Decarbonizing Road Freight Transport

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Climate plans and climate budgets: what does this mean for road freight transport?

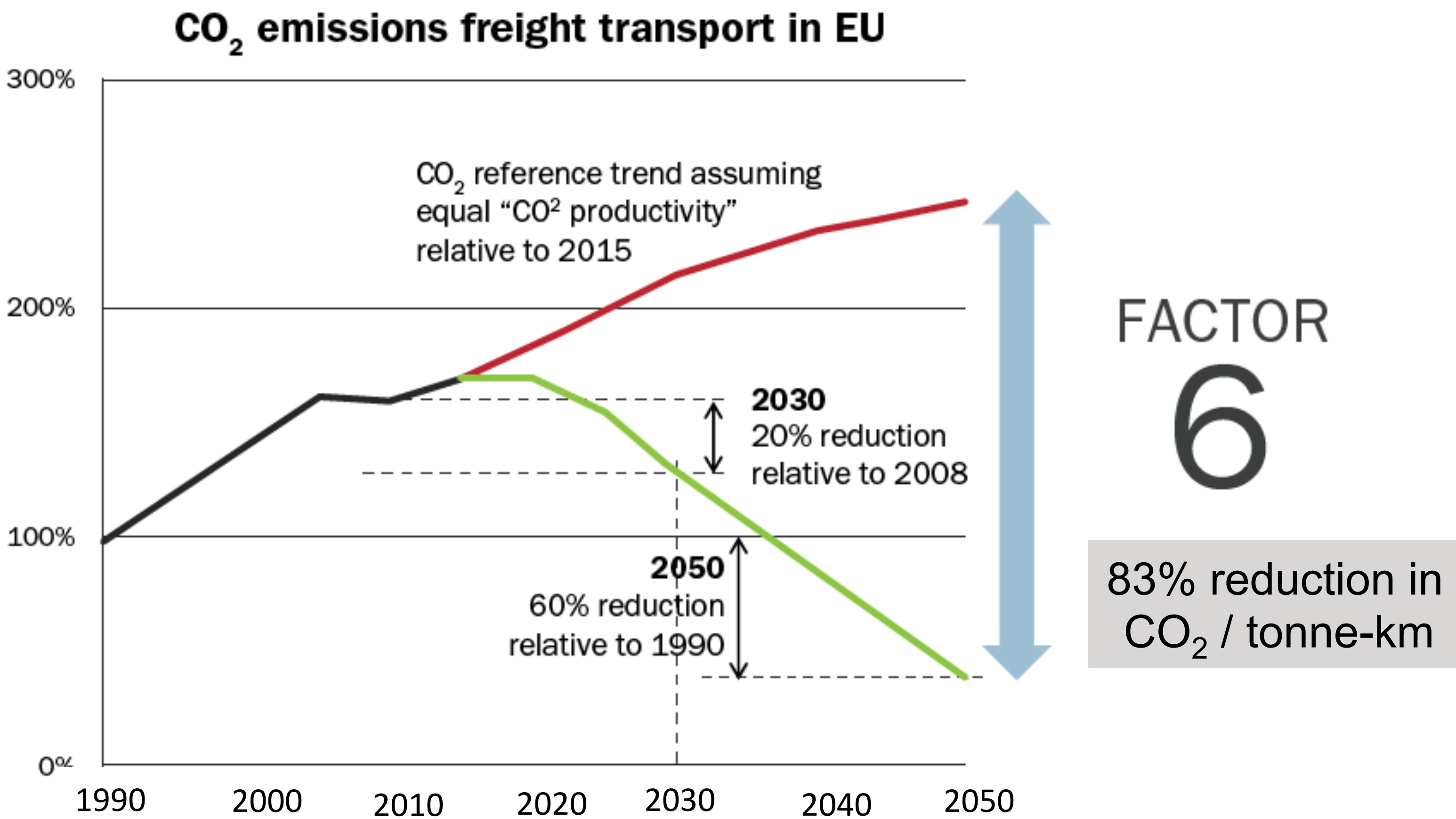
Energy Fund / Concito Workshop

Copenhagen

14 May 2019

Meeting EU 2011 Transport White Paper CO_2 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

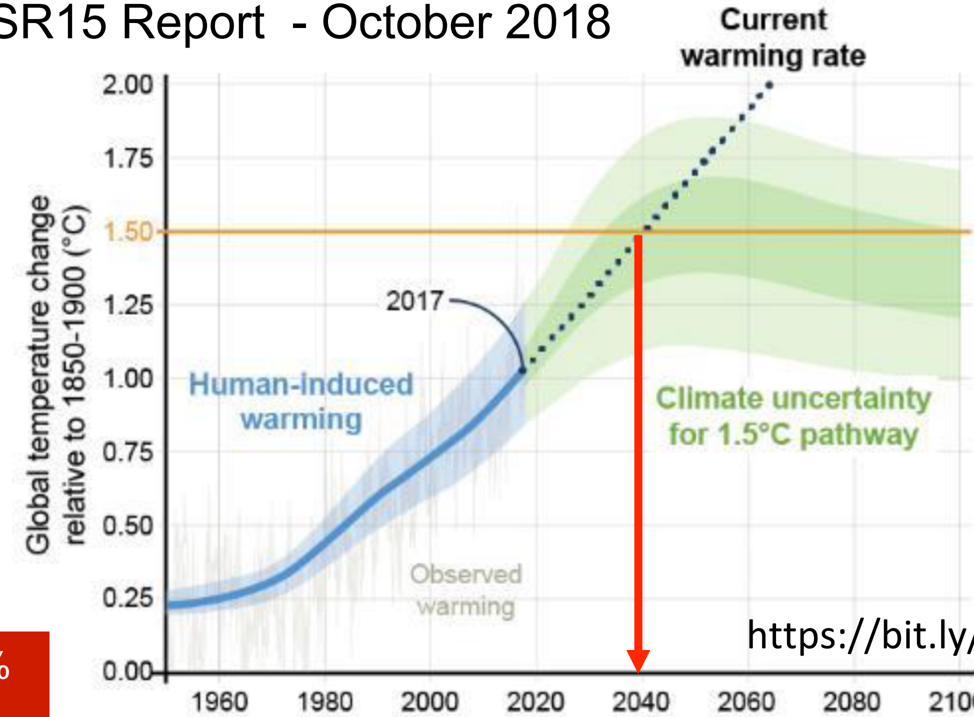
⬇

80% reduction in carbon intensity

achievable even in 35 years ?

may not be able meet the absolute CO_2 reduction target without restraining the growth in freight movement

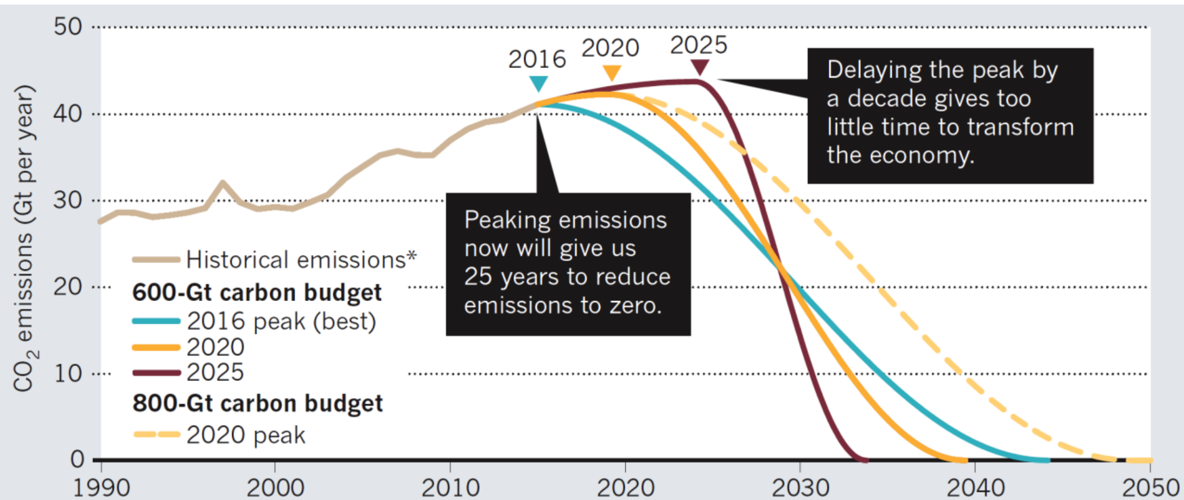
IPCC SR15 Report - October 2018



https://bit.ly/2AsMPky

Need to cut CO_2 emissions globally by 50% by 2030 and end them by 2050

Need to stay within tight carbon budgets to limit temperature rise to 1.5-2.0ºC

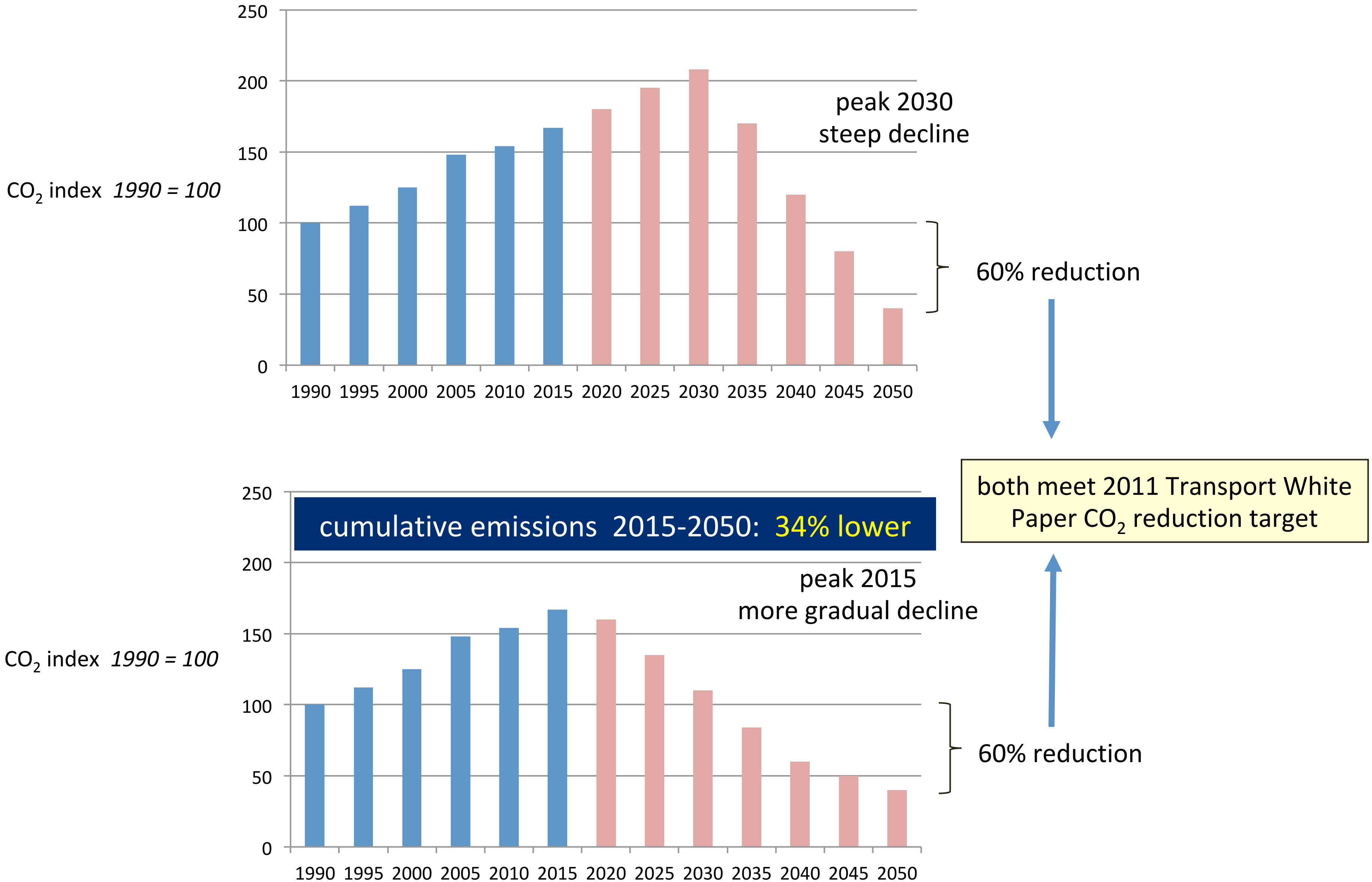


Source: Figueres et al, *Nature* June 2017

*Data from The Global Carbon Project.

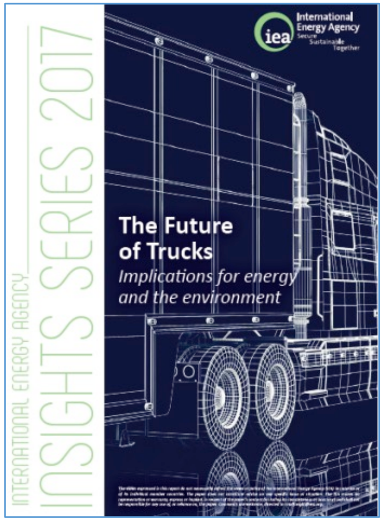
https://bit.ly/2WGTINT

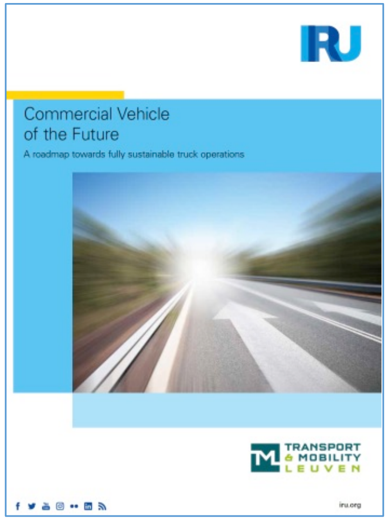
CO_2 emission reduction profiles for European freight transport

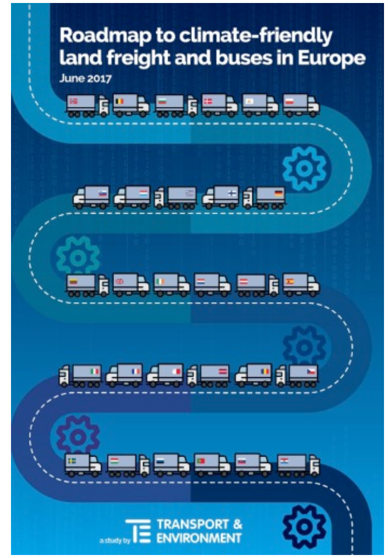


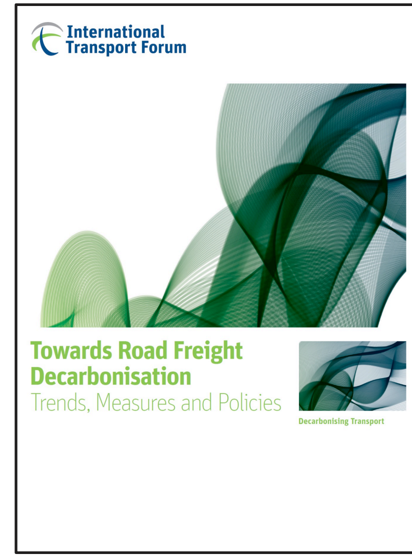
Source: McKinnon (2018) *Decarbonizing Logistics*

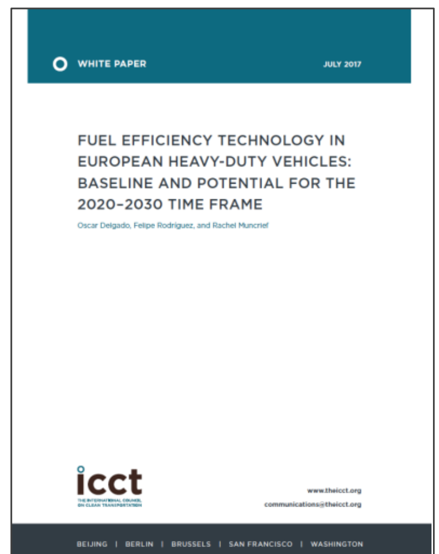
Examples of recent reports on the decarbonisation of road freight

