Decarbonizing Freight Transport:

Review of Opportunities and Challenges

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Climate Change Advisory Council
Dublin
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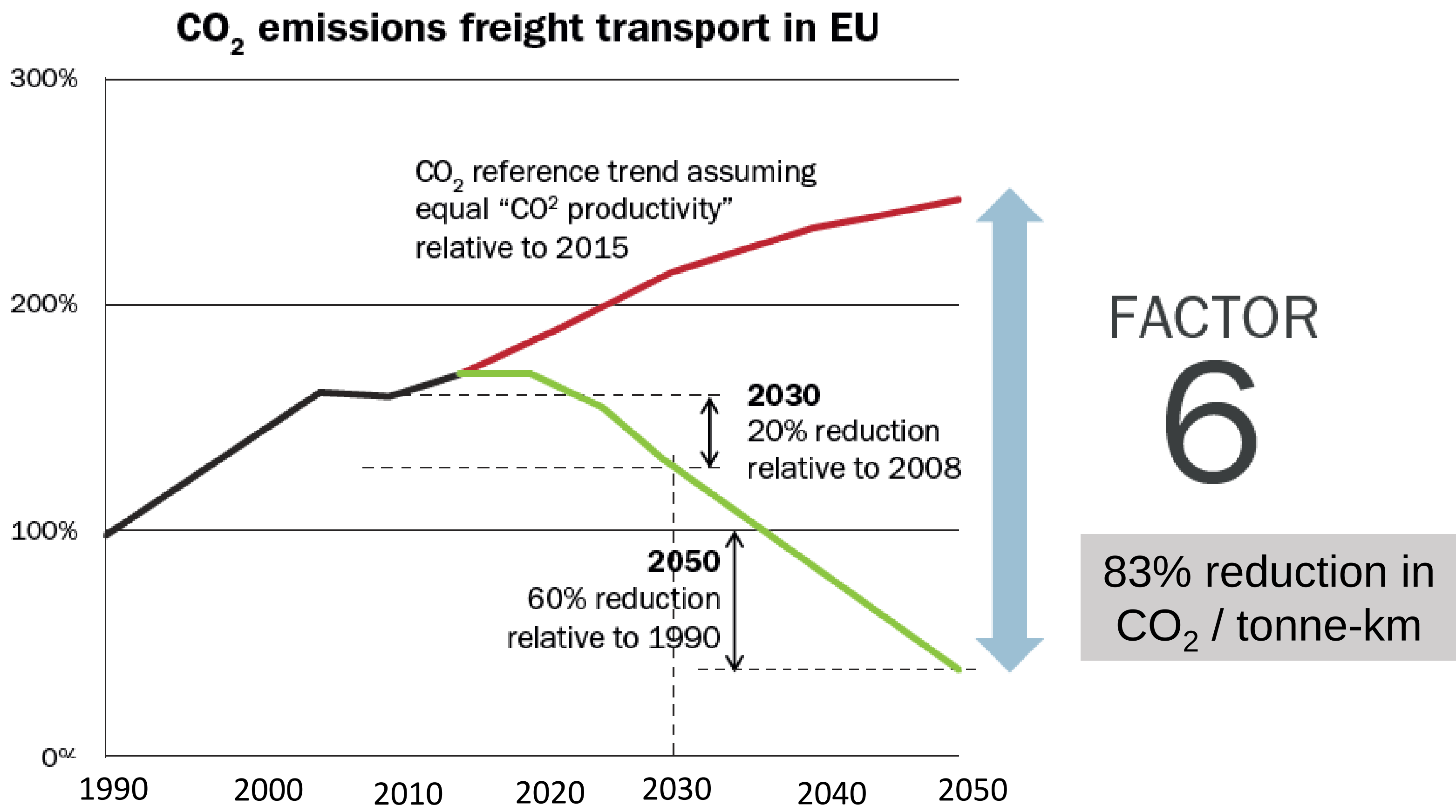
EU 2011 CO_2 Reduction Target for Transport: *60% reduction between 1990 and 2050*

Reduction in carbon intensity needed to achieve target in freight transport sector



Source: Smokers et al. (2017). *Decarbonising Commercial Road Transport*. Delft: TNO.

Leveraging freight decarbonisation parameters to achieve a 6-fold 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 truck energy efficiency

\+

50% drop in carbon intensity of truck energy

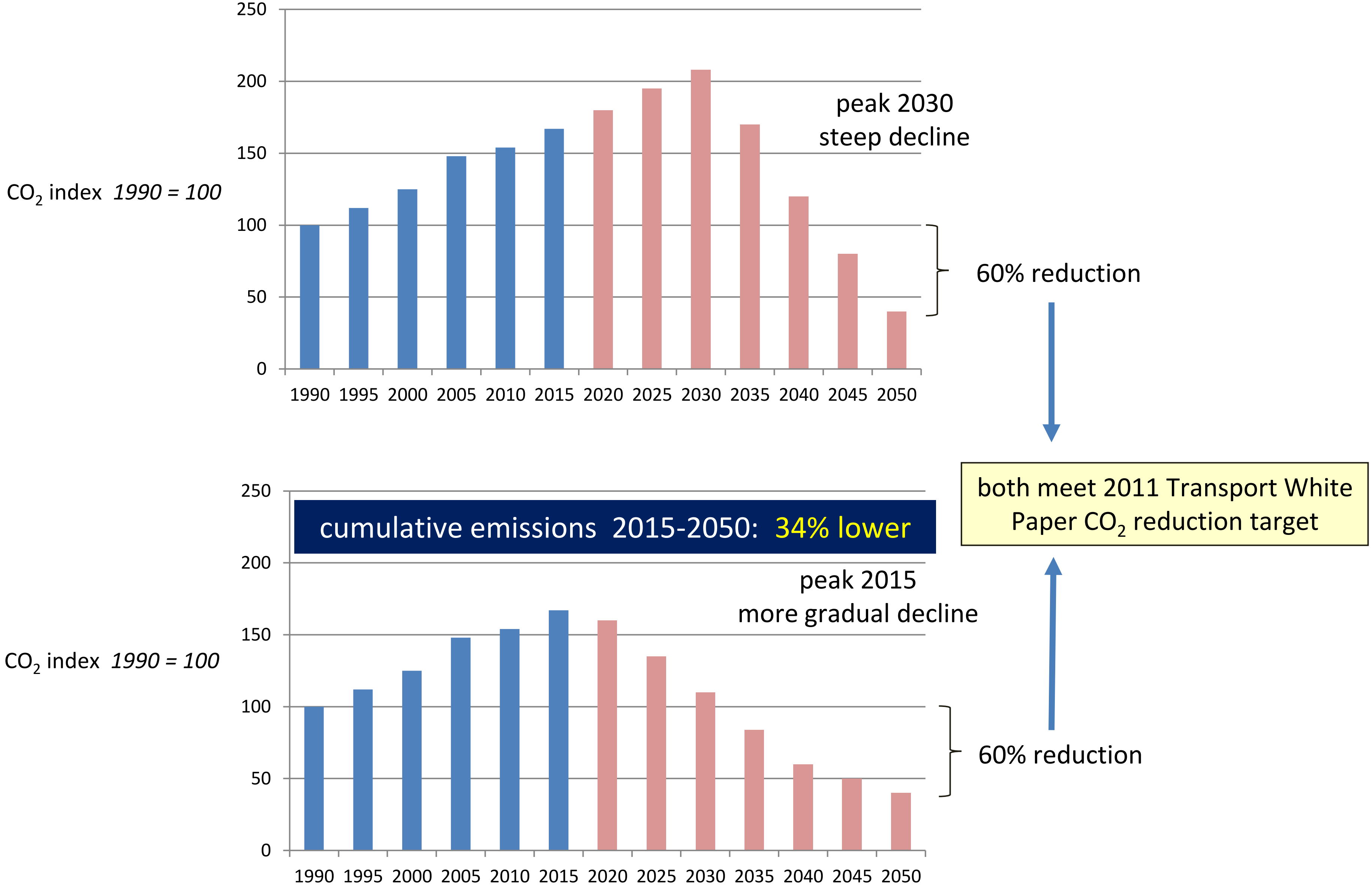
⬇

80% reduction in carbon intensity

achievable even in 30 years ?

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

CO_2 emission reduction profiles for European freight transport



Source: McKinnon (2018) *Decarbonizing Logistics*

Five Sets of Decarbonisation Initiatives for Freight Transport

Reduce Demand for Freight Transport

Shift Freight to Lower Carbon Transport Modes

Optimise Vehicle Loading

Increase Energy Efficiency of Freight Movement

Reduce the Carbon Content of Freight Transport Energy

Reduce the amount of stuff to be moved - Improve ‘*material efficiency*’

Share economy:

Ownership to multiple useage

Circular economy:

Increase recycling and remanufacturing

Design products with less material:

miniaturisation, lightweighting

Digitisation of physical products:

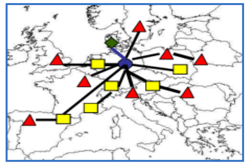
convert freight *consignments into electrons*

3D Printing:

less material used and wasted, simplified supply chains

Reduce Demand for Freight Transport

Restructuring of supply chains



- relocalize production / sourcing
- decentralize inventory
- reversal of key business trends
- high carbon-mitigation costs

