower speeds	No	Yes	Yes
1.3	Reduce engine idling	No	Yes	Yes
1.4	Switch from powered to fixed-deck trailers (for double-decks)	No	No	No
1.5	Reduce vehicle tare weight	No	No	No
1.6	Install cab roof fairing	Yes	Yes	Yes

22:59
12/05/2011

Downloaded from amonline.trb.org

Microsoft Excel non-commercial use - Decarbonisation P

Freight Transport Association
Delivering safe, efficient, sustainable logistics

Save | Main Menu | Inpu

Carbon-saving Measure 1.4

Switch from powered to fixed-deck trailers (for double-decks)

Most double-deck box trailers in the UK have powered-decks allowing operators to lower and offload the top deck anywhere. The hydraulic system for the powered deck adds extra weight to the trailer reducing its fuel efficiency. It is estimated that a trailer with a fixed second deck is around 3-4% more fuel efficient than one with a powered deck, other things being equal. Box double-deck trailers with a fixed deck require external lifting gear at factories, warehouses and shops. Where space permits these can be installed quite quickly and, for some types of logistics operation, offer a good rate of return. Allowance must be made for the electicity used by the external lifting equipment and related CO2 emissions.

Typical Value 3 %

2 % 5

Select a value within the typical ranges shown above

Note: Enter 0% if you wish a vehicle type to be excluded

		% of kilometres applied to measure		
		This Year	2013	2015
1	7.5 to 18 tonne rigids - urban distribution	0 %	0 %	0 %
2	Over 18 tonne rigids - special loads	0 %	0 %	0 %
3	Over 32 tonne artics - primary trunking	0 %	0 %	0 %

HERIOT WATT UNIVERSITY

ures

ons

		Applied	
		13	2015
1	Vehicle Design and S		
1.1	Adopt vehicles with auto	es	Yes
1.2	Set vehicle speed limiters	es	Yes
1.3	Reduce engine idling	es	Yes
1.4	Switch from powered to f	lo	No
1.5	Reduce vehicle tare weig	lo	No
1.6	Install cab roof fairing	es	Yes

23:00
12/05/2011

Downloaded from amonline.trb.org

Microsoft Excel non-commercial use - Decarbonisation Prediction Model Ver 1 7

Freight Transport Association
Delivering safe, efficient, sustainable logistics

Decarbonisation Model - Tabulated Results

HERIOT WATT UNIVERSITY

Save | Main Menu | Input Data | Select Measures | Display Results in Graphical Form

		Baseline			2013 (With measures applied)					2015 (With measures applied)				
	Vehicle Type	CO2 Emitted for This Year(kgs)	Projected CO2 Emitted in 2013 (kgs)	Projected CO2 Emitted in 2015 (kgs)	Estimated CO2 Emissions (kgs)	Saving (kgs) over This Year	Saving (%) over This Year	Saving (kgs) over Baseline 2013 Projected CO2	Saving (%) over Baseline 2013 Projected CO2	Estimated CO2 Emissions (kgs)	Saving (kgs) over This Year	Saving (%) over This Year	Saving (kgs) over Baseline 2015 Projected CO2	Saving (%) over Baseline 2015 Projected CO2
1	7.5 to 18 tonne rigids - urban distribution	183,913	193,109	202,305	170,795	13,118	7.1%	22,314	12.1%	176,238	7,676	4.2%	26,067	14.2%
2	Over 18 tonne rigids - special loads	475,857	499,649	523,442	449,035	26,822	5.6%	50,614	10.6%	463,456	12,401	2.6%	59,986	12.6%
3	Over 32 tonne artics - primary trunking	1,294,237	1,358,949	1,423,661	1,139,506	154,731	12.0%	219,443	17.0%	1,150,788	143,449	11.1%	272,873	21.1%
4	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
5	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
6	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
7	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
8	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
9	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
10	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
11	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
12	-- No Vehicle Type Selected --	0	0	0	0	0	0.0%	0	0.0%	0	0	0.0%	0	0.0%
	Total	1,954,007	2,051,707	2,149,408	1,759,336	194,671	10.0%	292,371	15.0%	1,790,481	163,526	8.4%	358,926	18.4%