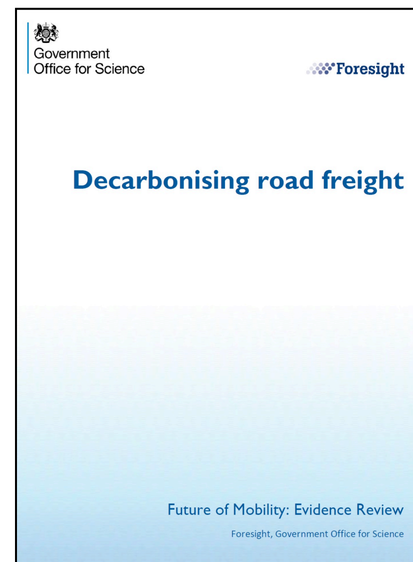




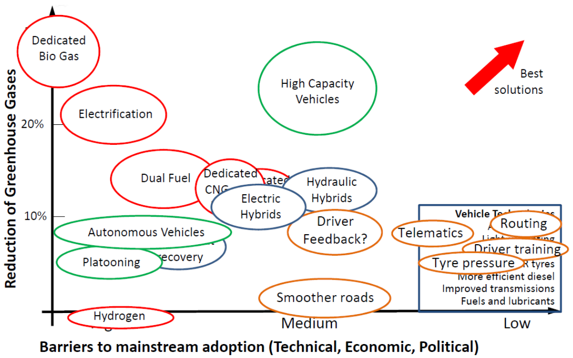




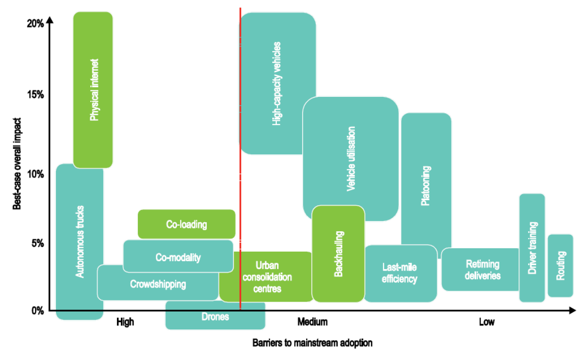




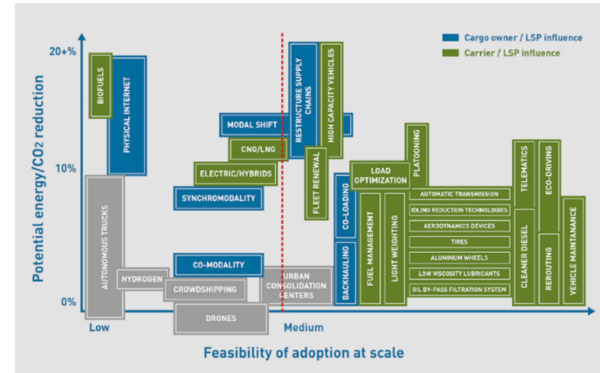
Road freight decarbonisation measures: *abatement – implementation graphs*



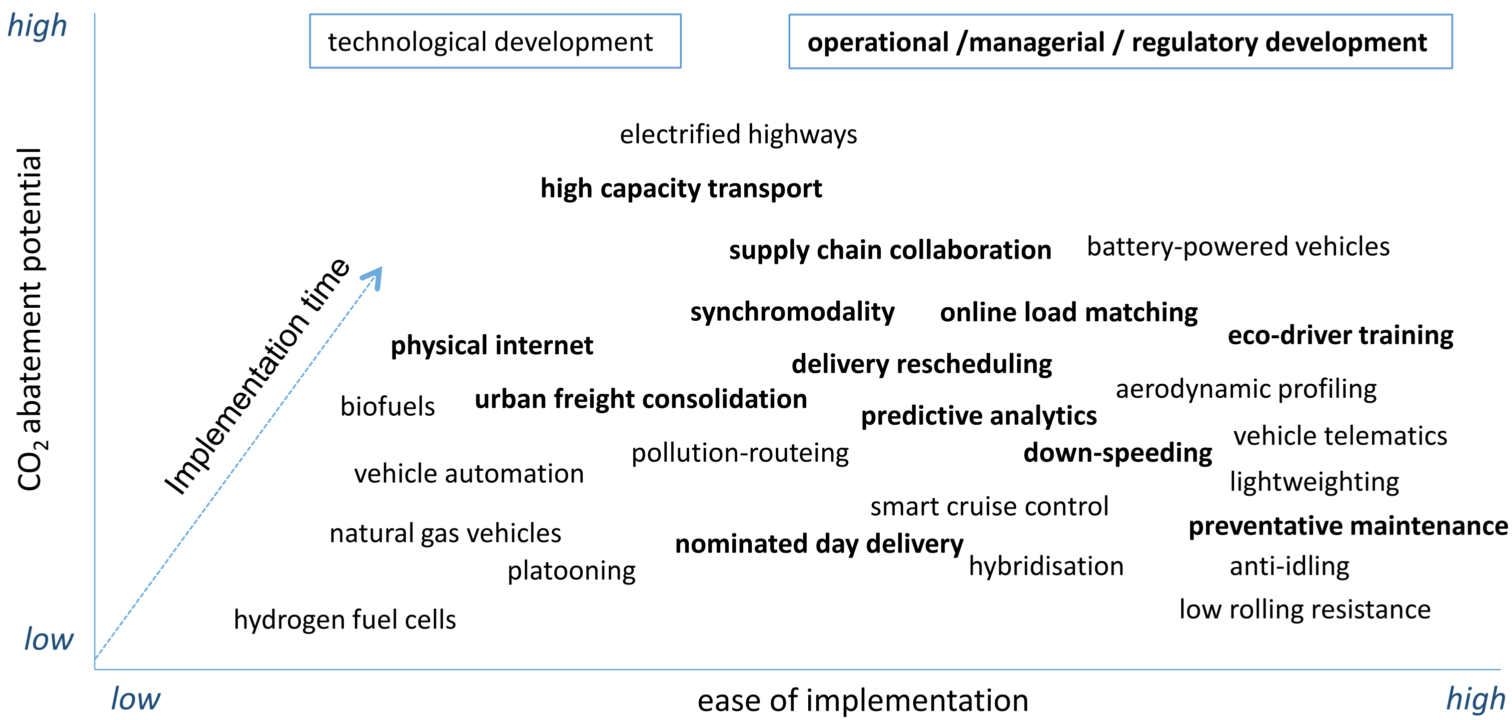
Professor Cebon



International Energy Agency

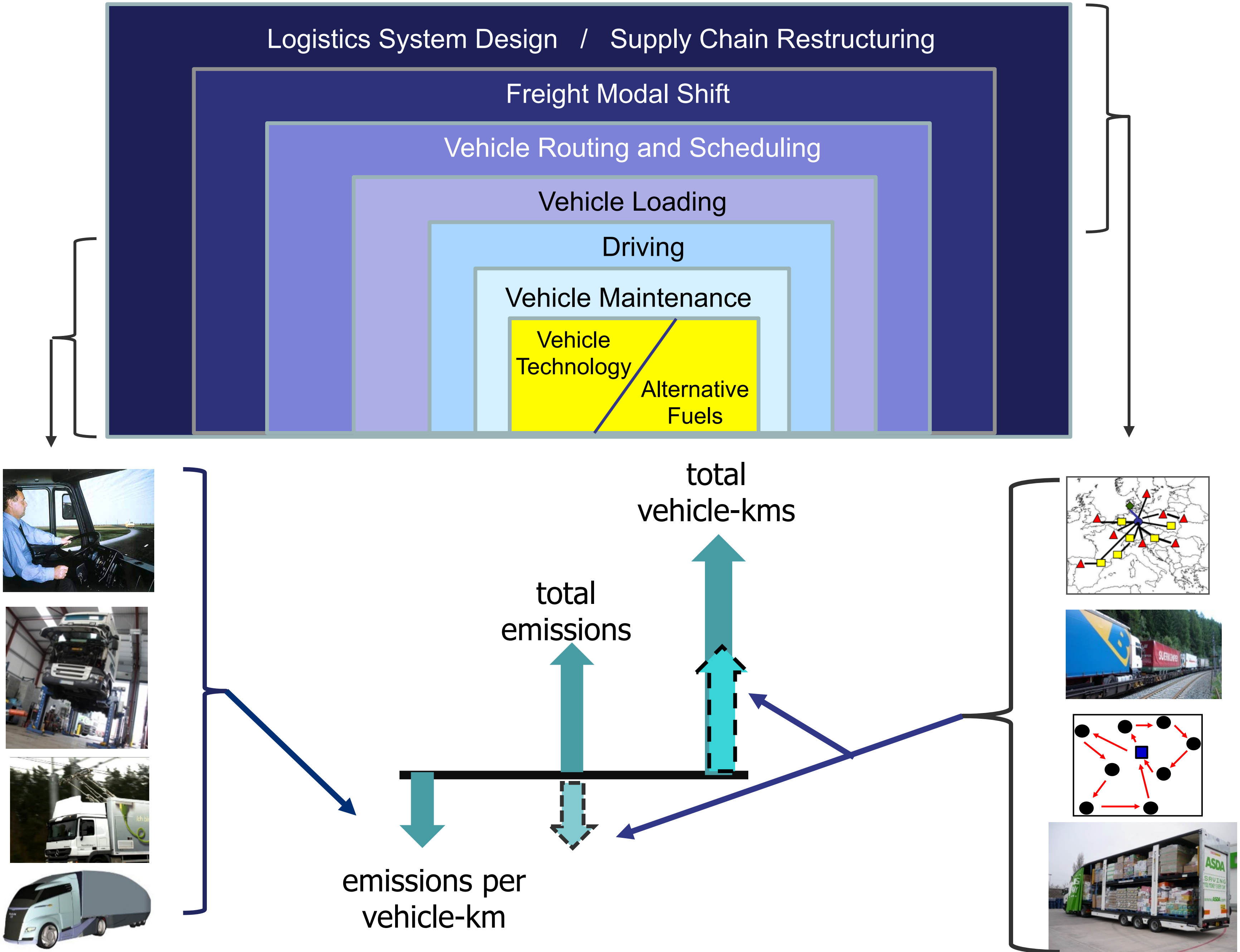


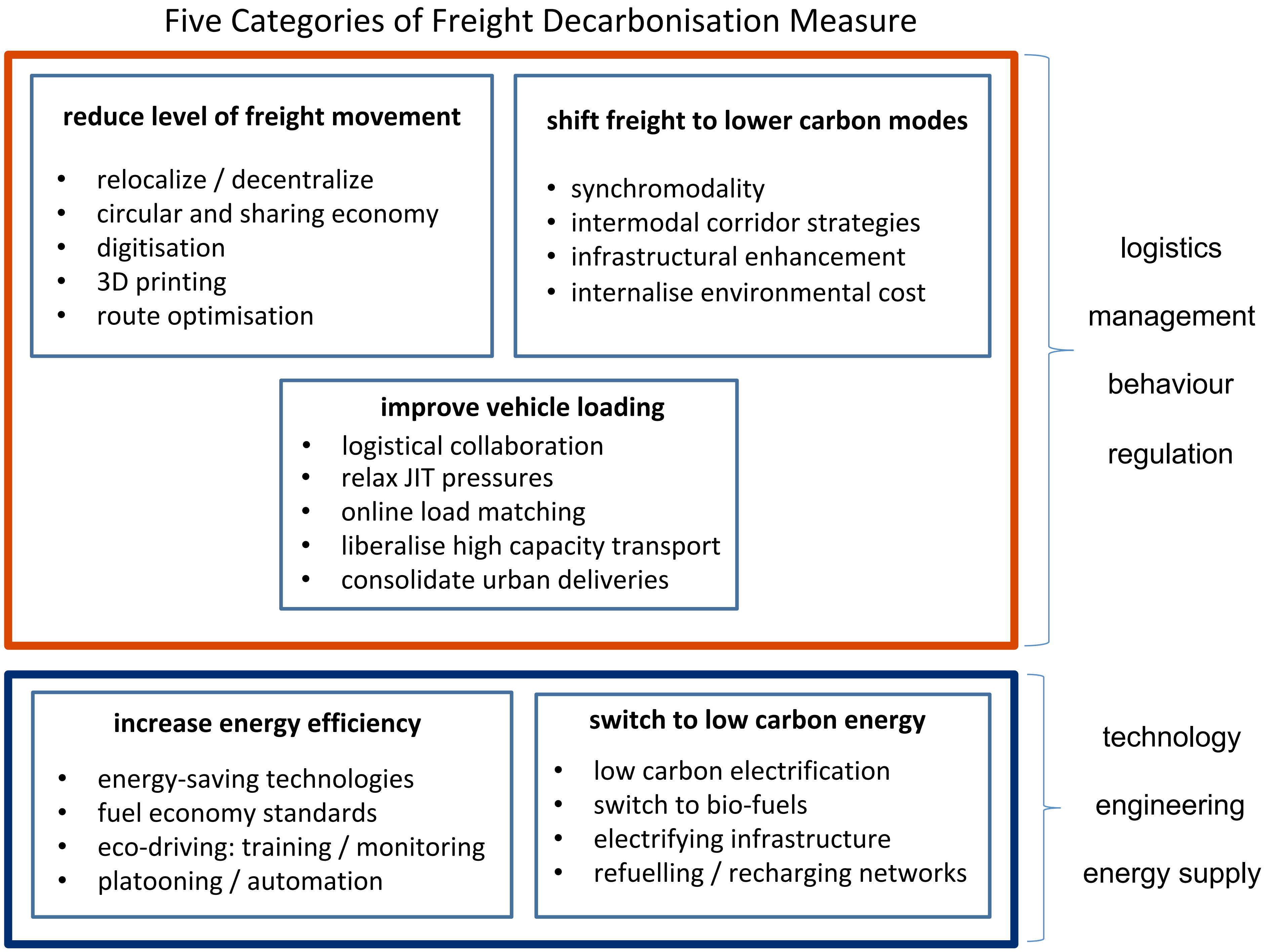
Smart Freight Centre



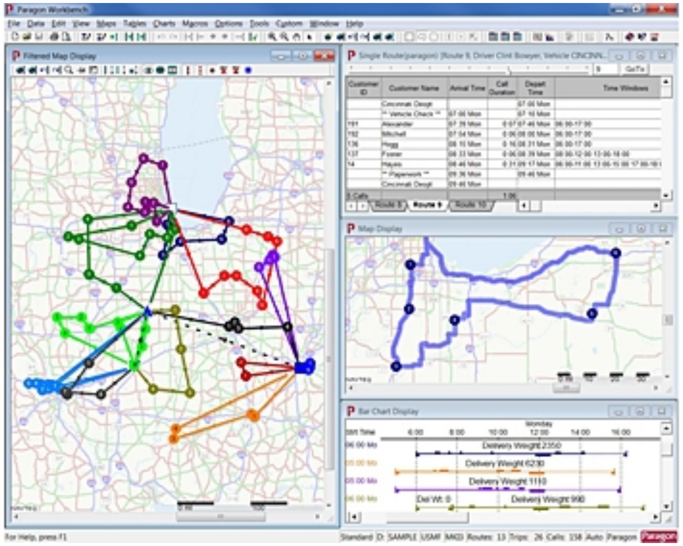
Source: McKinnon (2018) Decarbonizing Logistics

Scoping the Decarbonisation of Road Freight Transport




Five Categories of Freight Decarbonisation Measure
reduce level of freight movement
relocalize / decentralize
circular and sharing economy
digitisation
3D printing
route optimisation
shift freight to lower carbon modes
synchromodality
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
logistics
management
behaviour
regulation
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
technology
engineering
energy supply

Optimising Vehicle Routeing



Can reduce the distance travelled by freight consignments – *cutting freight transport intensity*

Yields economic and environmental benefits – *'win – win' option*

Use of computerised vehicle routing and scheduling (CVRS) software to optimise routes

Widely adopted technology / management tool in developed countries but being upgraded:

- as vehicles becoming more intelligent and connected – *dynamic re-routing of vehicles*
- use of predictive analytics and big data
- possible recalibration of optimization to minimize emissions - *'pollution routeing'*

Improve vehicle utilisation

Measurement of Vehicle Utilisation: *key parameters*

% empty running

loaded trips

weight-based measures

freight density

space-related measures

2-dimensional view

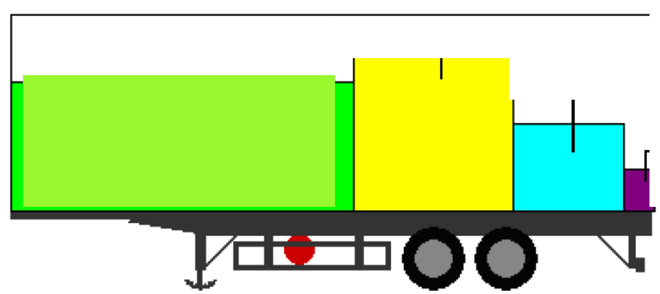
deck-area coverage

‘load length”

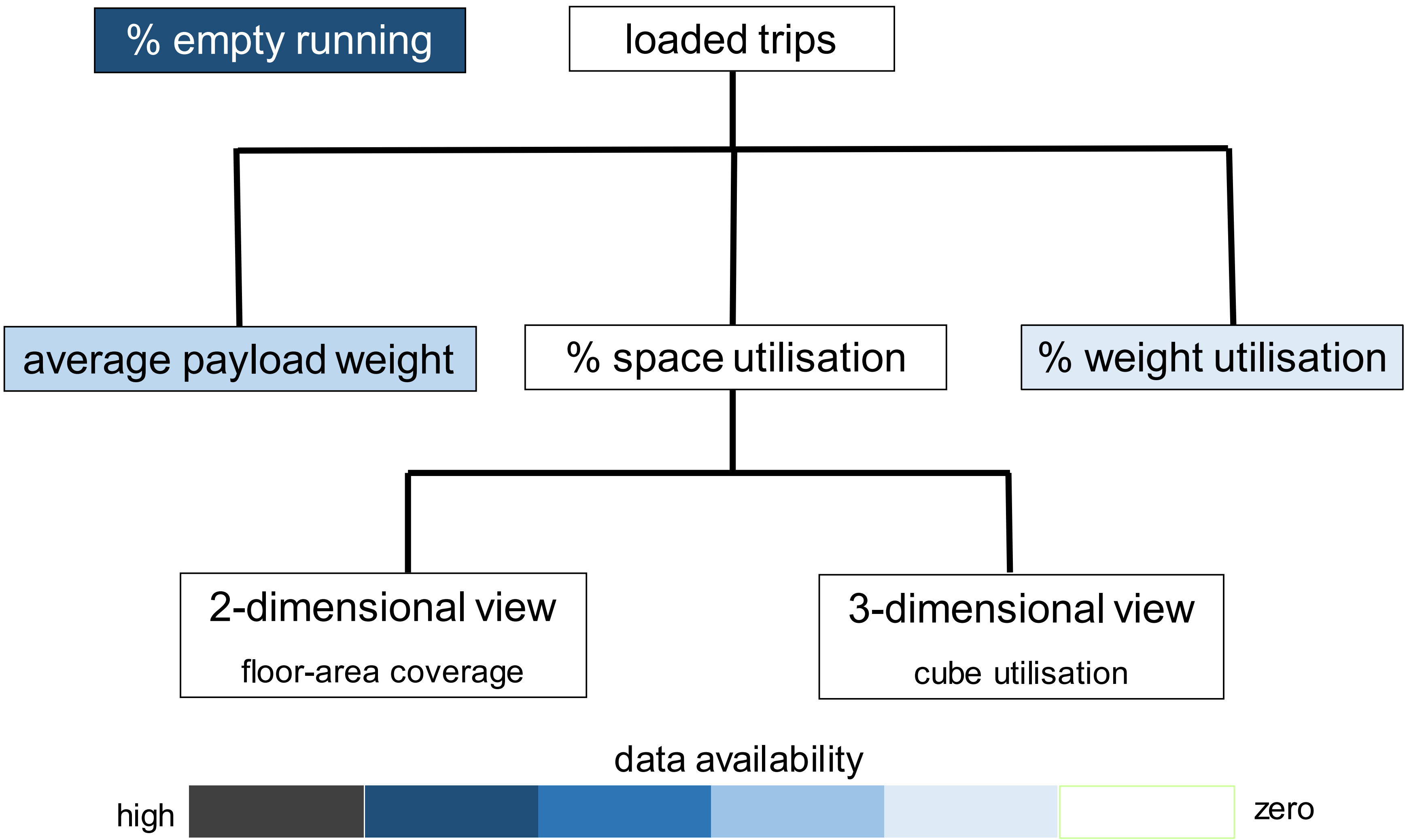
stacking height

3-dimensional view

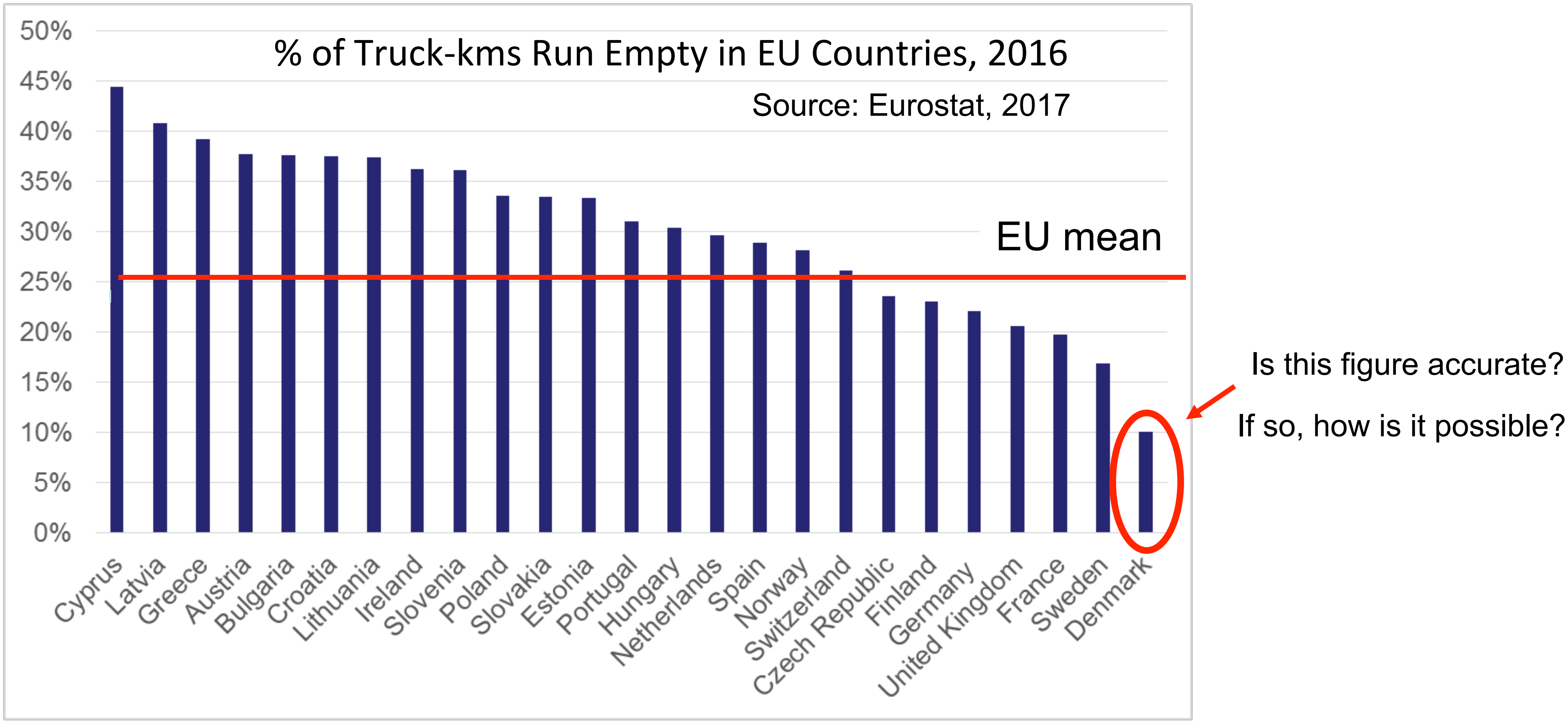
cube utilisation



Availability of macro-level truck utilisation data in Europe



Empty Running of Trucks



Constraints on Return Loading

- Requirements of the outbound service
- **Inadequate knowledge of available backloads**
- Unreliability of the backloading operation
- Incompatibility of vehicles and products
- Need to recover handling equipment
- Poor matching of locations and schedules
- Journey length too short

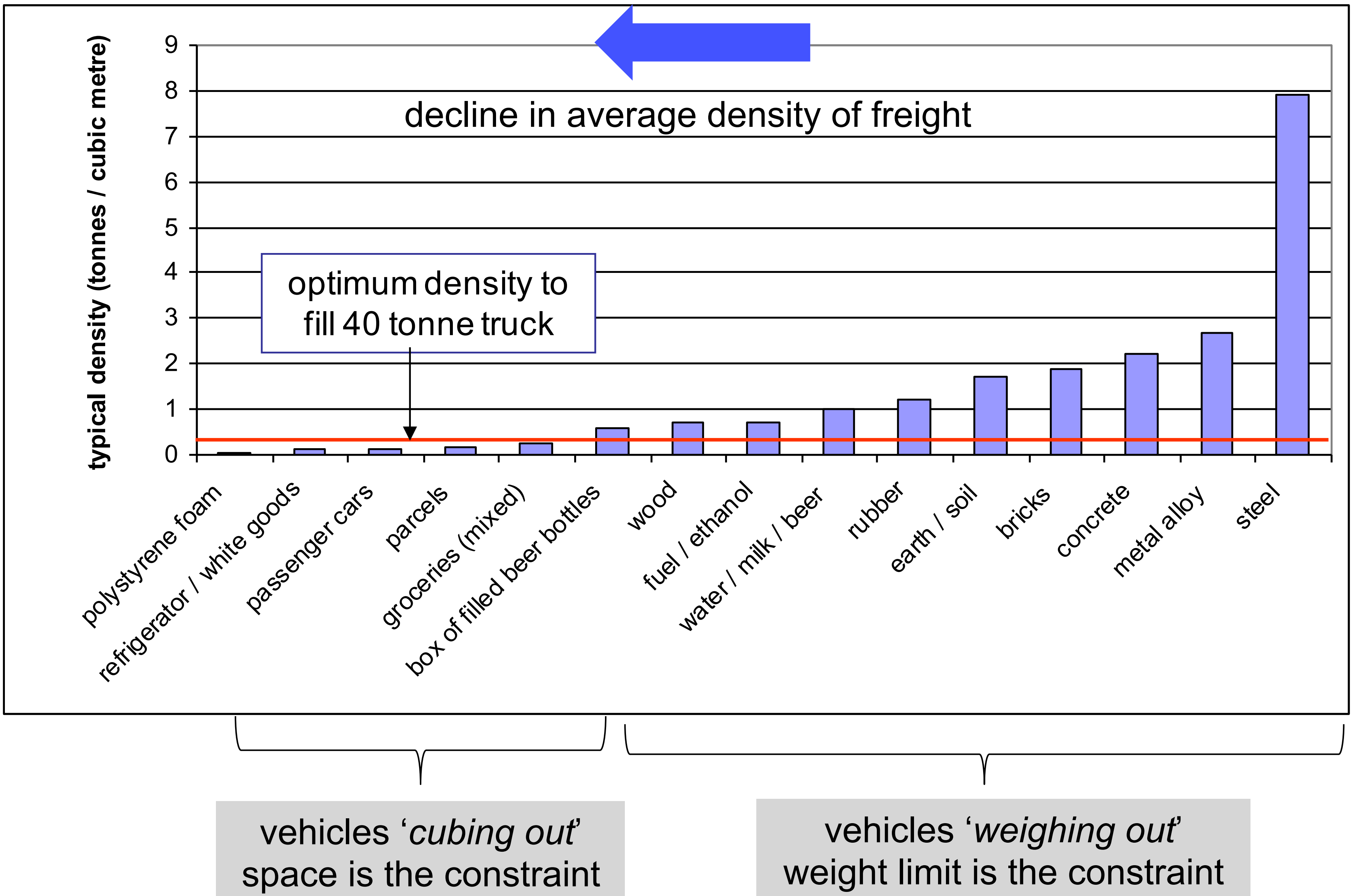
Online freight procurement: *a mature, well-established market in Europe and North America*

Increased functionality of web platforms: *inclusion of optimisers*

Diversification of UBER into the freight market (UBER Cargo)

TIMOCOM AUGMENTED LOGISTICS · FREIGHTOS · INSTAFREIGHT · CARGONEXX · coupa

Freight Density and the Utilization of Vehicle Carrying Capacity



Constraints on Truck Utilisation

Logistical cost trade-offs

Companies can be behaving perfectly rationally when they under-load their vehicles.

Making rational trade-offs between transport utilisation and:

- *inventory levels*
- *efficiency of warehousing and materials handling operations*
- *level of customer service - speed of delivery, order size etc.*

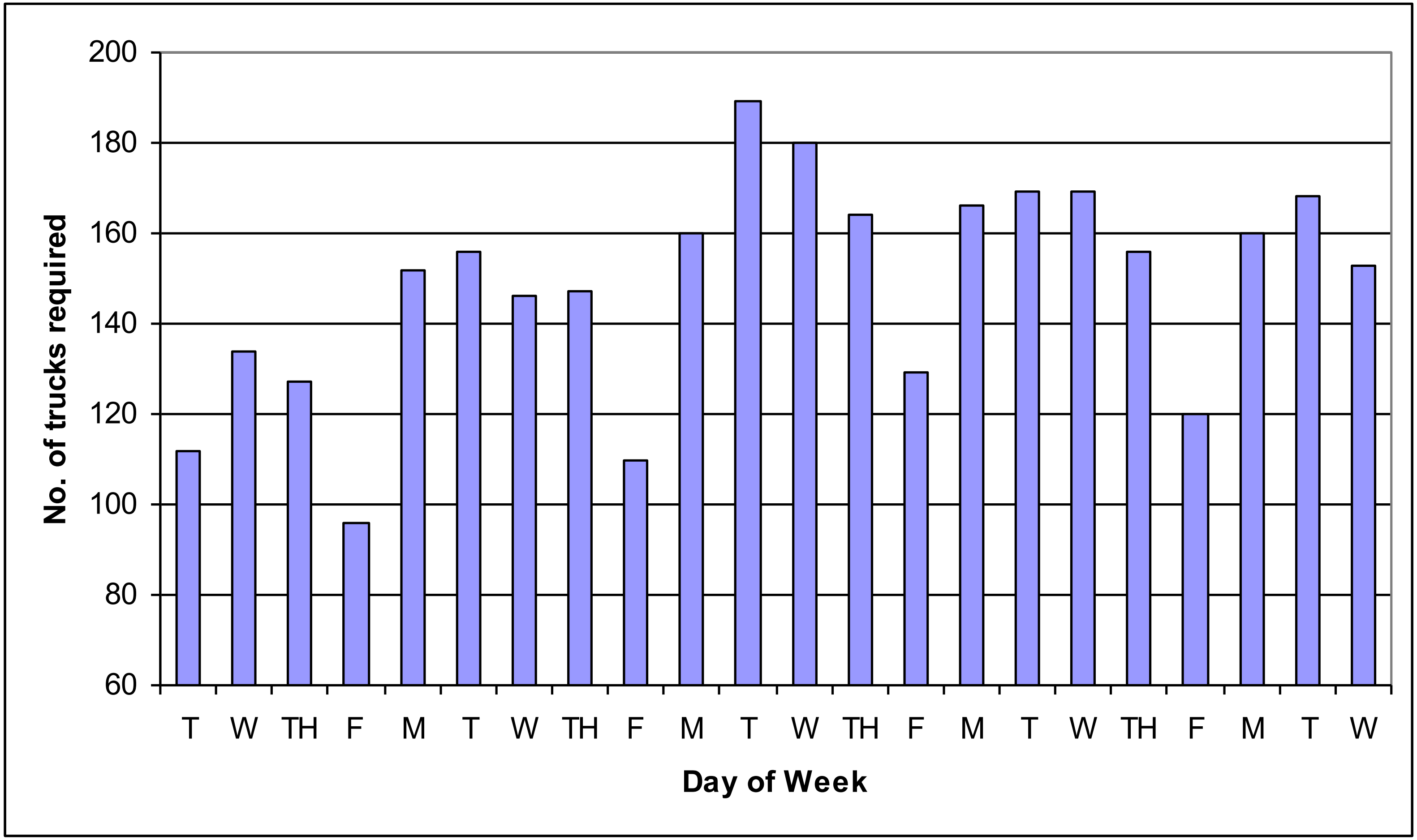
Minimising logistics costs / maximising profitability overall