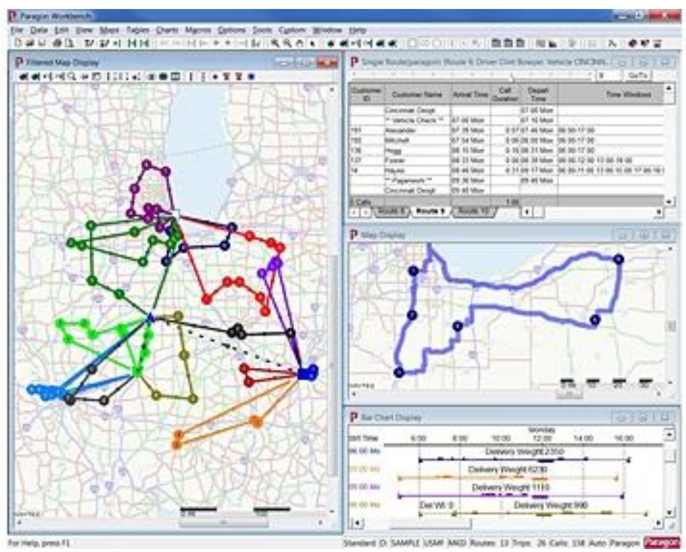
Fossil fuel phase-out

- 41% of international seaborne trade (2016)

Building renewable energy infrastructure

- infrastructure is material- and transport-intensive

optimise vehicle routing



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

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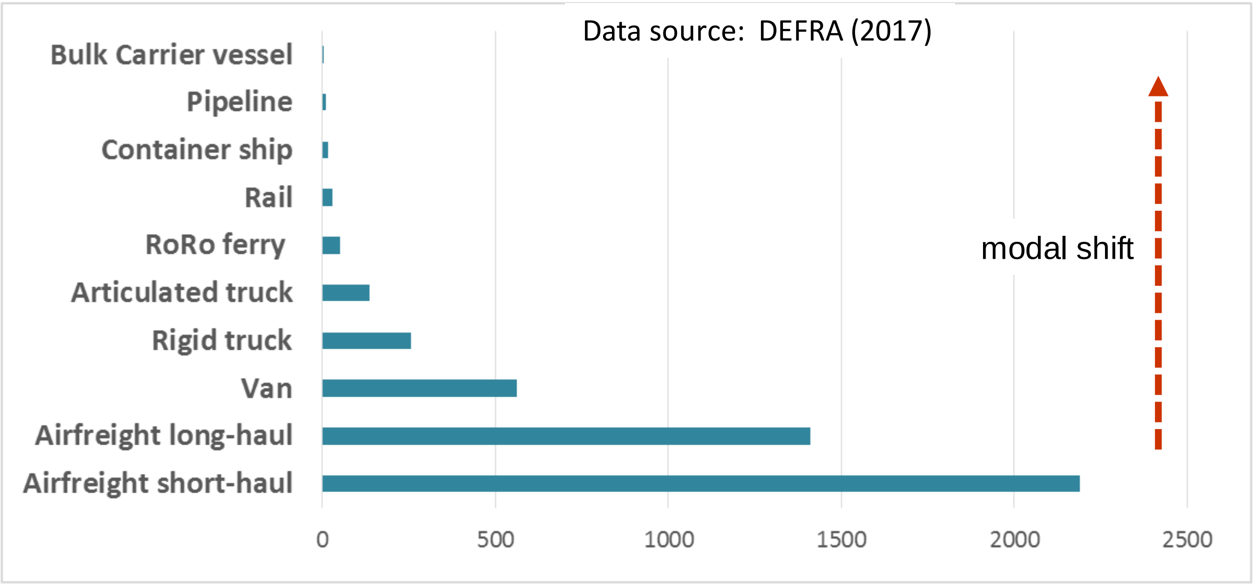
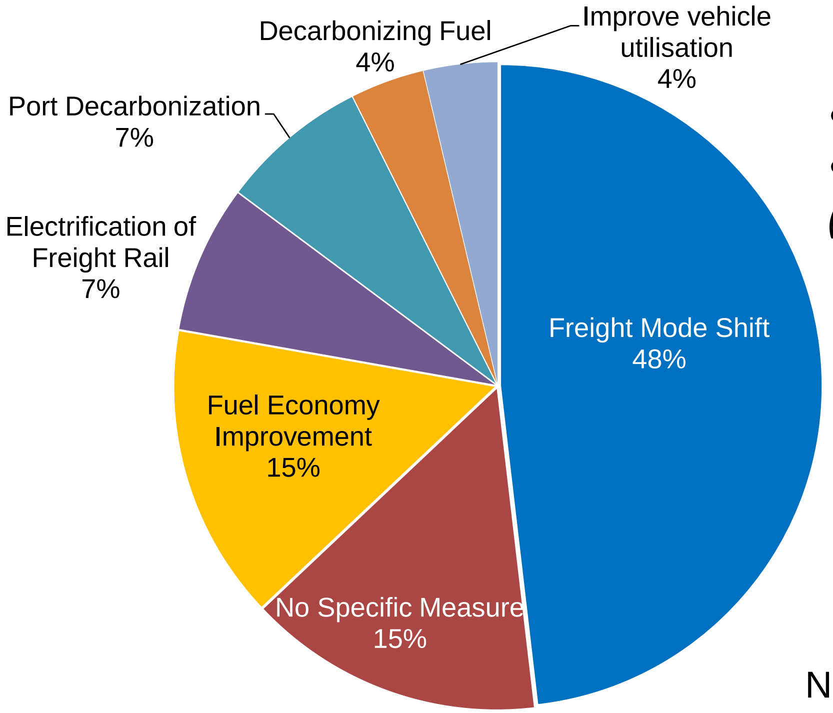
Average carbon intensity of freight transport modes: *gCO_2 / tonne-km*



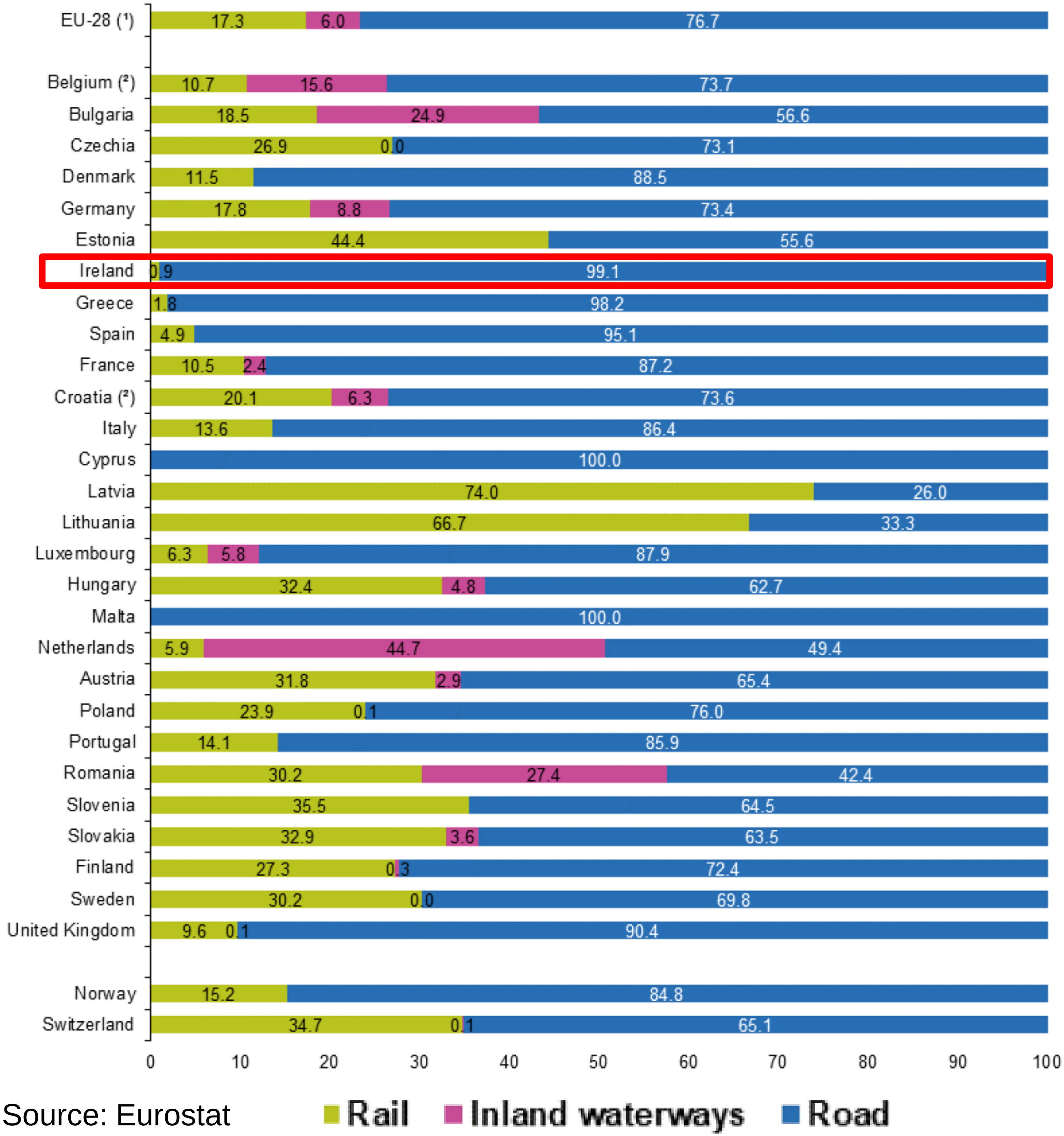


- analysis of 158 NDCs for 185 countries
- only 13% referred to freight transport

(analysis by Sudhir Gota)

% of NDCs specifying particular green freight measures

NDC – nationally determined contribution



Source: Eurostat

EU freight modal split (2017)

% of tonne-kms

EU freight modal split

Only Malta and Cyprus have lower rail share than Ireland – neither of which have a railway