23:01
12/05/2011

Downloaded from amonline.trb.org

n-commercial use - Decarbonisation Prediction Model Ver 1 7

Freight Transport Association
Delivering safe, efficient, sustainable logistics

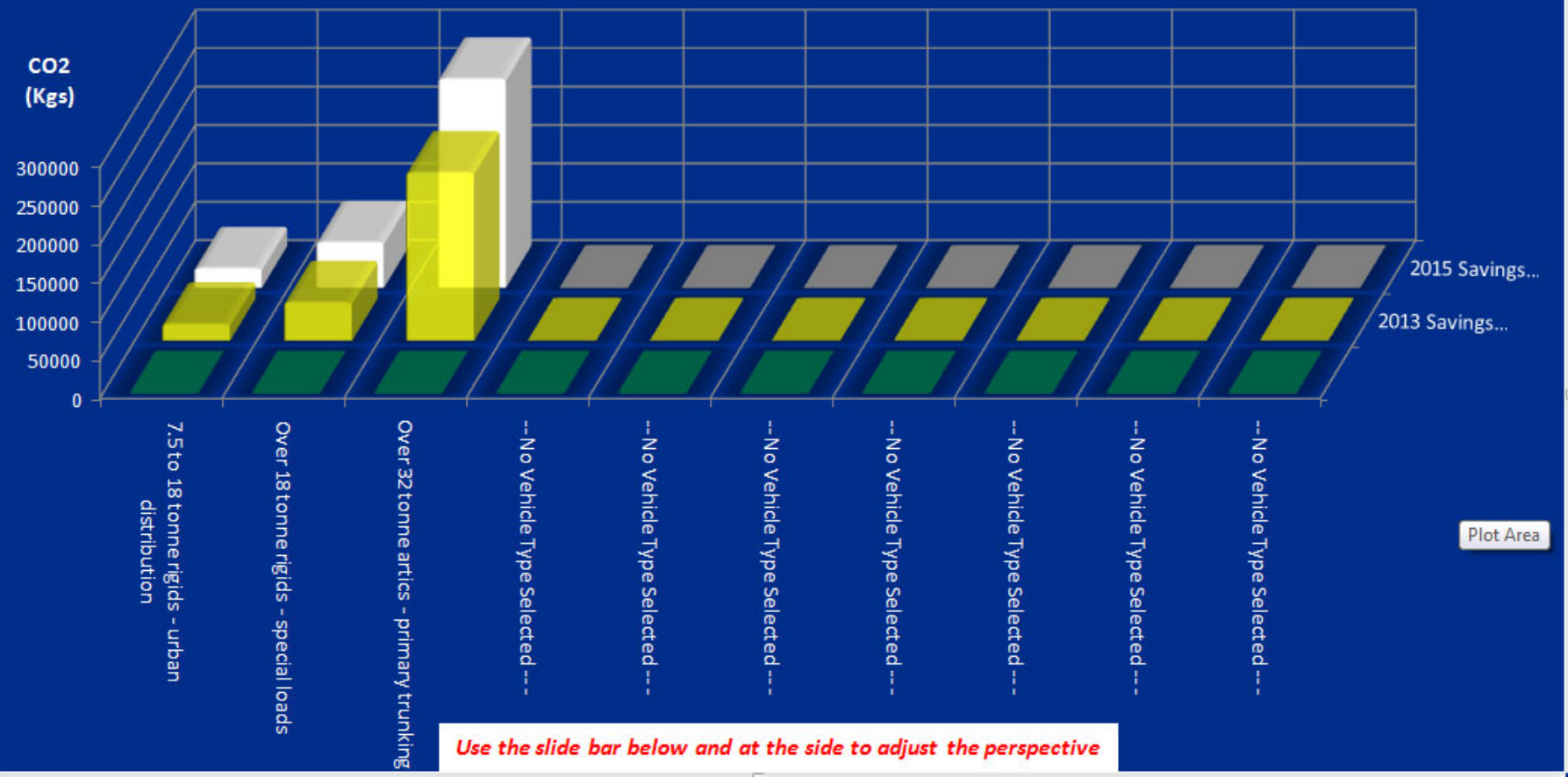
Decarbonisation Model - Graphical Results

2-D 3-D

HERIOT WATT UNIVERSITY

Kgs CO2 By Year With Measures | Kgs CO2 By Year Without Measuress | Kg Savings Over This Yea | Kg Savings Over Projected

Save | Main Menu | Input Data | Select Measures | Display Results in Tabular Form



Plot Area

Use the slide bar below and at the side to adjust the perspective

Downloaded from amonline.trb.org

Contact details

Kühne Logistics University – The KLU
Wissenschaftliche Hochschule für Logistik und Unternehmensführung
Brooktorkai 20
20457 Hamburg

E-Mail: alan.mckinnon@the-klu.org
Website: www.the-klu.org

Downloaded from amonline.trb.org