Constraints on Truck Utilisation

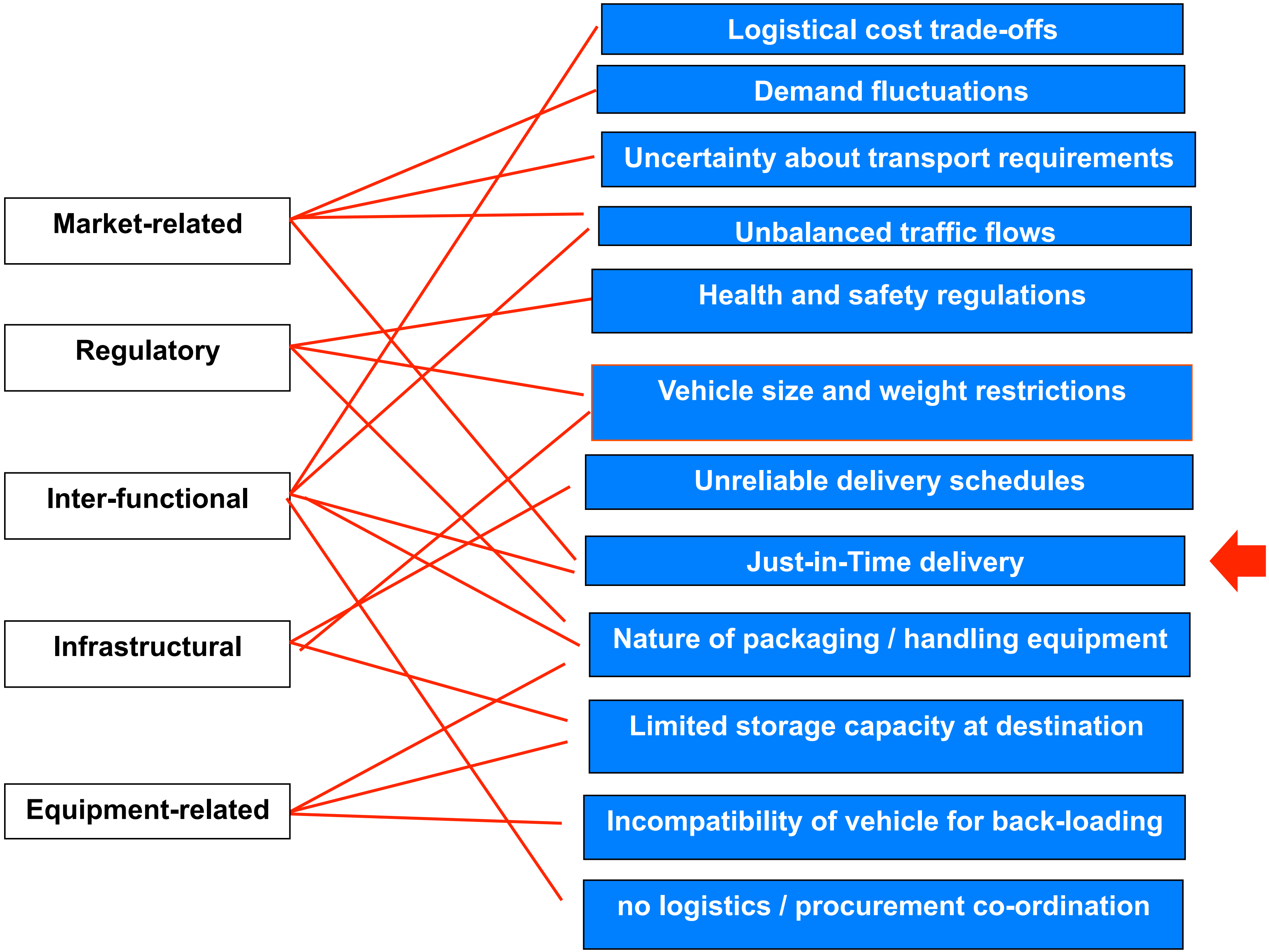
Logistical cost trade-offs

Demand fluctuations

Variations in the Daily Demand for Trucks Experienced by a Major Distributor of Steel Products

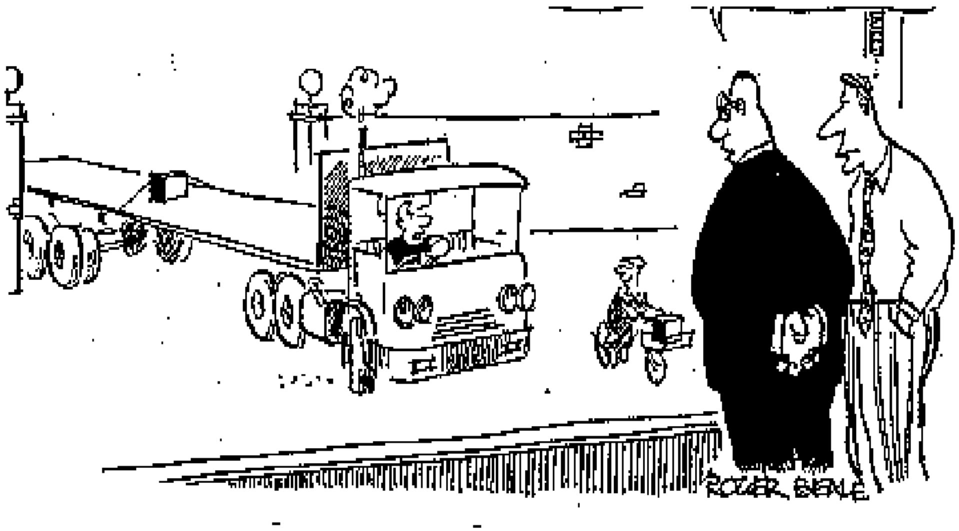


Constraints on Truck Utilisation



Should We Reverse the Just-in-Time Trend?

Some suppliers have adapted better than others to the disciplines of just-in-time delivery



Relaxing of JIT - an effective means of cutting carbon emissions?

Allowing more time to consolidate outbound loads and find backloads

More opportunity to switch to slower, less carbon-intensive transport modes

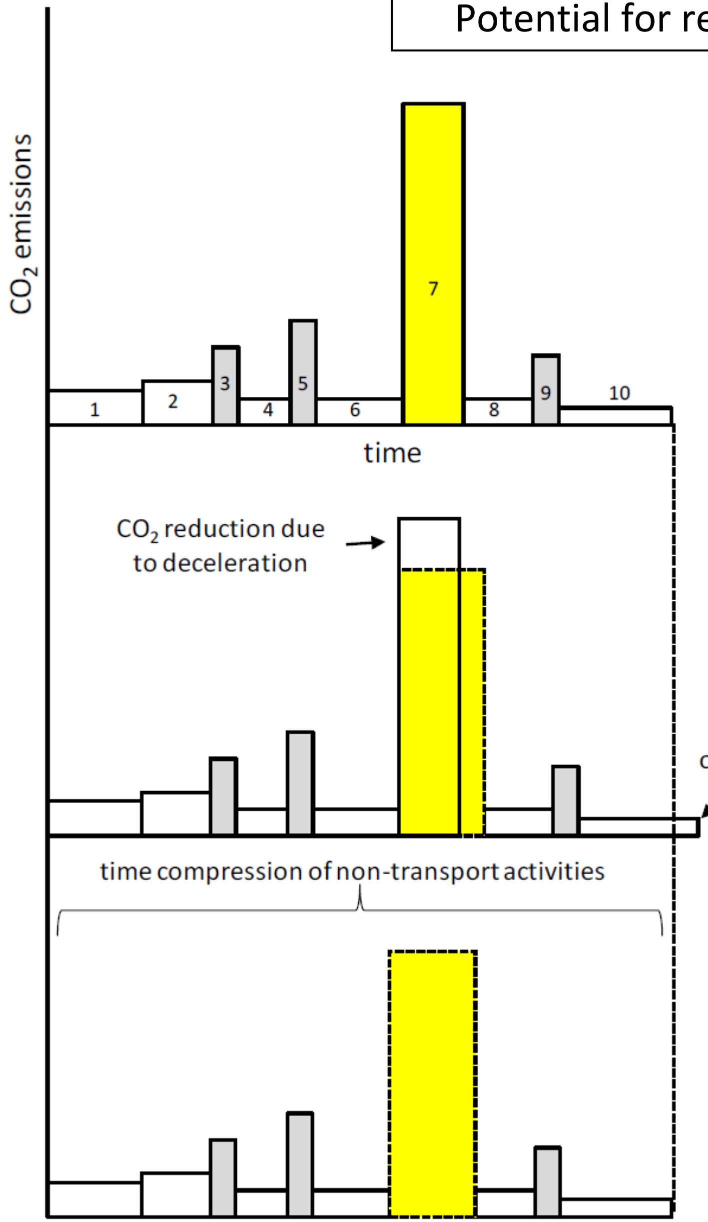
May cut transport-related CO_2 emissions, BUT....

Wider corporate CO_2 savings from JIT replenishment

Need comprehensive assessment of the CO_2 impact of JIT

Supply Chain Deceleration: *Heresy or Practical Suggestion?*

Potential for rescheduling supply chain processes to cut CO_2 emissions?



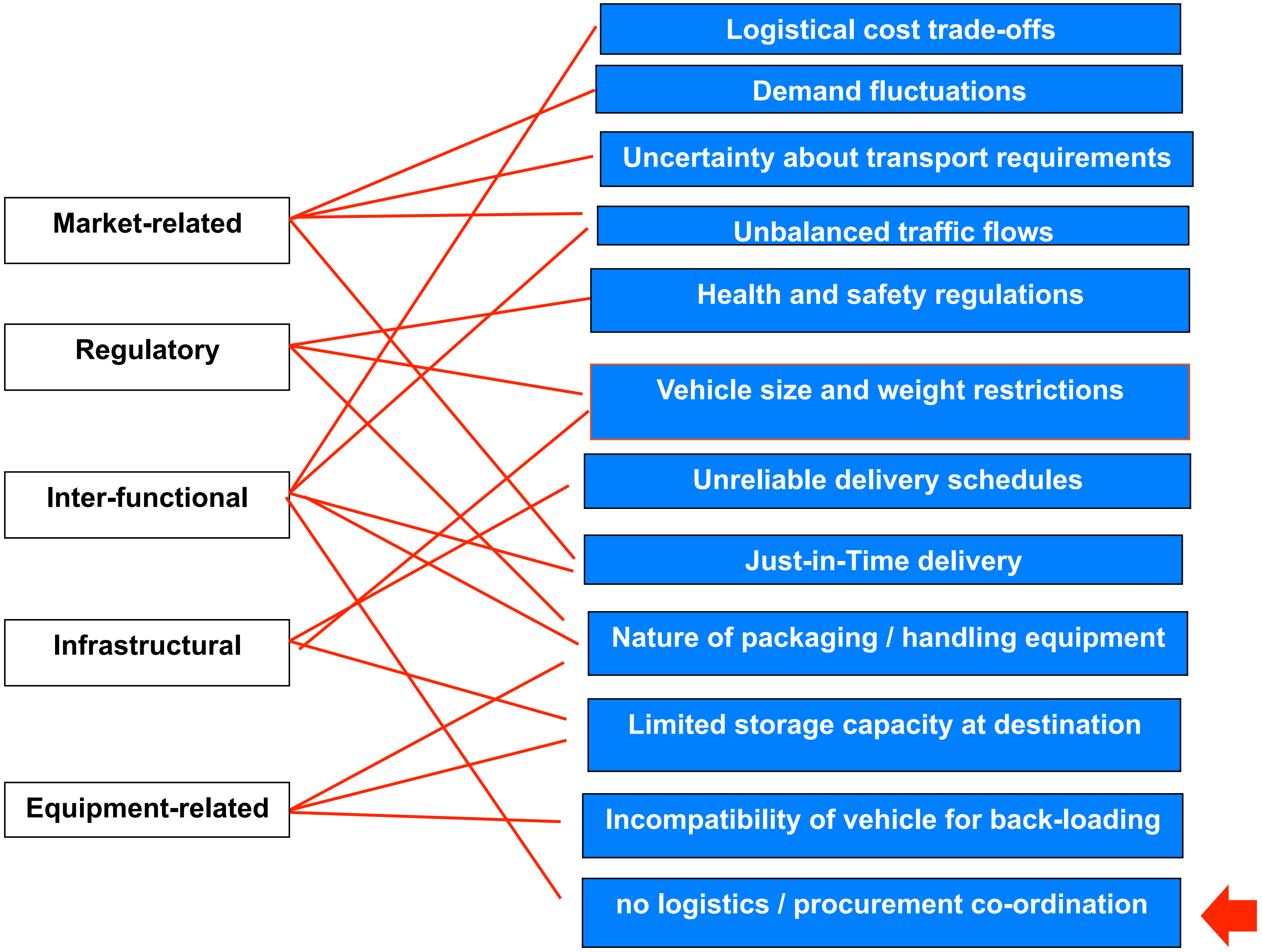
1. processing of inbound order
2. internal administration / checks
3. order picking
4. order awaiting loading
5. vehicle loading
6. vehicle waiting time
7. delivery
8. waiting time at reception point
9. vehicle off-loading and put-away
10. product storage prior to use / sale

- accelerate internal processes
- Internal time savings offset longer transit times
- net CO_2 saving within fixed order lead time

Freight Transport Deceleration: Its Possible Contribution to the Decarbonisation of Logistics

McKinnon (2016) *Transport Reviews*

Constraints on Truck Utilisation



Examples of Horizontal Logistical Collaboration between Shippers in Europe

Collaborating shippers	Sector	Geography
Pepsico and Nestle	FMCG	Benelux
Unilever and Kimberly Clark	FMCG	Netherlands
Nestlé and United Biscuits	FMCG	UK
Baxter, Colruyt, Eternit and Ontex	Healthcare, construction, wines & beverages, FMCG	Belgium-Spain
P&G and Tupperware	FMCG & household products	Belgium-Italy
Mars, United Biscuits, Saupiquet and Wrigley	FMCG	France
Tetley, Kellogg and Kimberly-Clark	FMCG	UK
JSP and Hammerwerk	Industrial equipment	Czech Republic
Spar and inbound suppliers	Retail chain, FMCG	Belgium

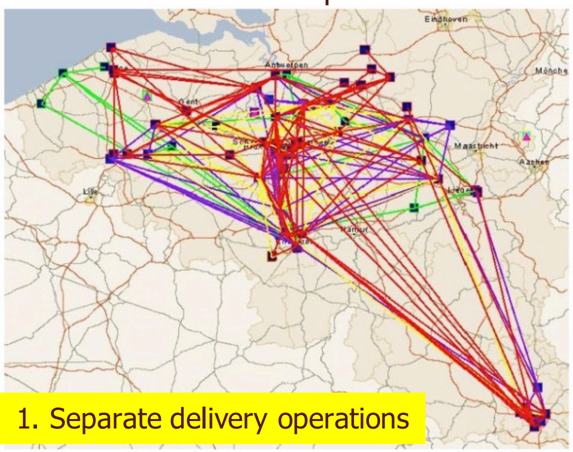
Source: McKinnon (2018)