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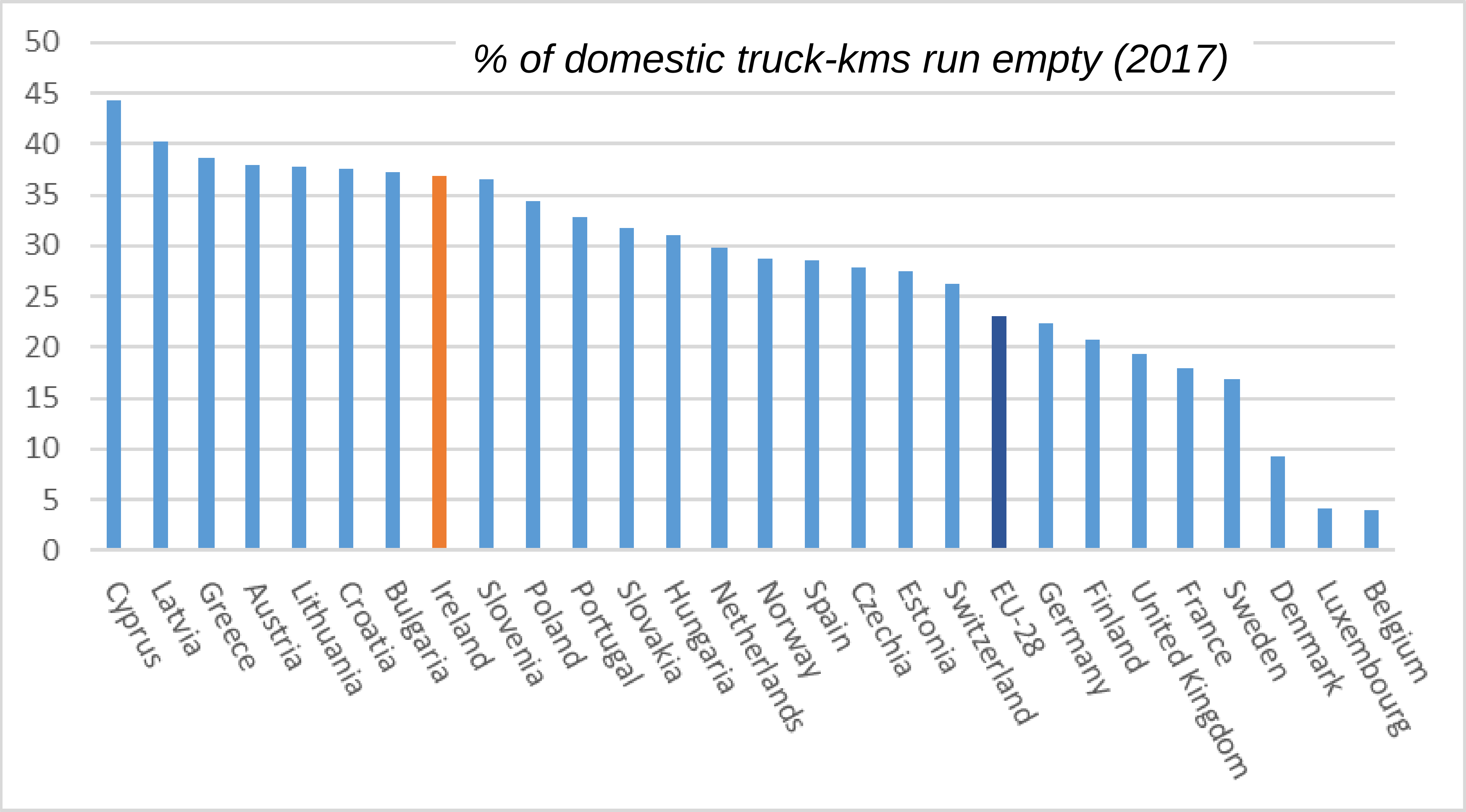
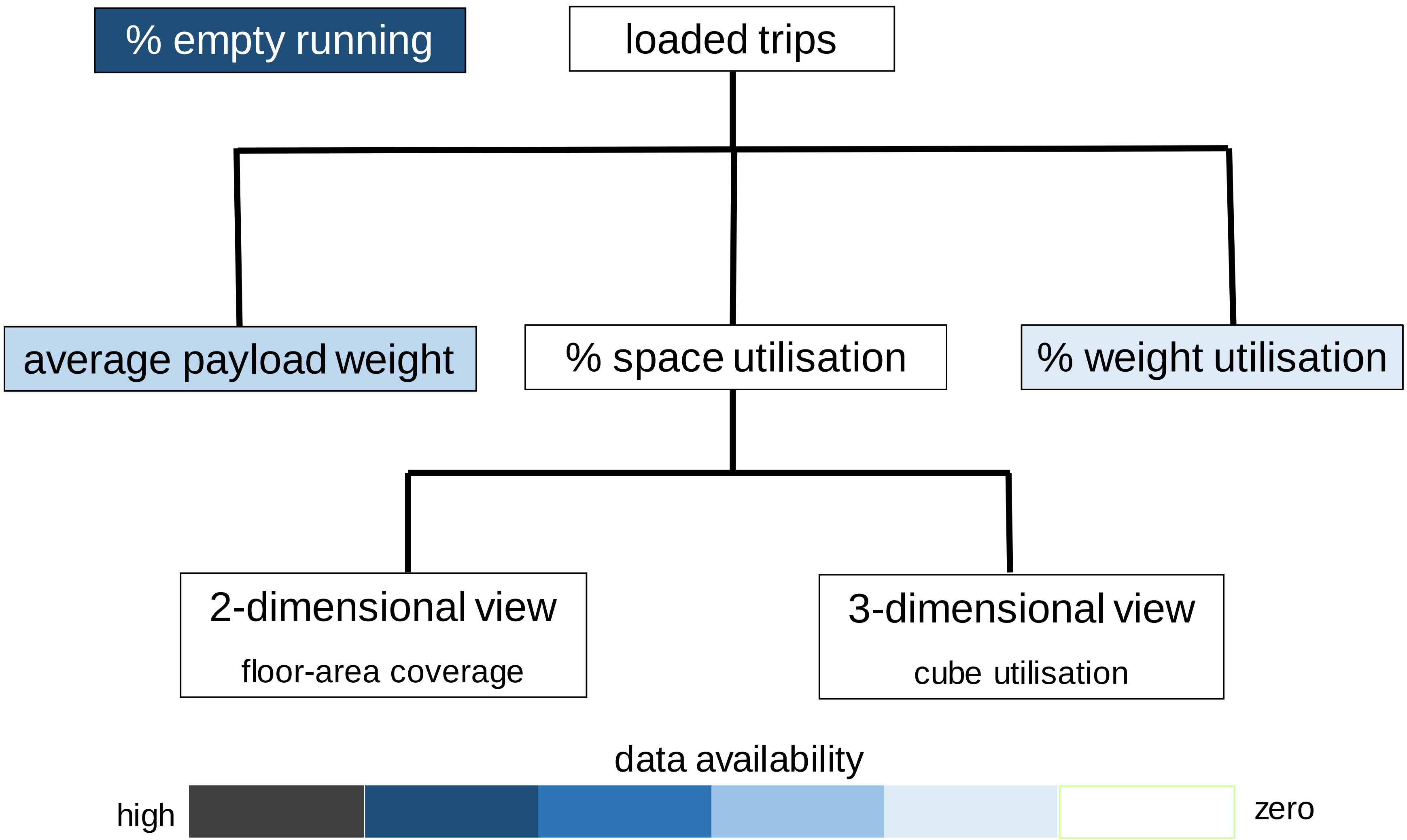
Reduce empty running of trucks