Supply Chain Collaboration

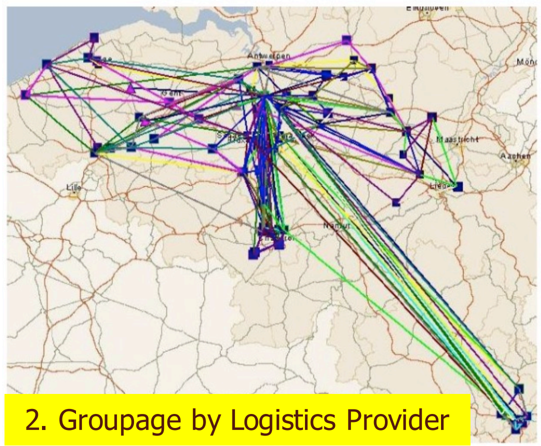
Deep decarbonisation of freight transport will require much greater sharing of logistics assets

- change in the corporate mindset
- exhaustion of internal efficiency improvements
- confirmation of legality
- new IT tools support collaborative working

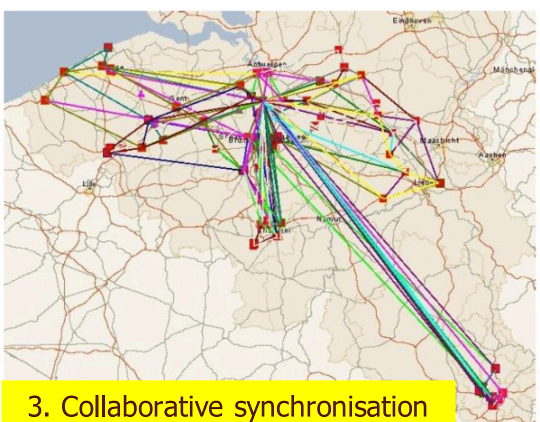
Nestle – Pepsico Horizontal Collaboration in Benelux



1. Separate delivery operations



2. Groupage by Logistics Provider



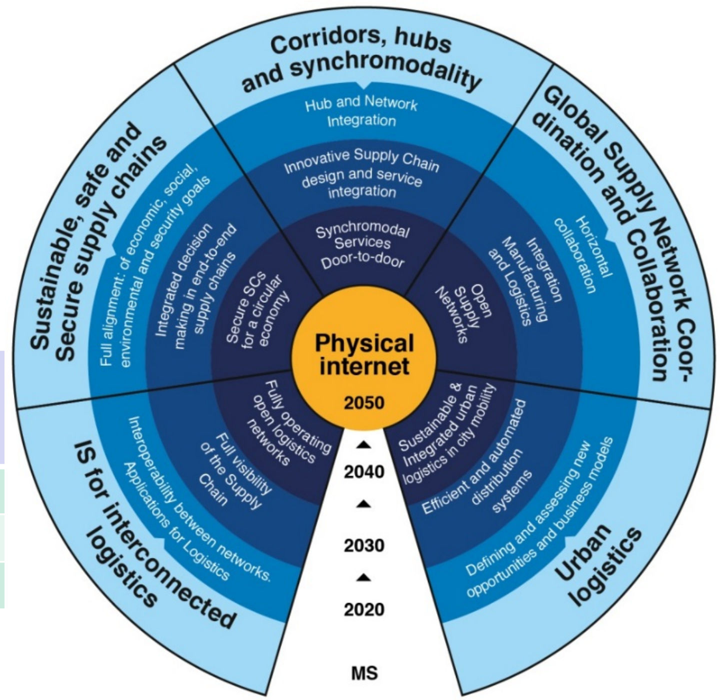
3. Collaborative synchronisation

	Kg CO2 / tonne
1. Separate delivery	43.8
2. Groupage	27.3
3. Collaborative synchronisation	20.3

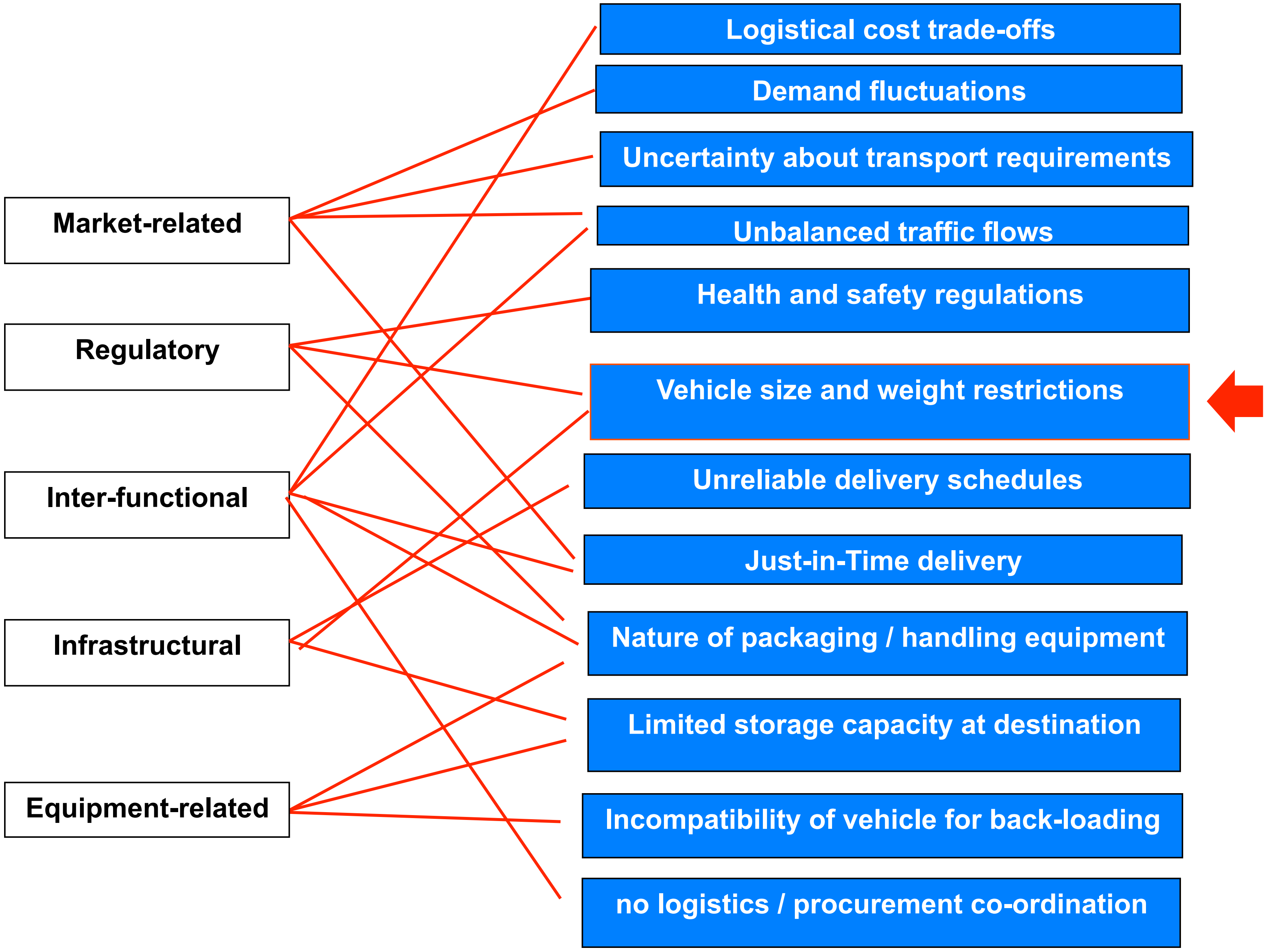
EU project: CO3

Source: Jacobs et al 2014

Long term contribution of the Physical Internet to logistics decarbonisation



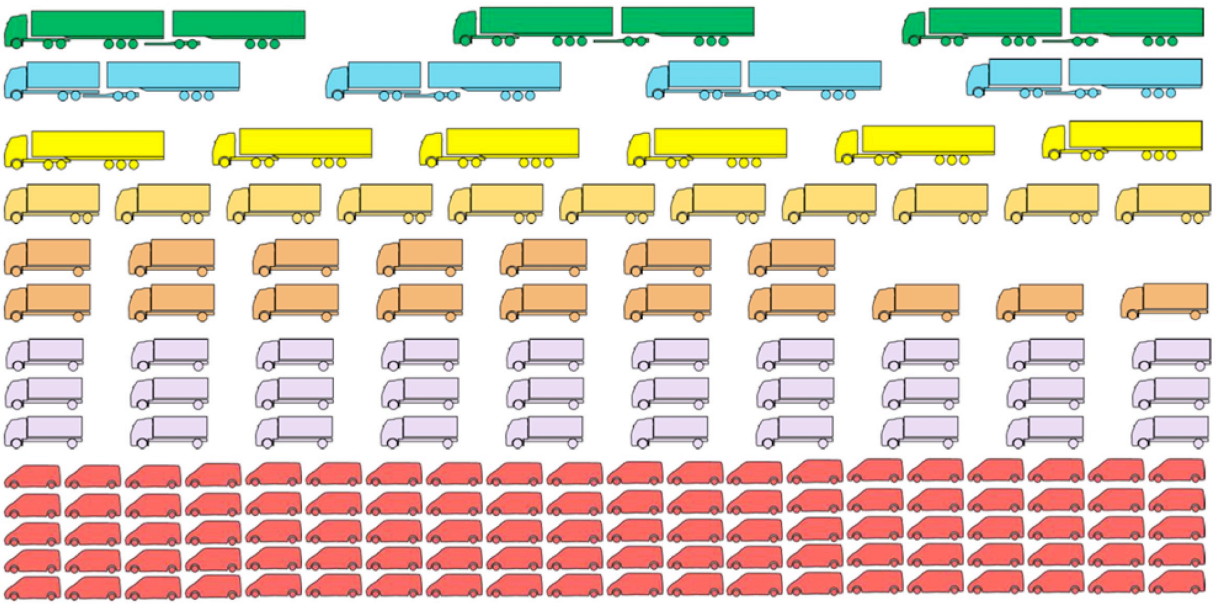
Constraints on Truck Utilisation



Environmental and Infrastructural Benefits of Consolidating Freight in Larger / Heavier Vehicles

Capacity needed to transport 200 pallets from Malmo to Gothenburg (600kg per pallet)

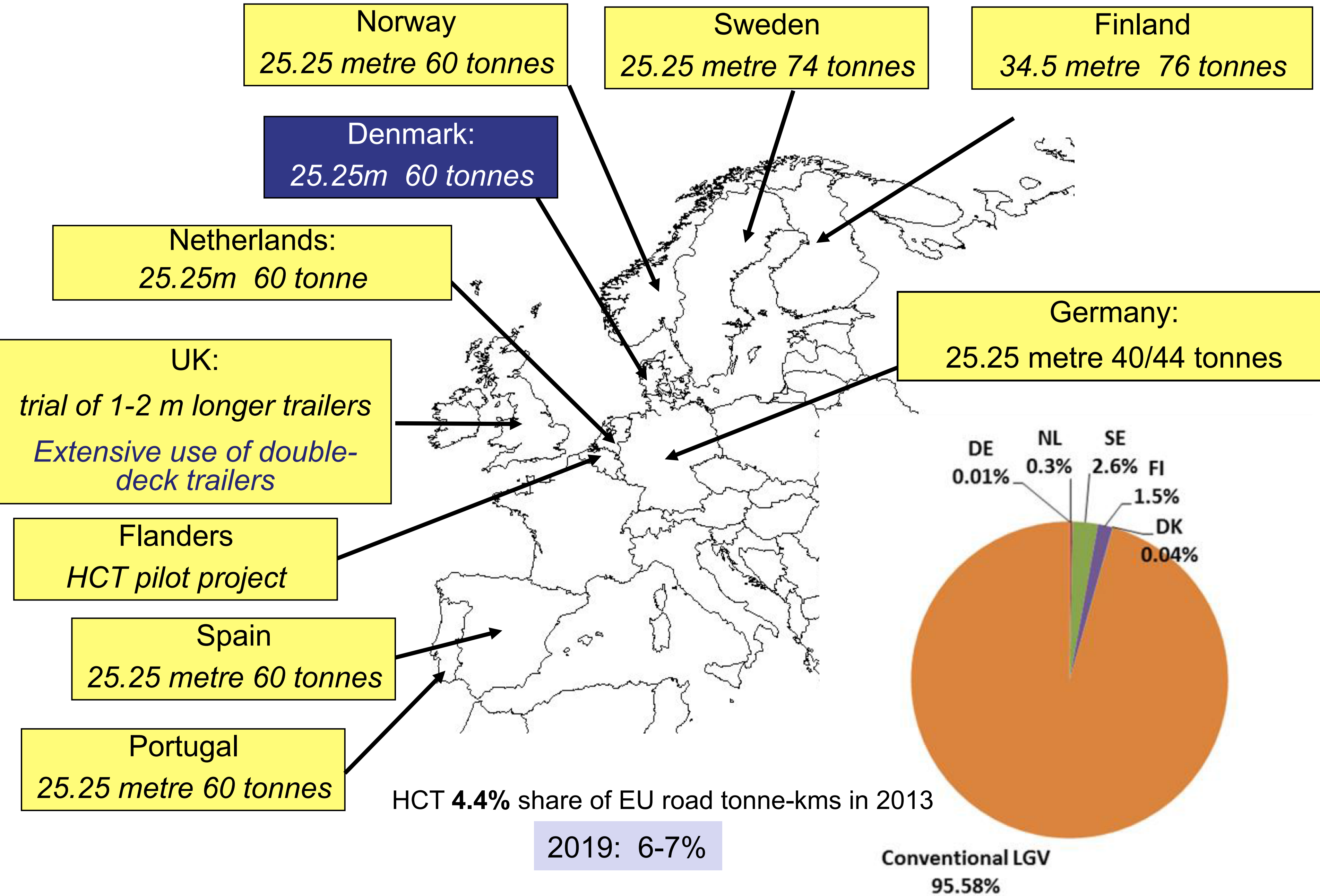
Trucks Drivers	Total space on road	Fuel	Fuel Index	CO_2/ Pallet	Maximum authorized vehicle weight	EU driving licence
No	*meter*	*ml/tkm*	*40 t base*	*kg*	*tonnes*	*categorie*
3	294	14	72%	7	(76-90)	**CE**
4	364	15	80%	8	60	**CE**
6	492	19	**100%**	10	40	**CE**
11	836	28	150%	14	26	**C**
17	1275	34	180%	17	18	**C**
30	2220	47	250%	25	12	**C1E**
100	7100	94	500%	48	3,5	**B**