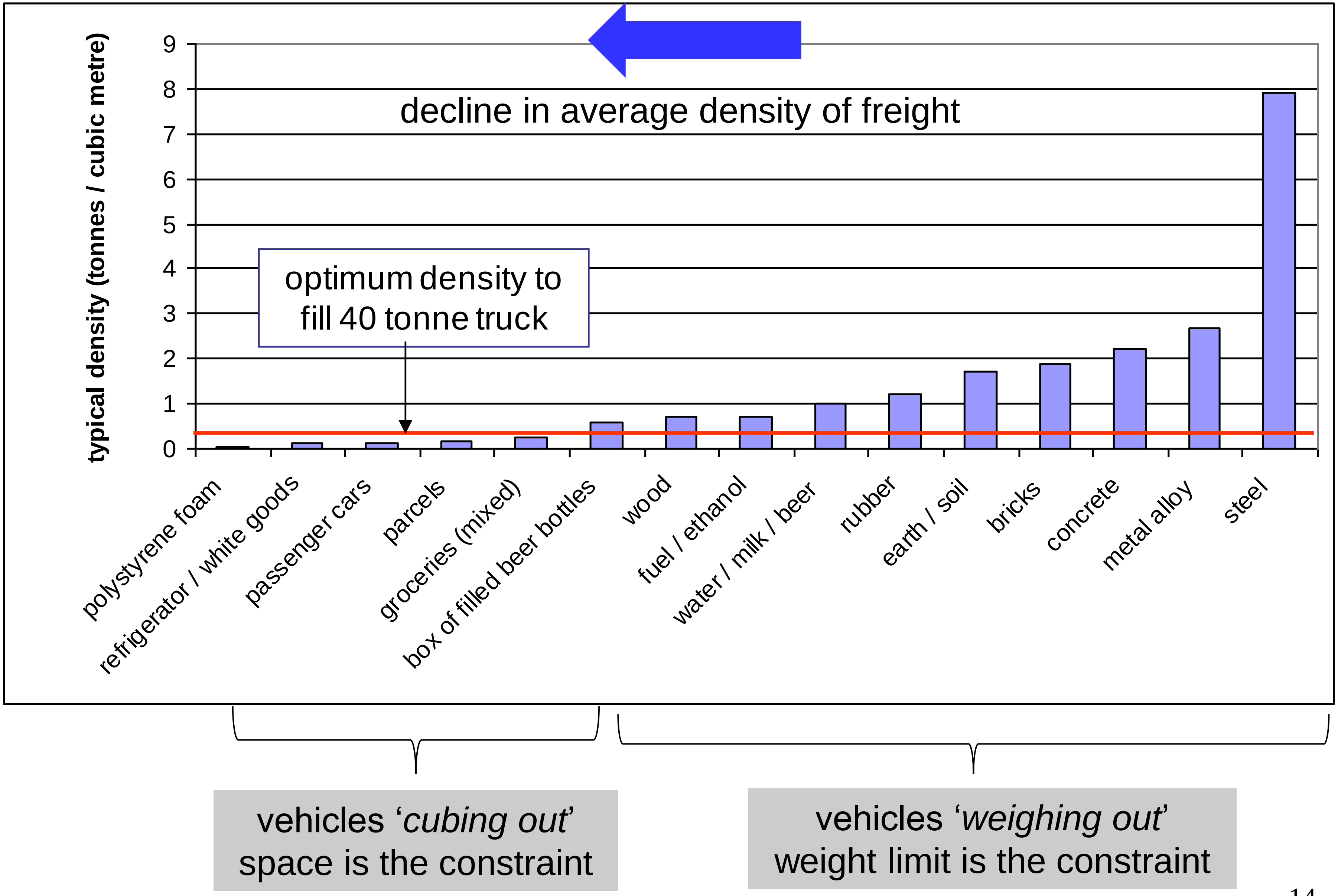
Source: Eurostat

https://ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_by_journey_characteristics#Empty_runnings

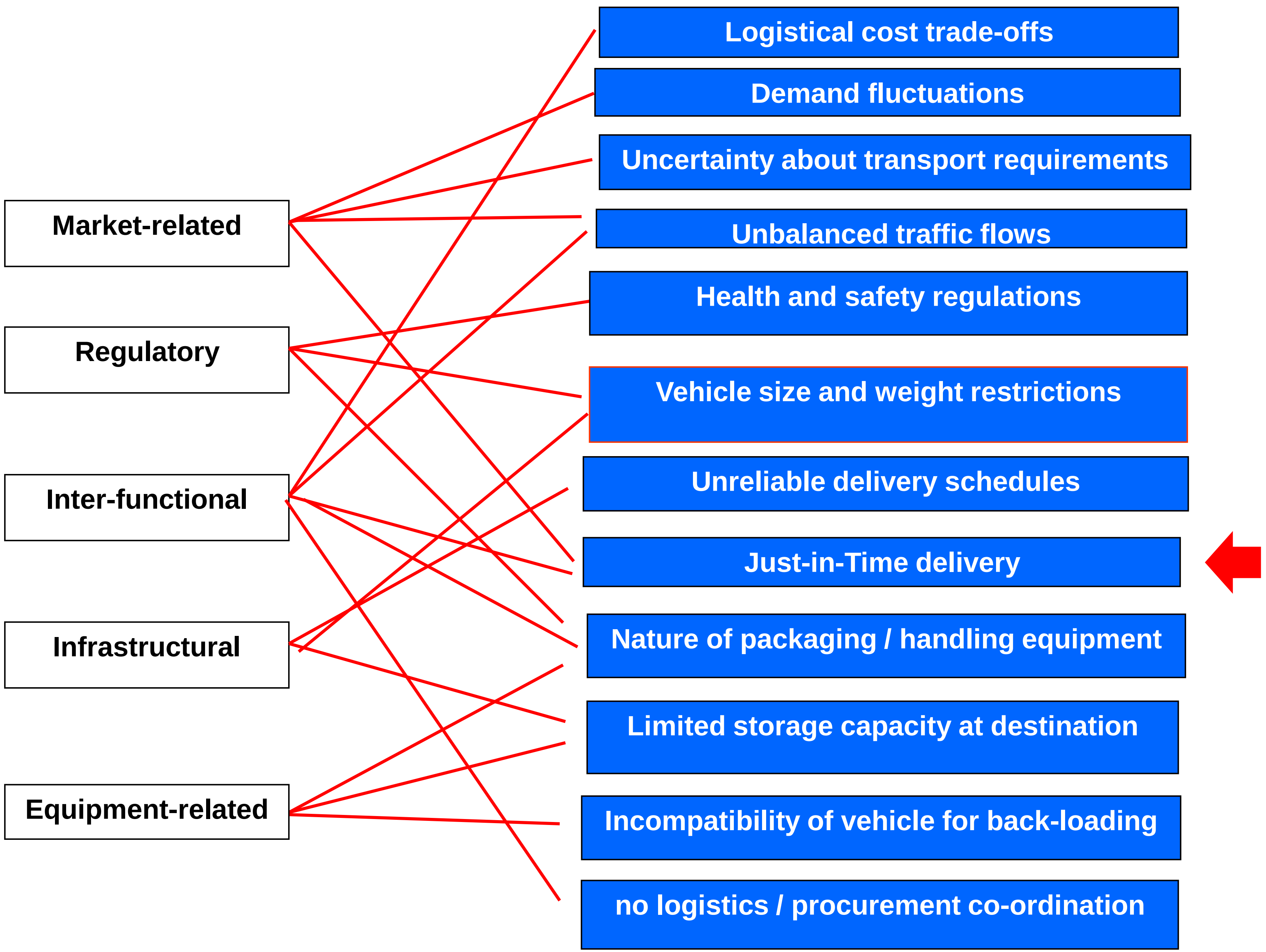
Availability of macro-level truck utilisation data in Europe



Freight Density and the Utilization of Vehicle Carrying Capacity



Constraints on Truck Utilisation

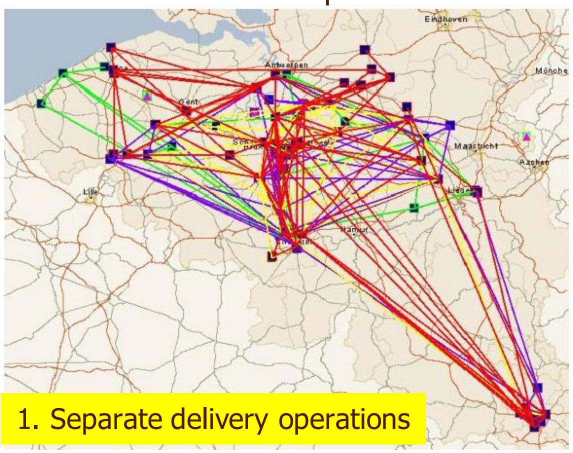


Supply Chain Collaboration

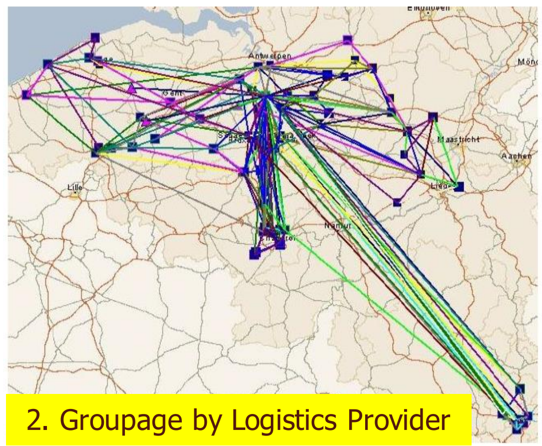
Deep decarbonisation of freight transport will require much greater sharing of logistics assets

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

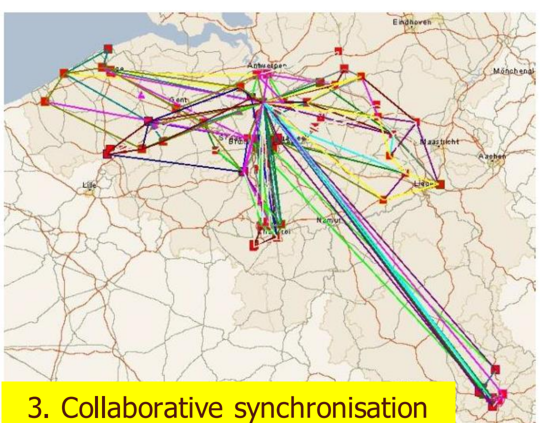
Nestle – Pepsico Horizontal Collaboration in Benelux



1. Separate delivery operations



2. Groupage by Logistics Provider



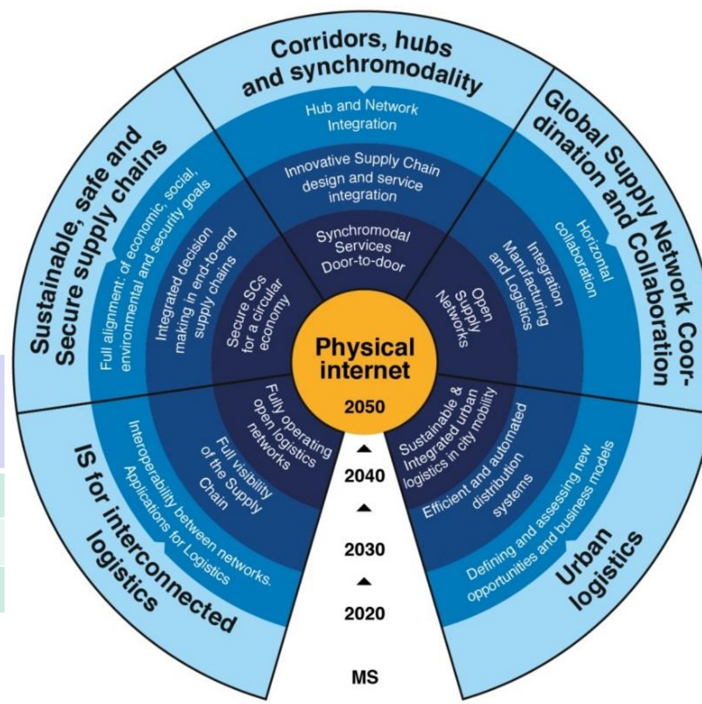
3. Collaborative synchronisation

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

EU project: CO3

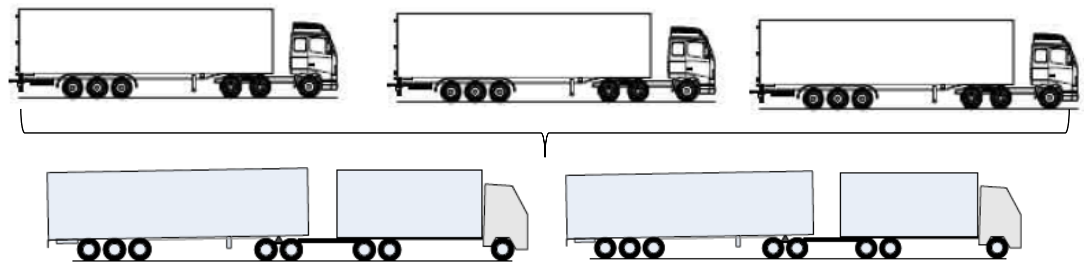
Source: Jacobs et al 2014

Long term contribution of the Physical Internet to logistics decarbonisation



Increasing truck size and weight – *within infrastructural constraints*

Semitrailer + center axle trailer



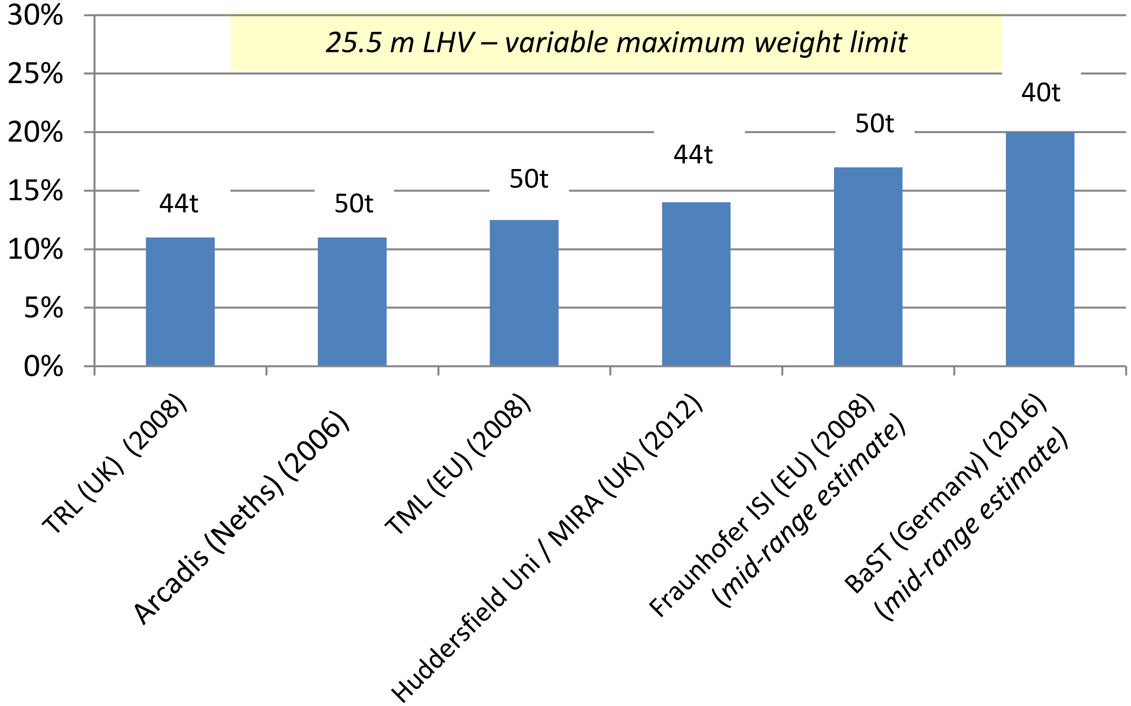
2 truck for 3 substitution: load consolidation → reduced energy use and emissions per tonne-km

vehicle level analysis → system level analysis

Net effect on CO_2 depends on:

- vehicle adoption rate
- induced traffic
- circuitous routing
- vehicle load factor
- freight modal shift

% reduction in carbon intensity against baseline vehicle



European studies of high capacity transport

double-deck trailer (UK)

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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:

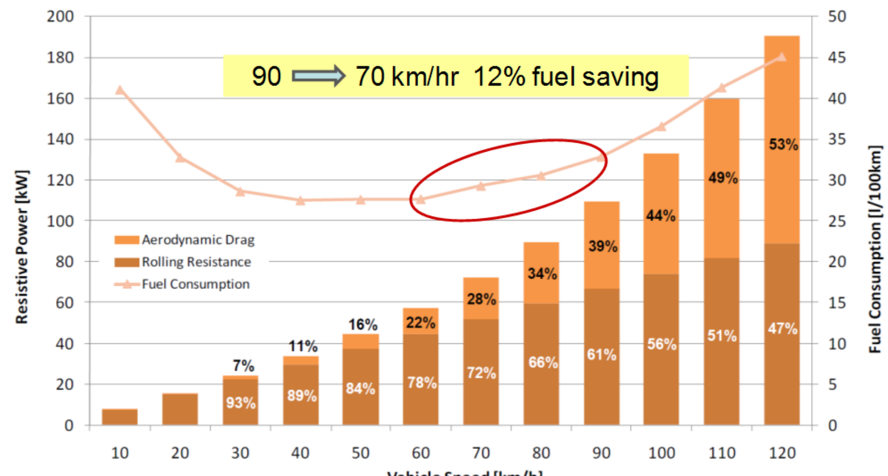
Fuel Economy Standards for Heavy Duty Vehicles

	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					
EU: 15% less CO_2 by 2025 30% by 2030														
India									Phase 1					
Mexico									Phase 1					
S. Korea									Phase 1					

Hashed areas represent unconfirmed projections of the ICCT

Source: ICCT (2015)

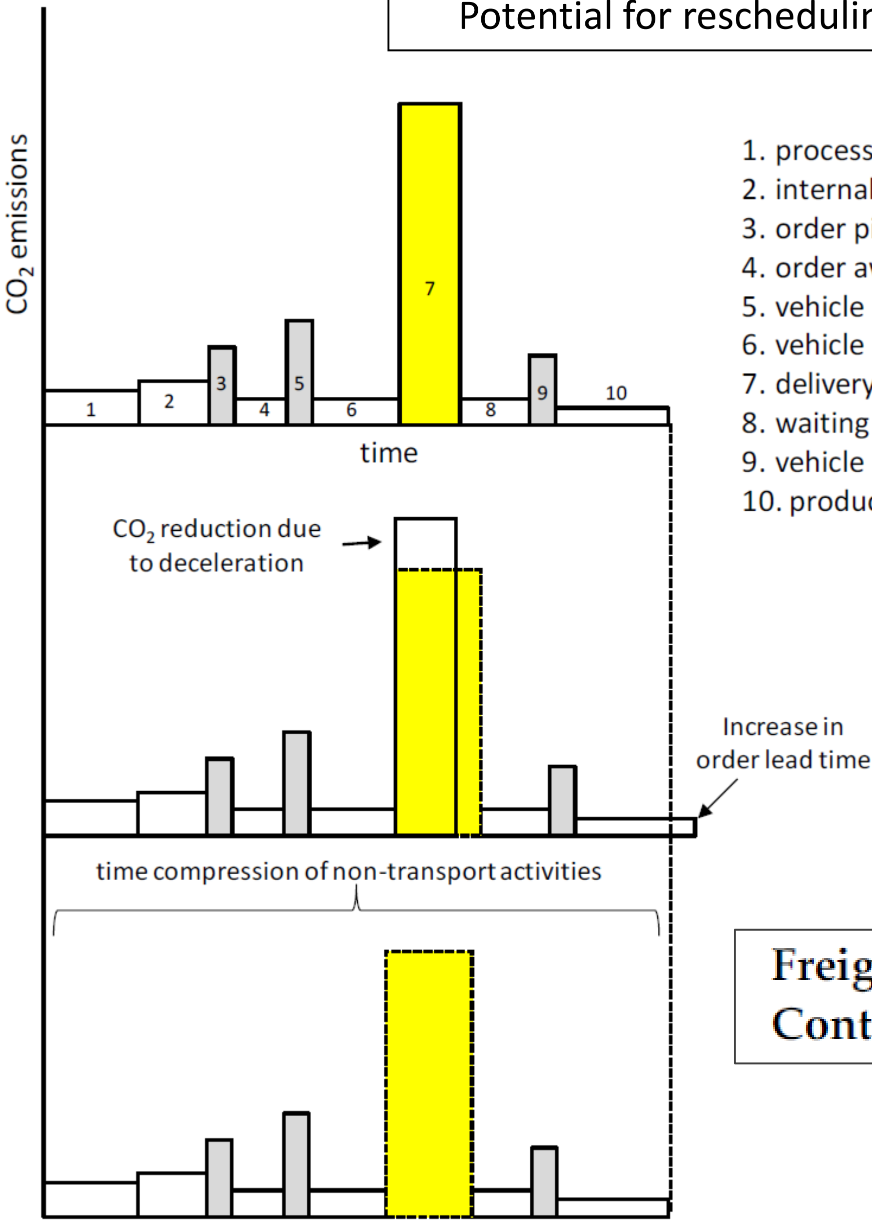
business practice: e.g. *lower vehicle speed*