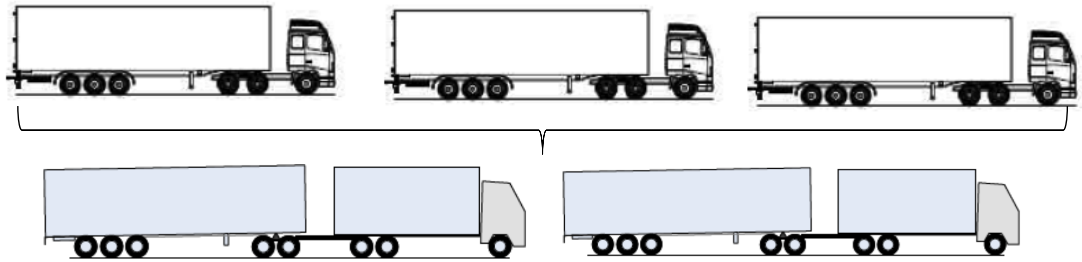
Source: Volvo Trucks, 2019

HCT in Europe: *a much-researched and very controversial subject*

High Capacity Transport in Europe 2019



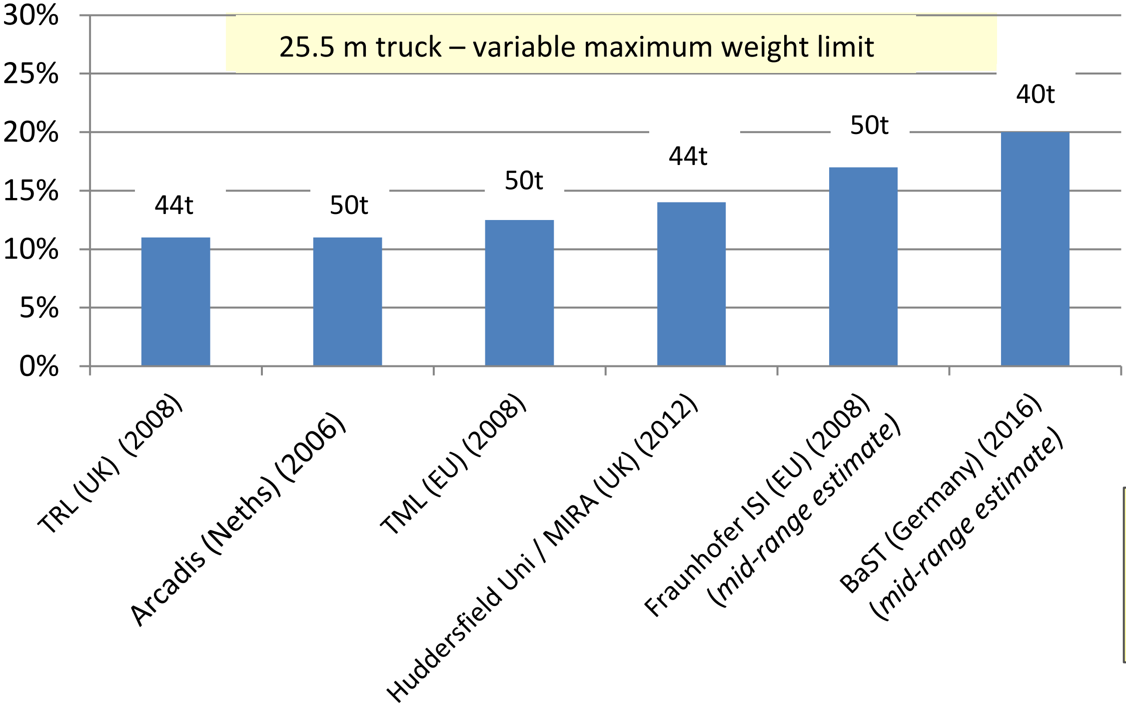
Potential contribution of HCT to road freight decarbonisation



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

vehicle level analysis → system level analysis

% reduction in carbon intensity against baseline vehicle



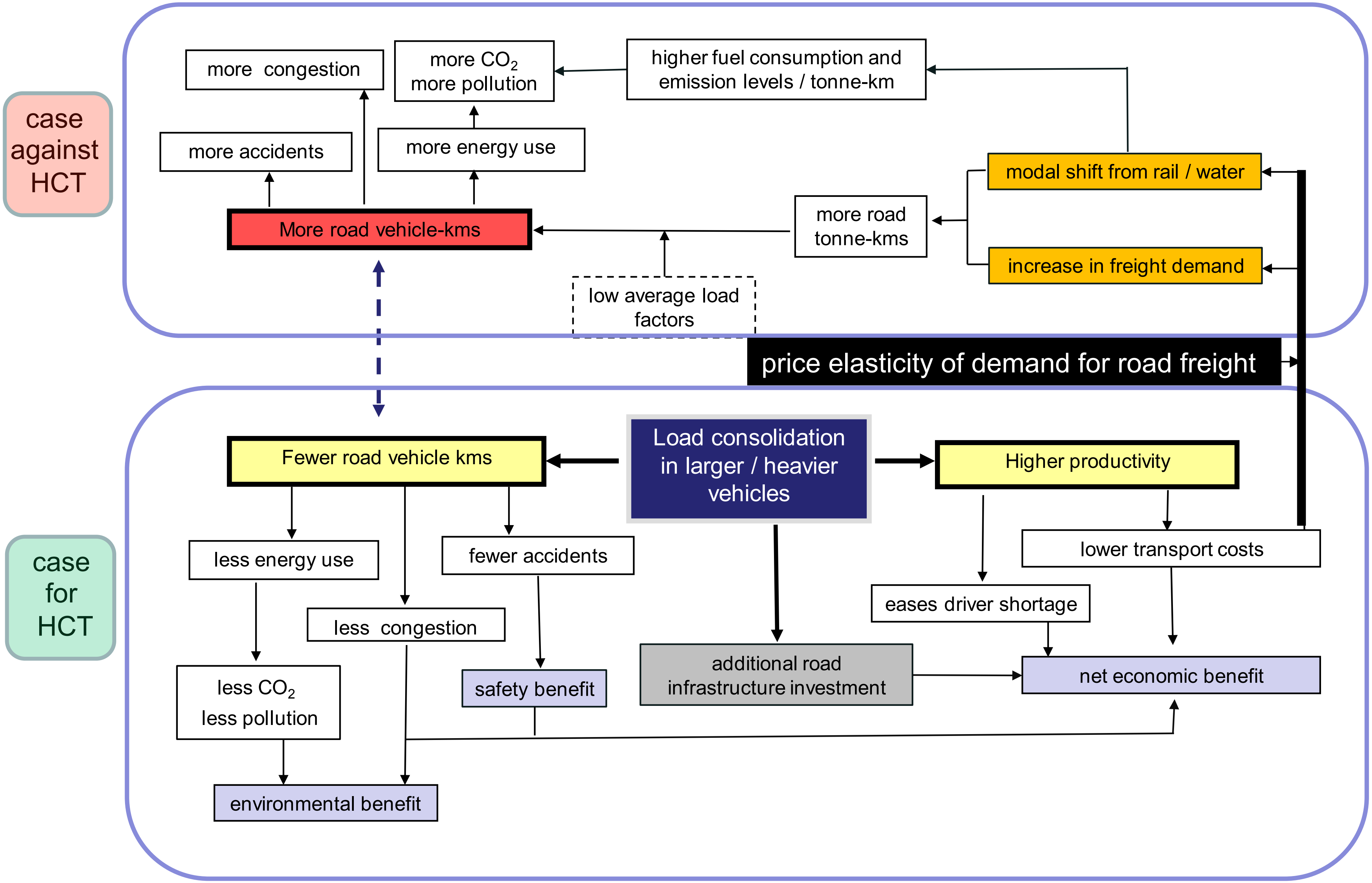
Net effect on CO_2 depends on:

- adoption rate of LHVs
- induced traffic
- circuitous routing
- load factor assumptions
- modal shift

freight modal shift
versus
road freight efficiency improvement

Conflict between core freight decarbonisation strategies

High capacity transport: *polarisation of the arguments for and against*



Increase energy efficiency

Improve Energy Efficiency in the Freight Transport Sector

vehicle technology: *new build + retrofits*

- upgraded drive-trains
- light-weighting
- low-rolling resistance tyres
- improved aerodynamics


Over cab spoiler

Teardrop

Cheetah


Boat-tails

Trailer under-tray


Dolphin

vehicle operation: *IT , training, monitoring*


eco-driver training

telematic monitoring

platooning


automation

fuel economy standards for new trucks:

Fuel Economy Standards for Heavy Duty Vehicles

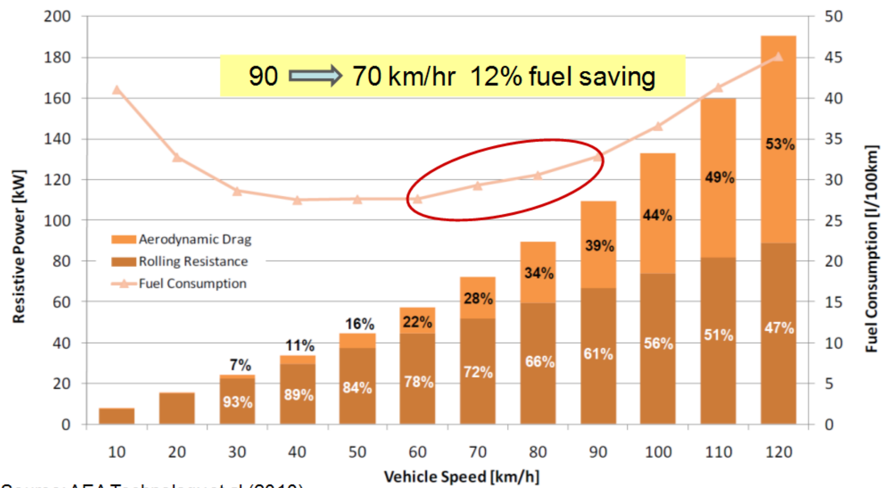
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Japan				Phase 1										Phase 2
U.S.			Phase 1					Phase 2						
Canada			Phase 1					Phase 2						
China	Phase 1		Phase 2						Phase 3					
India									Phase 1					
Mexico									Phase 1					
S. Korea									Phase 1					

EU: 15% less CO_2 by 2025 30% by 2030

Hashed areas represent unconfirmed projections of the ICCT

Source: ICCT (2015)

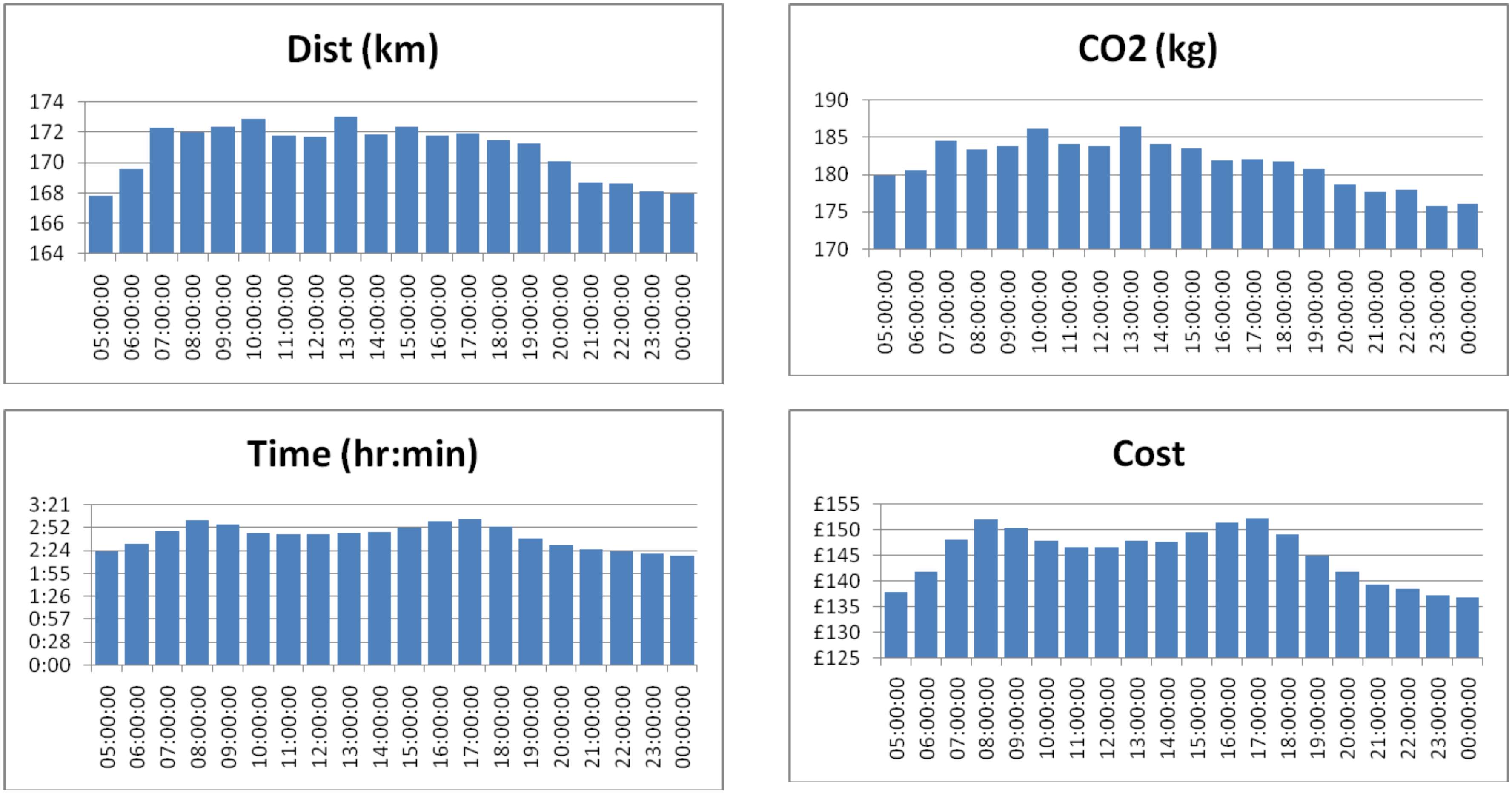
business practice: e.g. *deceleration*



Source: AEA Technology et al (2010)

Effects of Varying Start Times for Long Haul Road Deliveries Network

Simulation modelling of truck trips across UK trunk road network

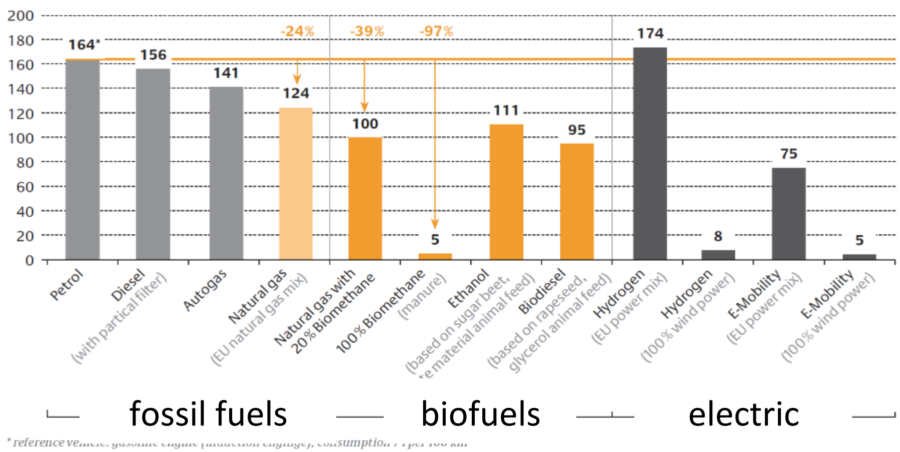


Source: Palmer and Piecyk, 2010

constraints on the rescheduling of deliveries to minimize congestion

Switch to low carbon energy

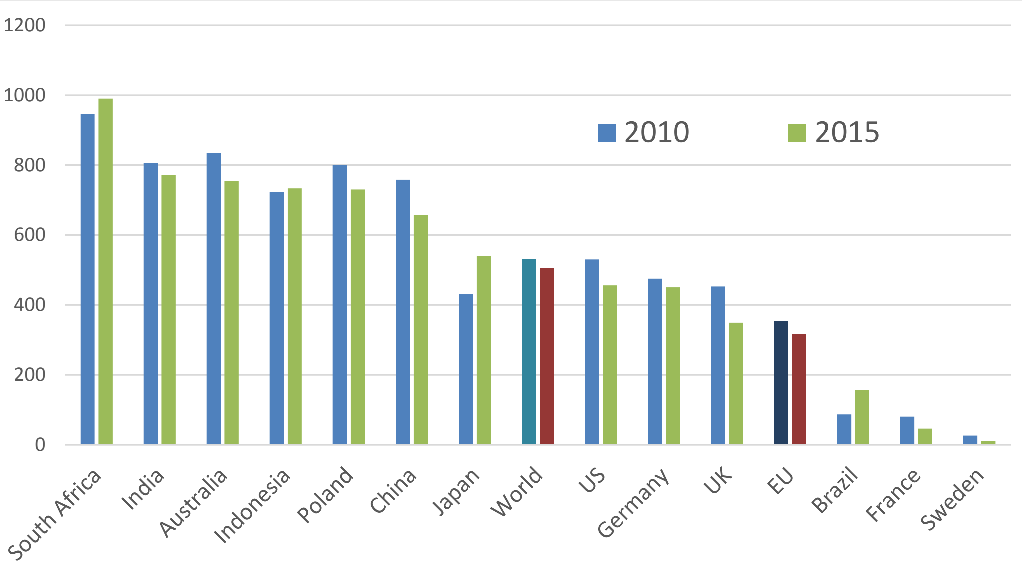
Switch to Cleaner, Low Carbon Energy



biofuel fuels: *slow uptake*

- uncertainty about net GHG impact
- limited supply of sustainable biofuels
- lack of refuelling infrastructure for gas
- ‘*methane slip*’ problem