Source: AEA Technology et al (2010)

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

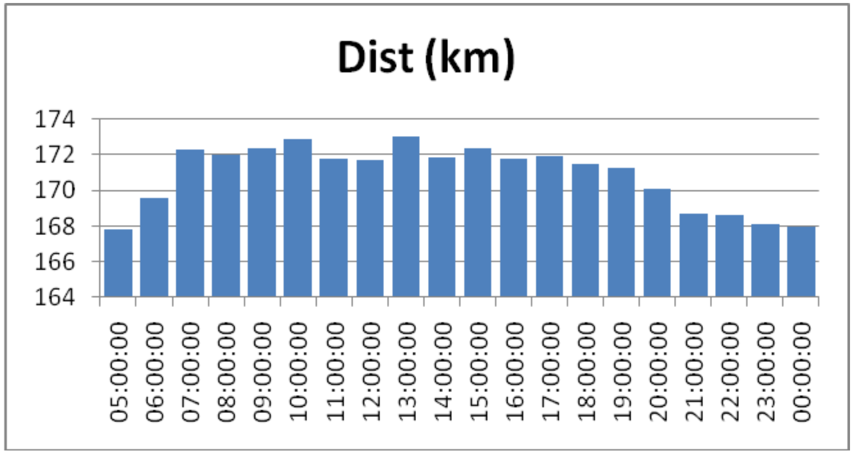
- accelerate internal processes
- Internal time savings offset longer transit times
- net CO_2 saving within fixed order lead time

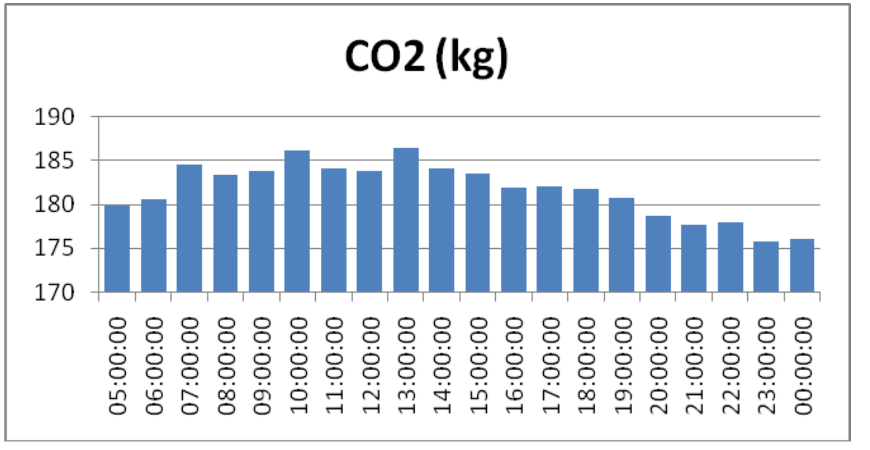
Freight Transport Deceleration: Its Possible Contribution to the Decarbonisation of Logistics

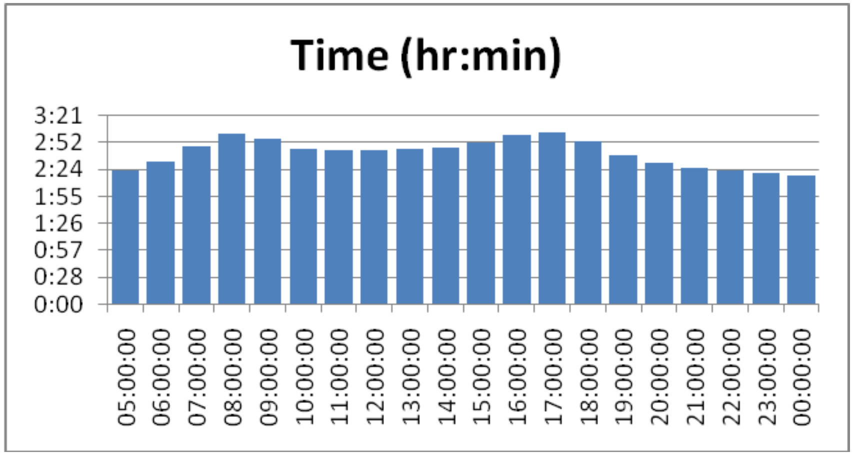
McKinnon (2016) *Transport Reviews*

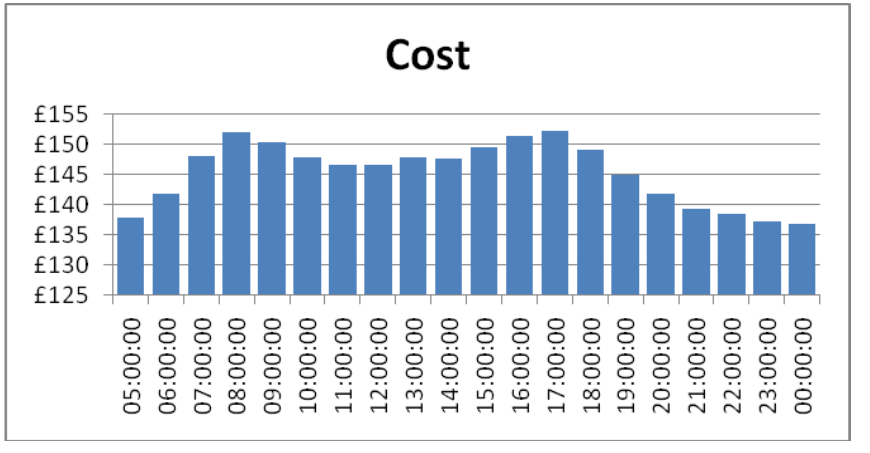
Effects of Varying Start Times for Long Haul Road Deliveries Network

Simulation modelling of truck trips across UK trunk road network









Source: Palmer and Piecyk, 2010

constraints on the rescheduling of deliveries to minimize congestion

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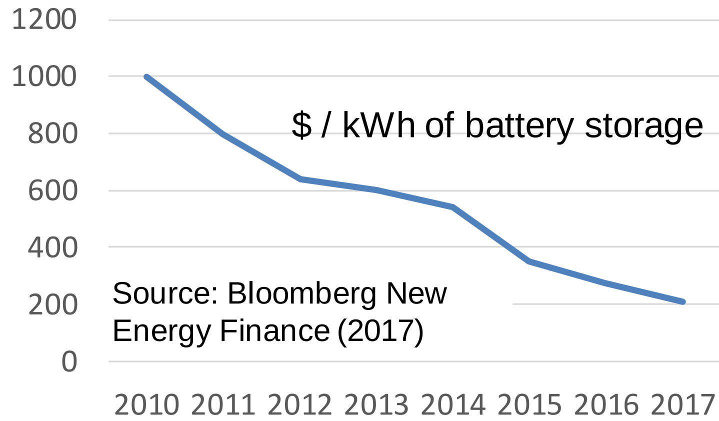
Road Freight Transport

local delivery operations

battery power



- increasing delivery range
- narrowing price differential
- expanding recharging network

long distance trucking

battery power

hydrogen fuel-cell truck

disagreement on weight, size recharging time for batteries

Sripad & Visvanathan, McKinsey etc

10-12 tonnes for US Class 8 truck
400 kW per hour charging time

Tesla, ETC* etc

4-6 tonnes for US Class 8 truck
1600 kW per hour (Tesla)

Bossel, Cebon etc

energy losses so high never likely to be viable option

IDDRI, ETC* etc

despite high energy losses, still viable decarbonisation option

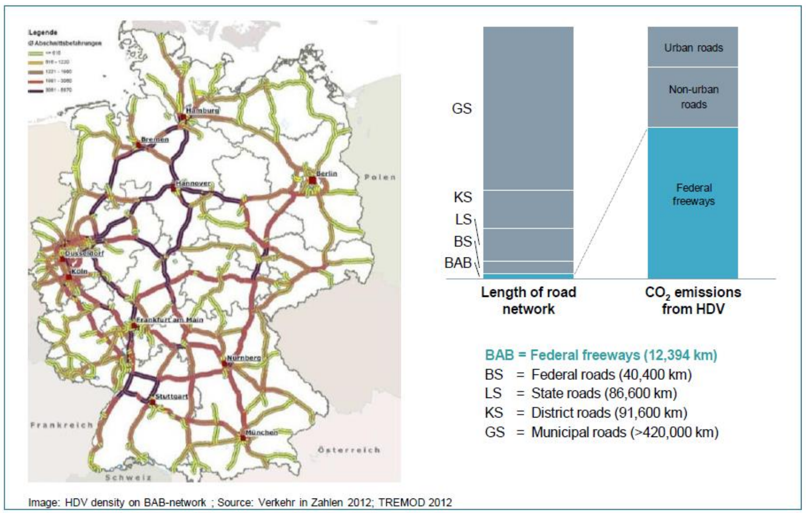
* Energy Transition Commission

Hydrogen as the energy carrier of low carbon electricity

3rd option: electrify the road network

Highway electrification: *the e-Highway*

electrified roads: Trials in Sweden, Germany and the US



Source: Siemens

60% of heavy truck CO_2 emissions in Germany occur on only 2% of road network

89% of truck trips after leaving highway have a length of 50km or less.

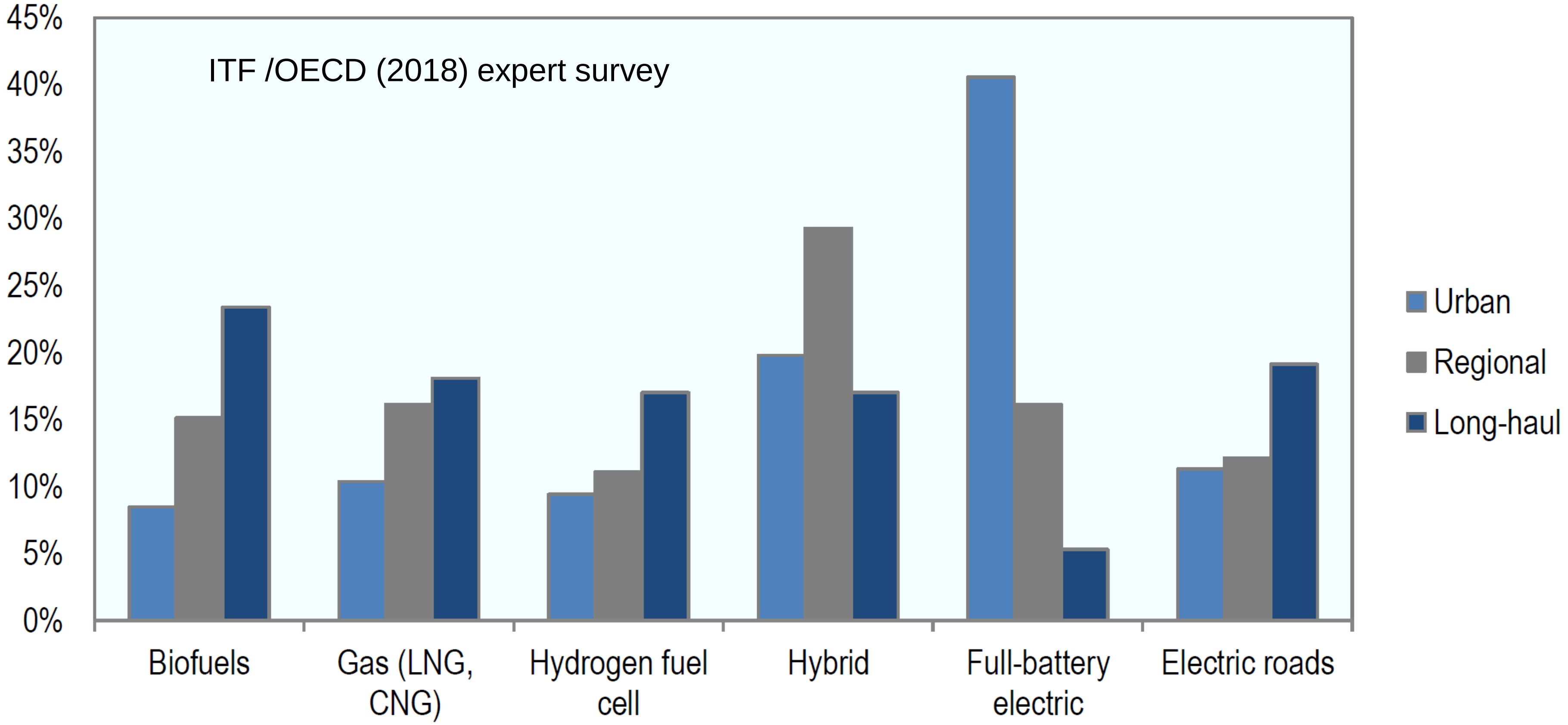
BDI / Boston Consulting Group / Prognos study:

Recommends that 4000-8000 km of German autobahn network be electrified (out of 13000 km)

Capital cost of highway electrification: around €1.5 – 2.0 million per km

Uncertainty over most cost-effective energy decarbonisation pathways for trucking

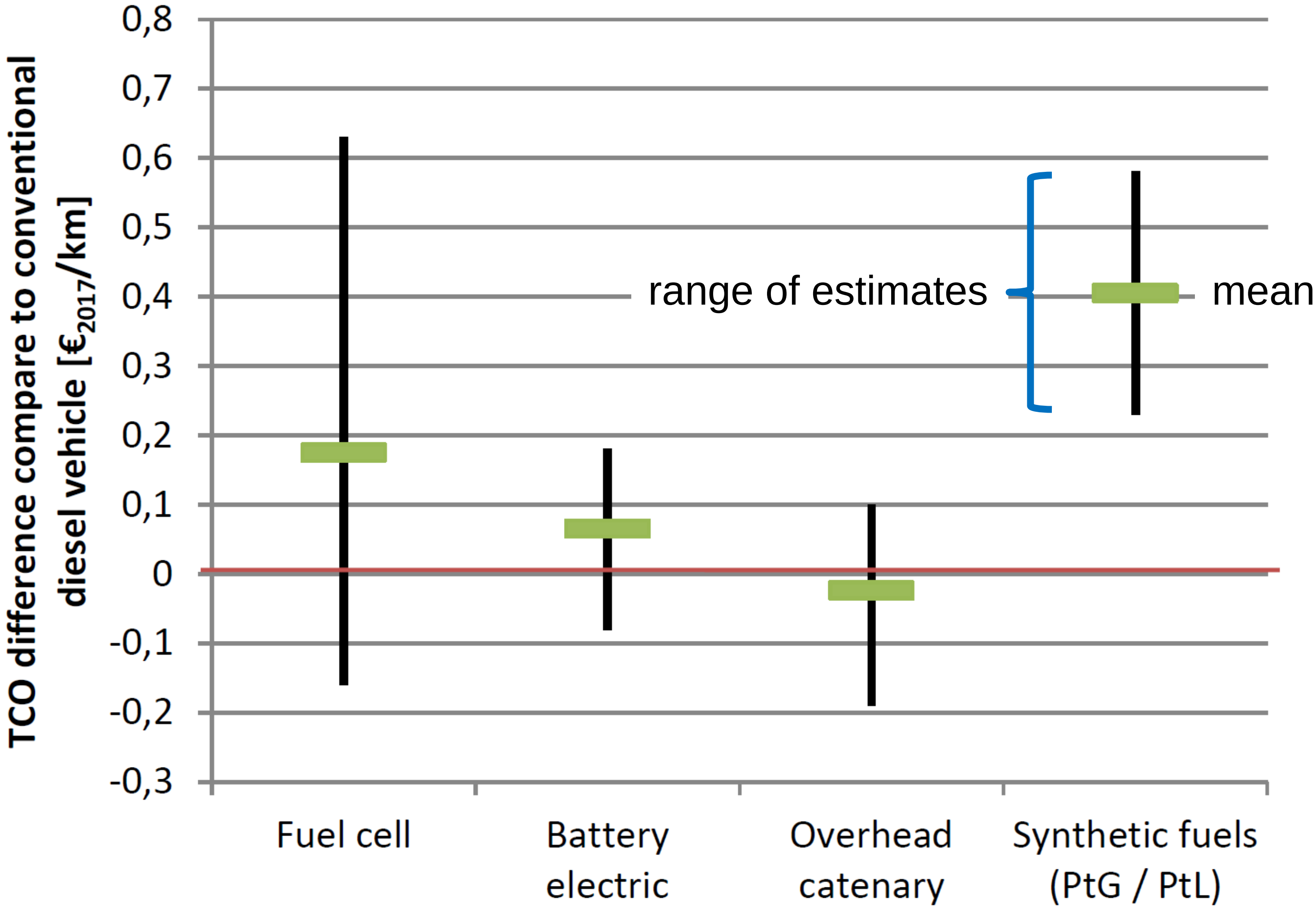
What are the most cost-effective alternative energies for each type of road freight operation?



Optimum mix of decarbonisation pathways likely to vary by country

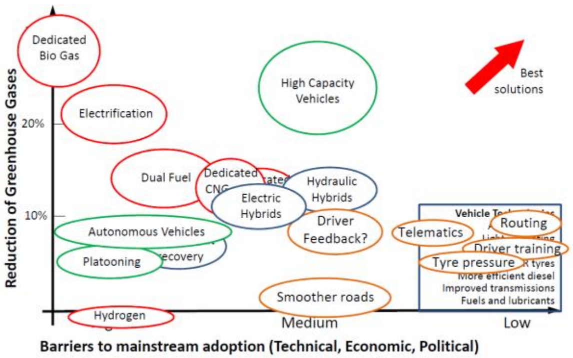
Alternative drive trains and energy sources for long haul road freight

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

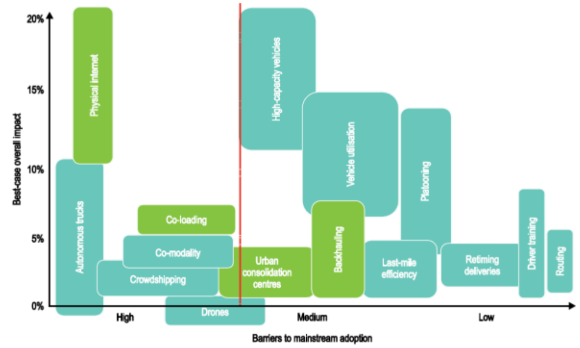


Source: Oeko Institute, Fraunhofer ISI & IFEU

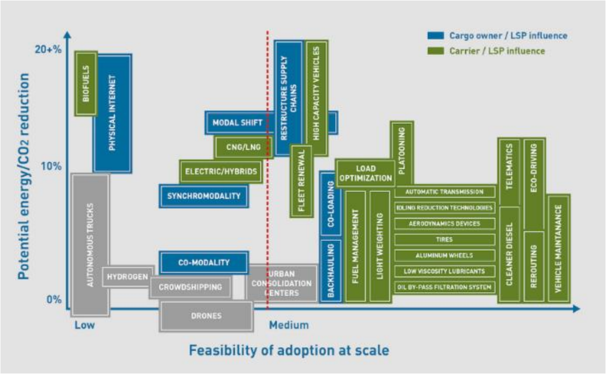
Road freight decarbonisation measures: *abatement – implementation graphs*