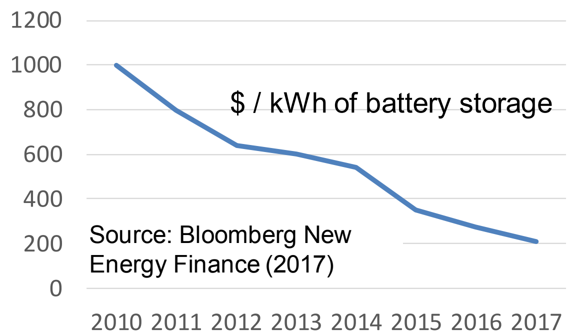
decarbonisation by electrification



Carbon intensity of electricity generation (gCO_2 / kWh)

Source: McKinnon, 2018

battery-powered road freight



Local delivery operations

- recharging infrastructure
- future battery performance
- E- vehicle price differential

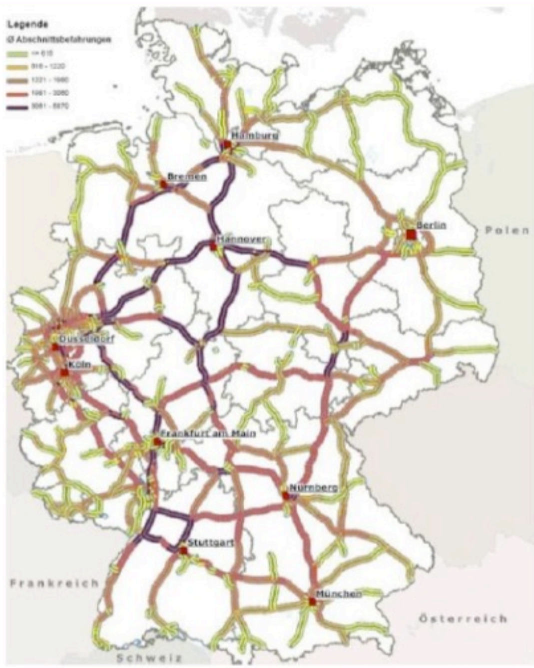
Long haul operations

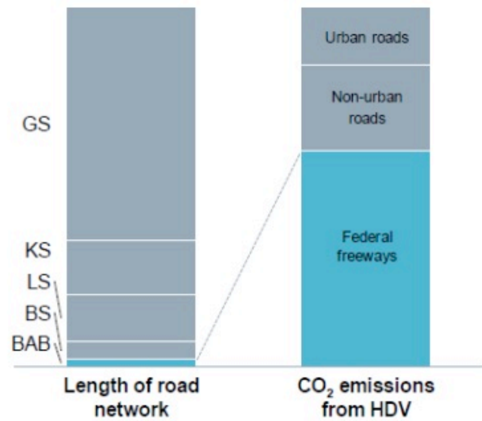
Tesla Semi
a gamechanger?

- battery weight & size?
- max payload?
- cost?

Highway electrification: *the e-Highway*

electrified roads: Trials in Sweden, Germany and the US





BAB = Federal freeways (12,394 km)
BS = Federal roads (40,400 km)
LS = State roads (86,600 km)
KS = District roads (91,600 km)
GS = Municipal roads (>420,000 km)

Image: HDV density on BAB-network ; Source: Verkehr in Zahlen 2012; TREMOD 2012

The analysis of the German road network leads to the following key messages:

1. **60%** of the HDV emissions occur on 2% of the road network (BAB = 12,394 km)
2. **89 %** of German truck trips after leaving the highway are **50 km or less**

Source: BMVI website. Study available here

Source: Siemens

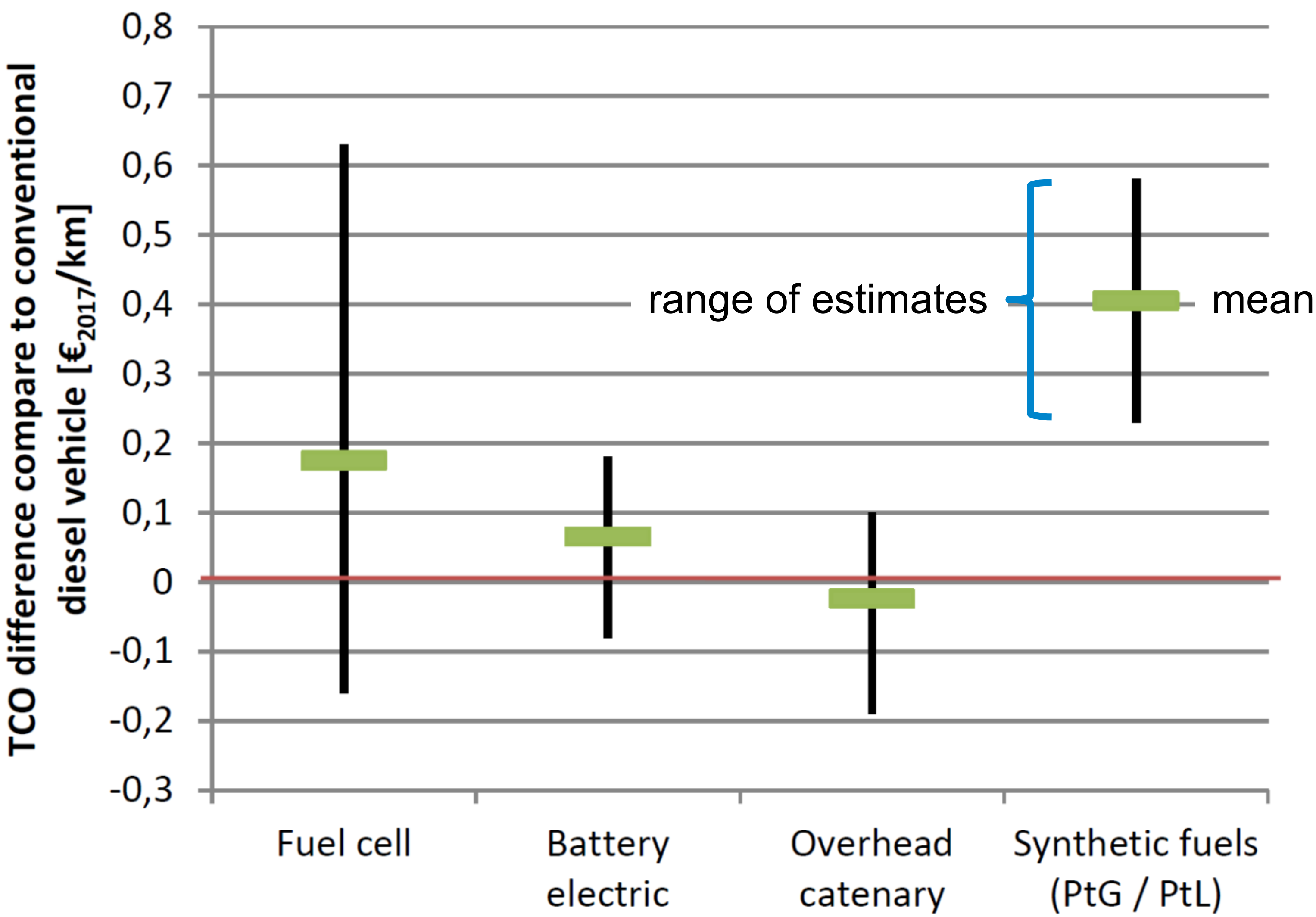
BDI / Boston Consulting Group / Prognos study:

Recommends that 4000-8000 km of German autobahn network be electrified

Capital cost of highway electrification: €1.1 – 2.5 million per km (TML, 2017).
25,000 km of EU motorway: €30-65 bn + €5 bn annual maintenance (Fraunhofer IBP et al, 2015)

Alternative drive trains and energy sources for long haul road freight

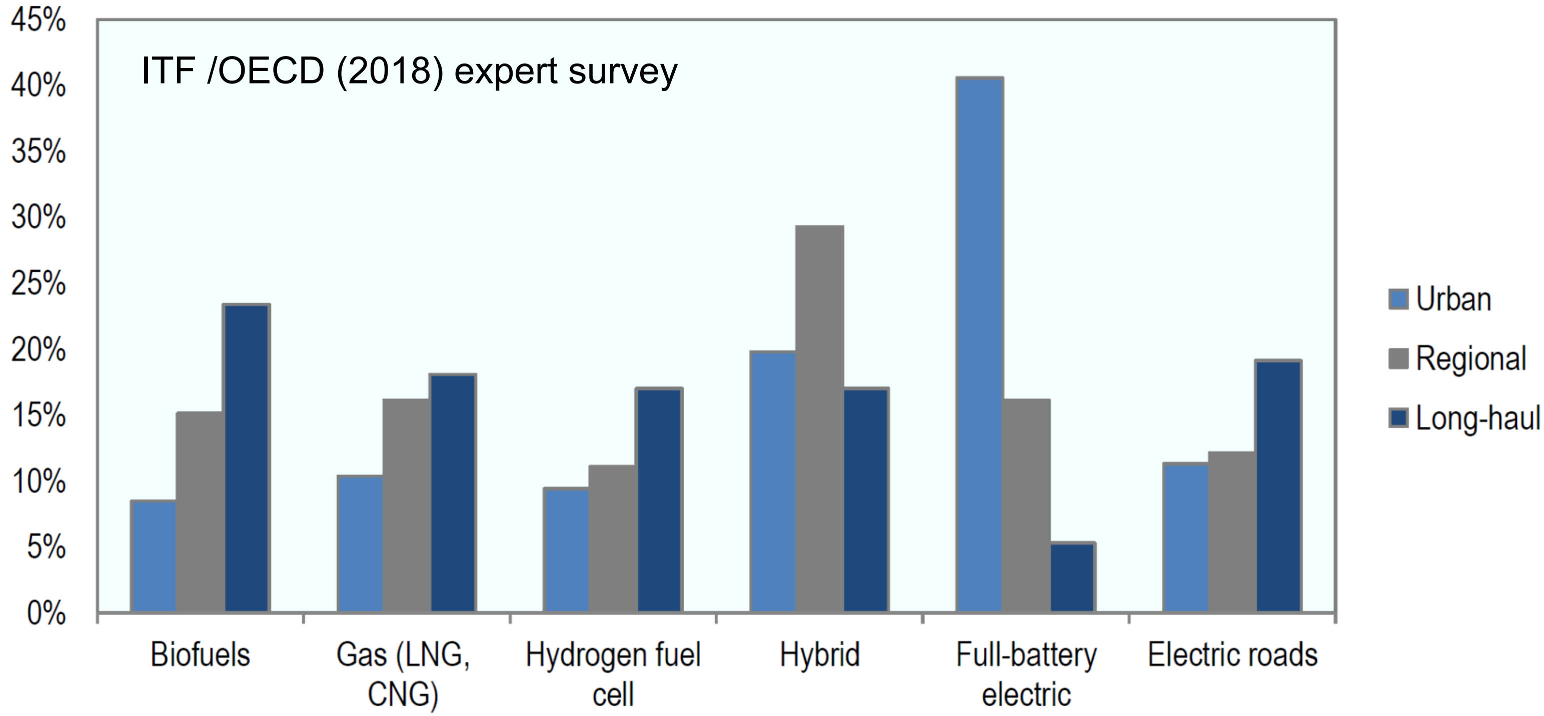
Variation in total cost of ownership relative to fossil diesel vehicles over period 2020=2030



Source: Oeko Institute, Fraunhofer ISI & IFEU

Disagreement over most cost-effective energy decarbonisation pathway for trucking

What are the most cost-effective alternative energies for each type of road freight operation?



weight, size, recharging time and cost of long haul truck batteries

Sripad & Visvanathan (2017)

16 tonne Li-ion battery for 960 km range

Energy Transitions Commission (2018)

3.4 tonnes battery for 700 km range

practicality and cost-effectiveness of hydrogen fuel cells in HDVs

Pye et al (2015), Energy Transitions Commission

despite high energy losses, potentially viable decarbonisation option

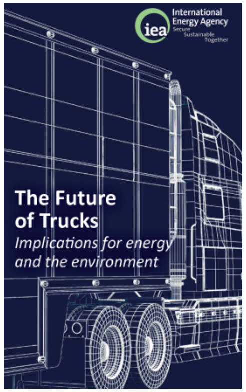
Bossel (2004), Cebon (2018)

energy losses so high never likely to be viable option

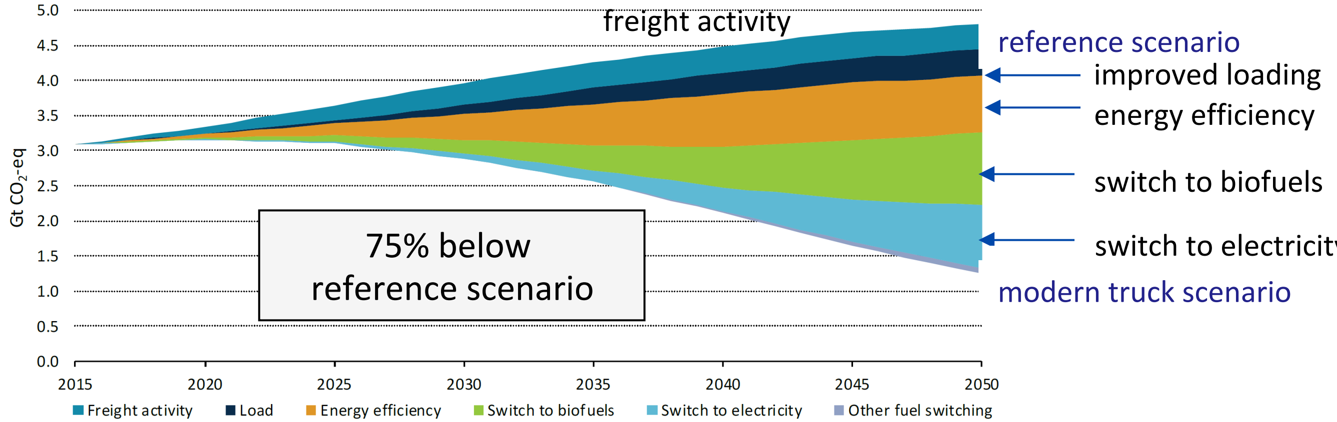
https://bit.ly/2tc20uc https://bit.ly/2BoQQGN https://bit.ly/2MSVIZk

Assessing Carbon Savings from Efficiency Improvements and Switch to Alternative Energy

CO_{2e} emissions from road freight transport: reference (i.e. baseline) scenario vs modern truck (i.e. low carbon) scenario

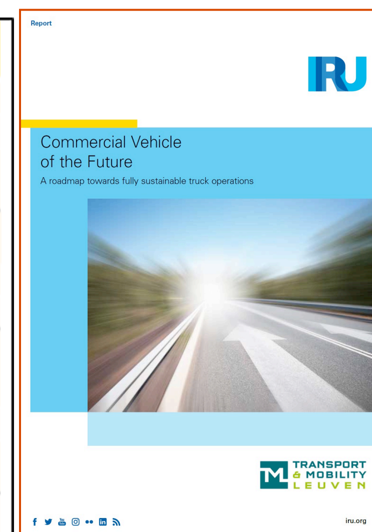


source: IEA (2017)

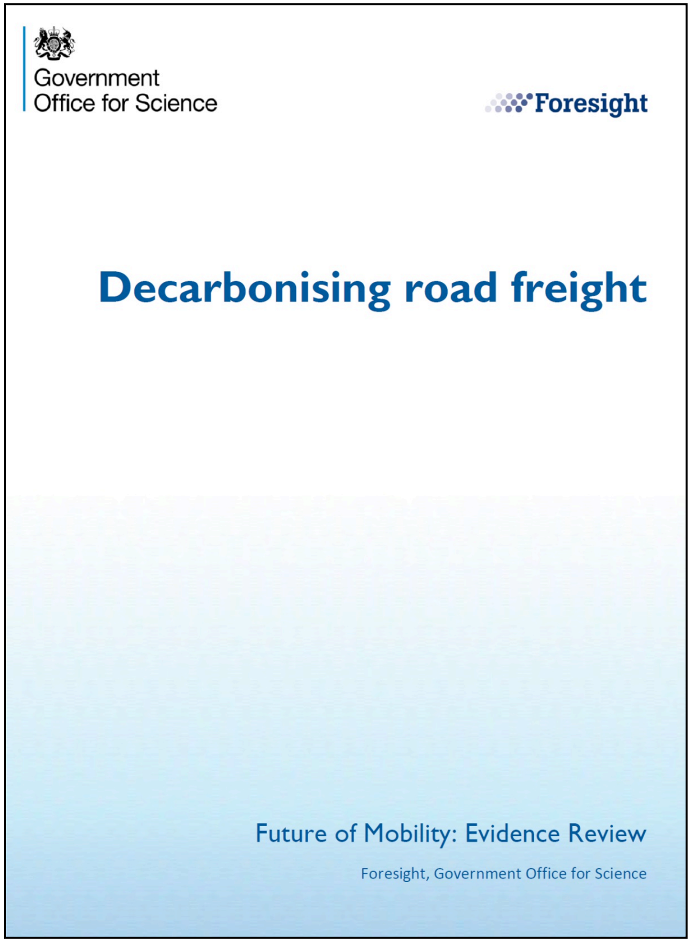


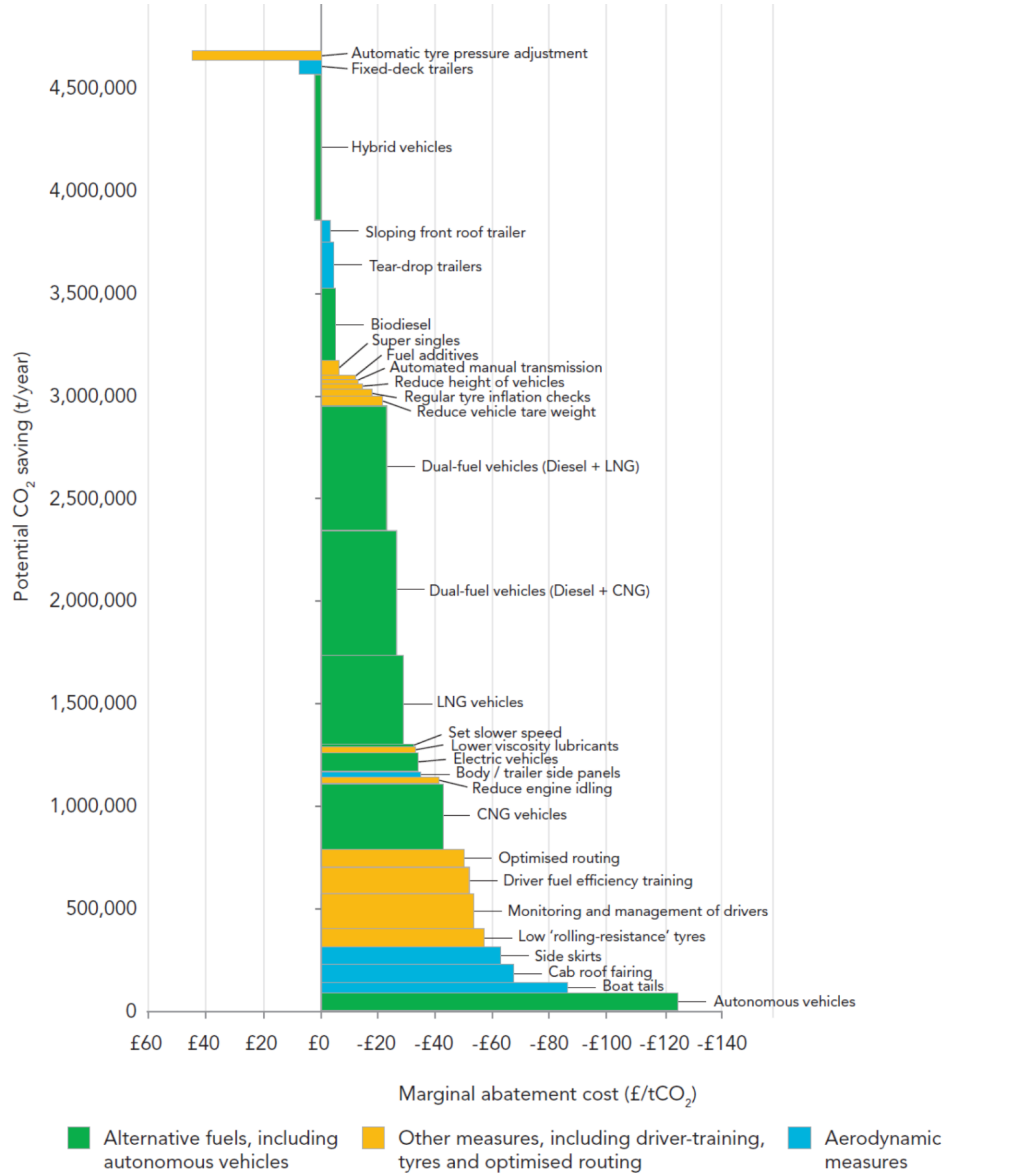
IRU (2017) '*Commercial Vehicle of the Future*'

Long haul	2030	2050	Comment	cumulative reduction 2030	cumulative reduction 2050
Powertrain efficiency (diesel)	10%	15%	Includes engine, transmission, auxiliaries,...	10.0%	15.0%
Gas vehicles	2%	4%	Minimise methane emissions	11.8%	18.4%
Renewable fuels (gas & liquid)	2%	24%	IEA general target, large increase in 2nd generation biofuels needed. Includes biogas.	13.6%	38.2%
Driver training and driver assistance systems	6%	8%	Includes ACC, PCC,...	18.8%	43.2%
Reduce max speed	2%	2%	To 80 km/h	20.4%	62.8%
ITS & communications	1%	4%	Platooning	21.2%	46.5%
Aerodynamics	6%	10%	Important contribution expected from trailers and semi-trailers, including solutions developed in the TRANSFORMERS Project	25.9%	51.3%
Tyres	7.5%	12.5%	Includes super singles	31.5%	57.4%
Lightweighting	0%	0%	Compensated by increased weight from other measures	31.5%	57.4%
Pavement	3%	3%	Improved rolling resistance (maintenance or new pavement)	33.5%	58.7%
Reduce empty running, improve load factors, digitalisation	2%	10%	Rollout of coordinated system needed	34.8%	62.8%
More flexibility in weights and dimensions (including EMS)	3.5%	7.5%	Allowance of EMS in cross border transport in the EU	37.1%	65.6%
More renewables – hybridisation (2030)/electrification (2050) ?????	3%	37%	For 2050, most from full electrification ???????	**39.0%**	**78.2%**

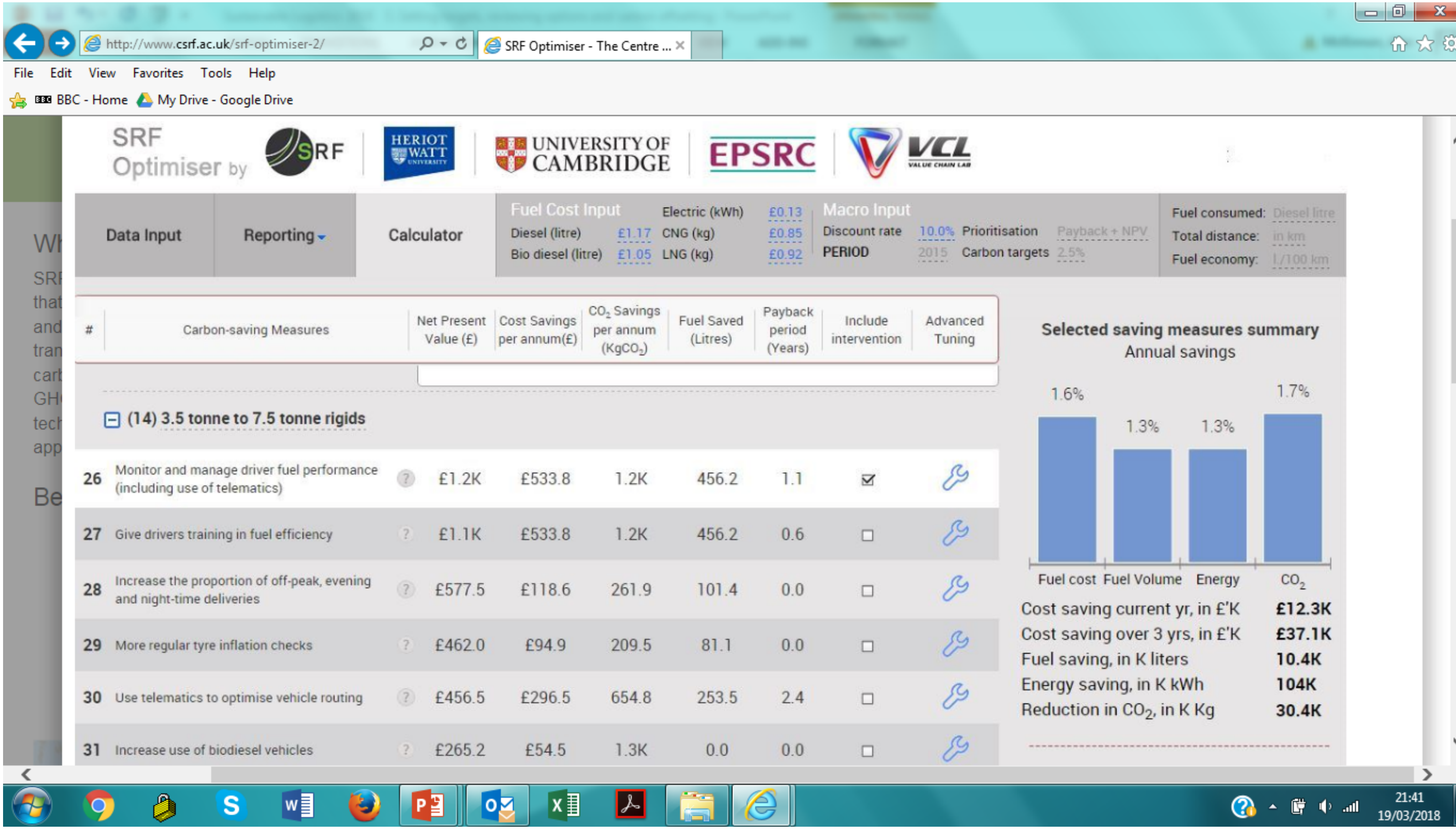


Marginal Abatement Cost (MAC) analysis for decarbonisation of articulated trucks in the UK by 2040





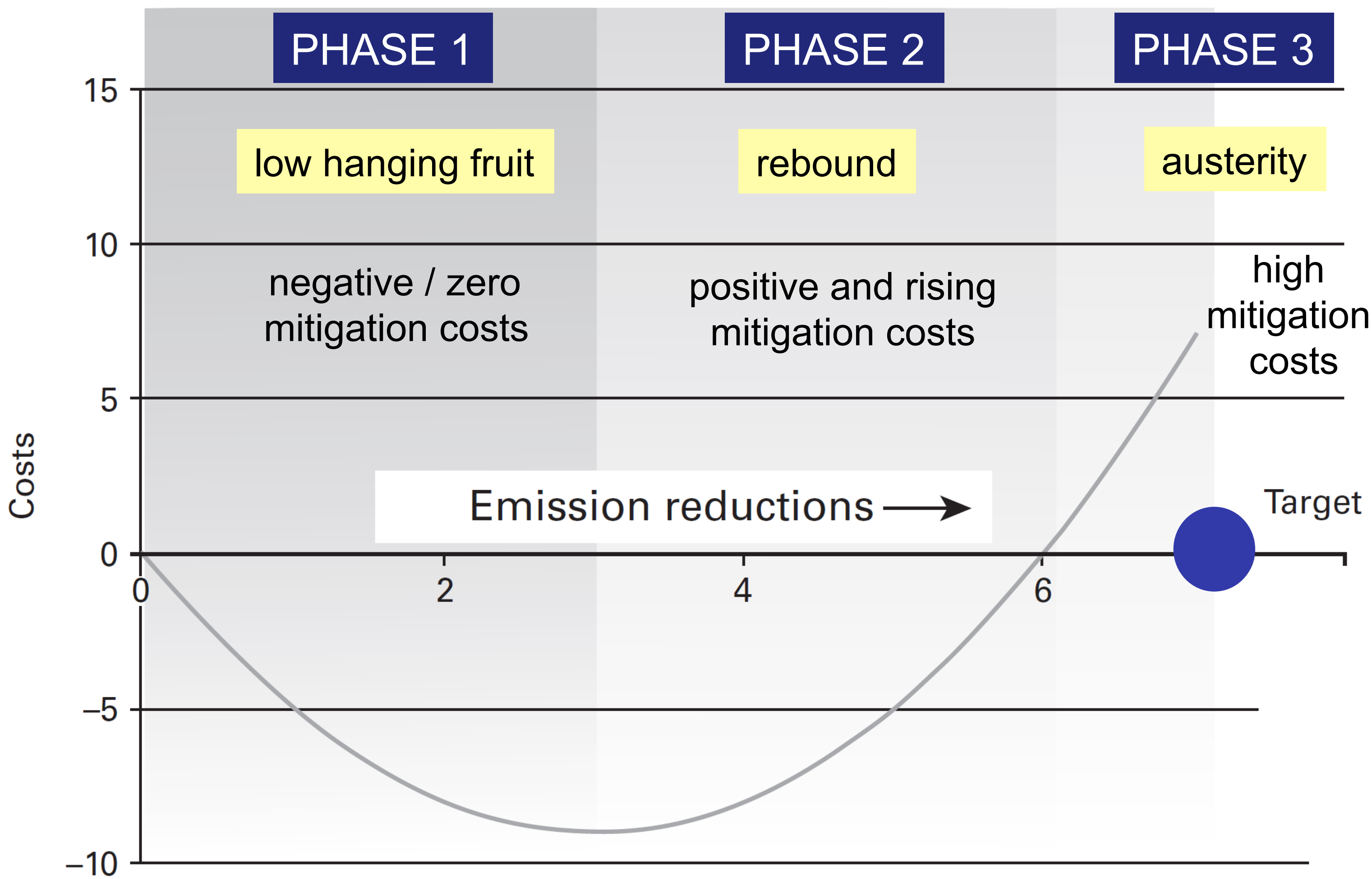
Sustainable Road Freight (SRF) Optimiser



http://www.csrf.ac.uk/srf-optimiser-2/

Source: Centre for Sustainable Road Freight

3 Phases in the Economics of Logistics Decarbonisation



Adapted from Tavasszy (2014)

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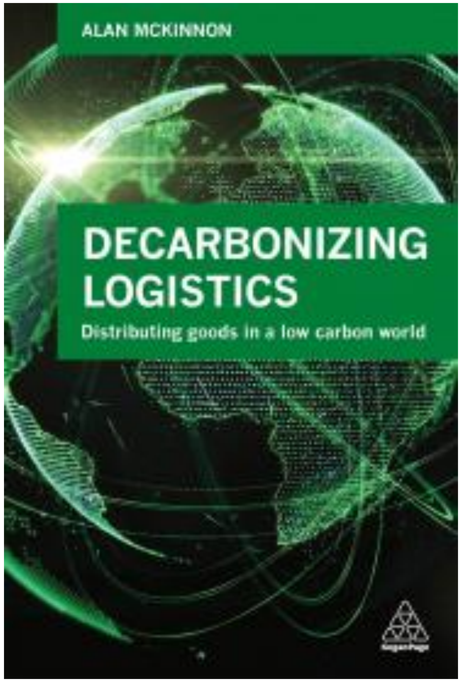

https://www.koganpage.com/product/decarbonising-logistics-9780749483807