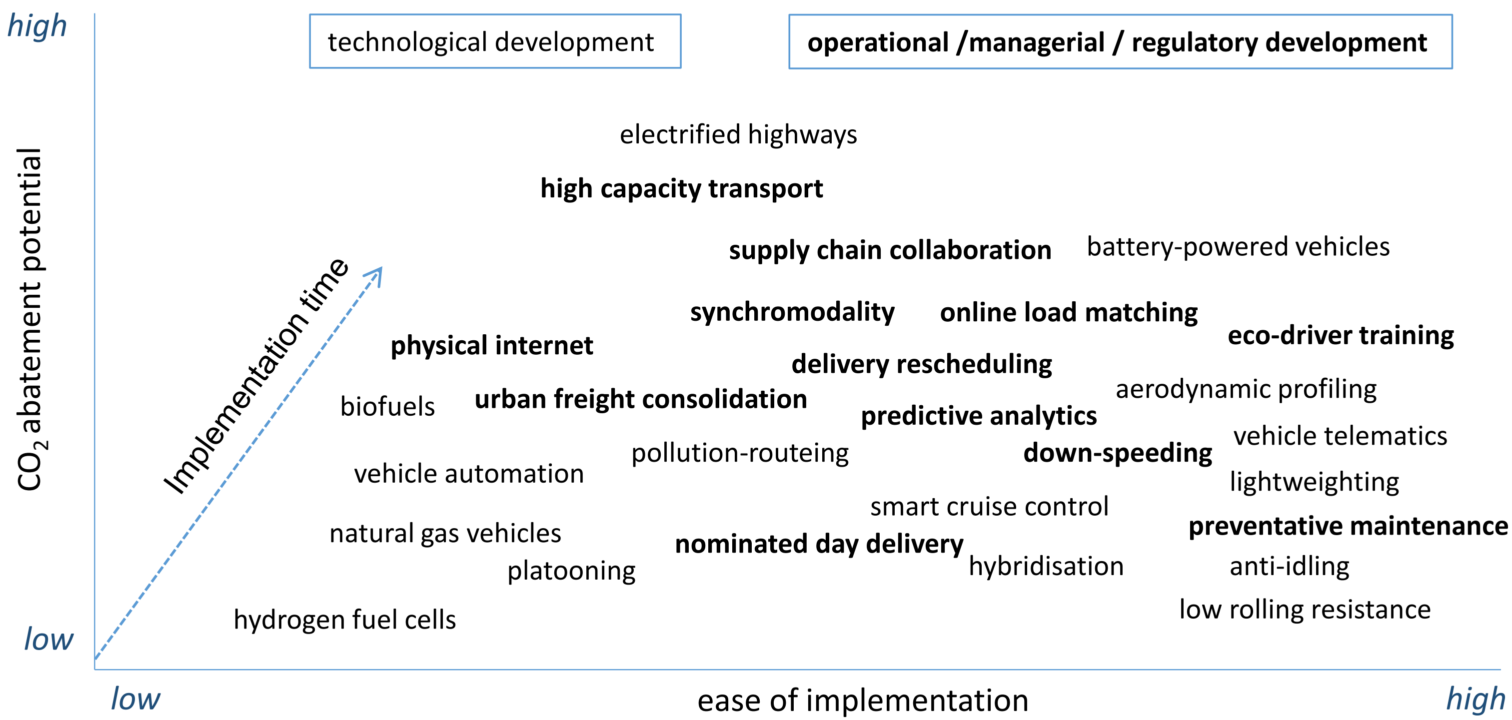
Professor Cebon



International Energy Agency

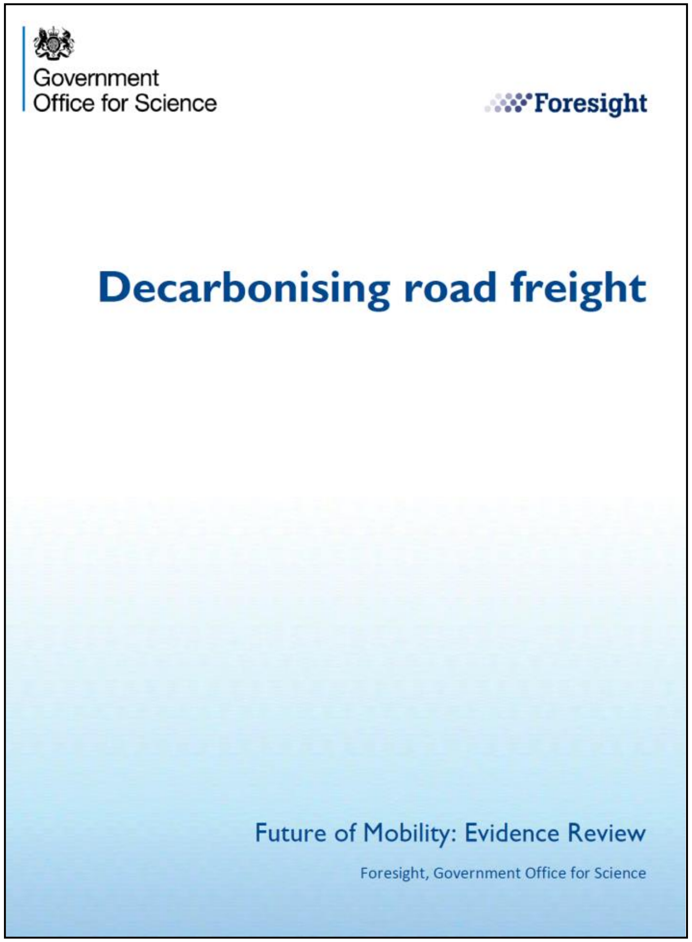


Smart Freight Centre



Source: McKinnon (2018) Decarbonizing Logistics

MAC analysis for decarbonisation of articulated trucks in the UK by 2040

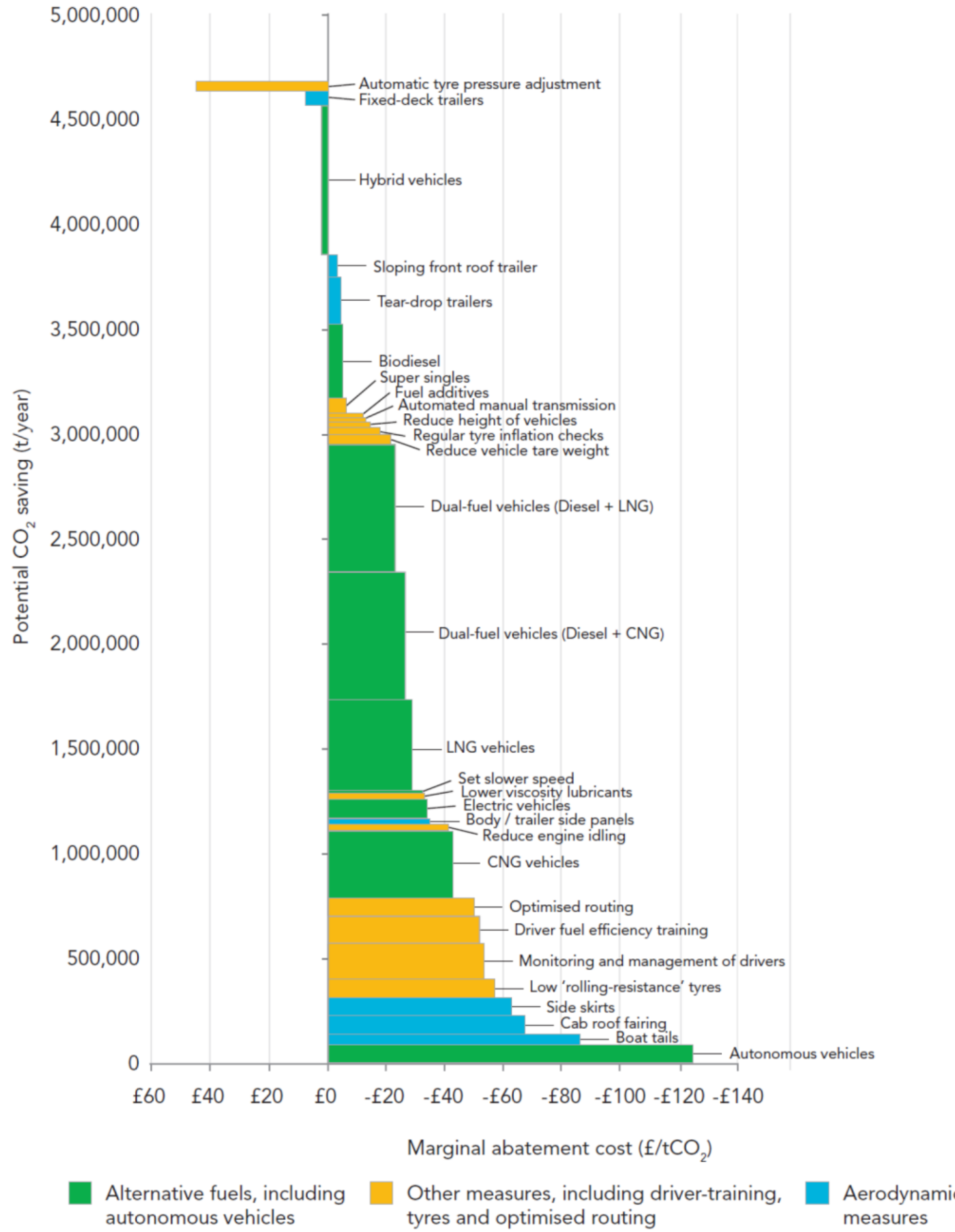

Government Office for Science

Foresight

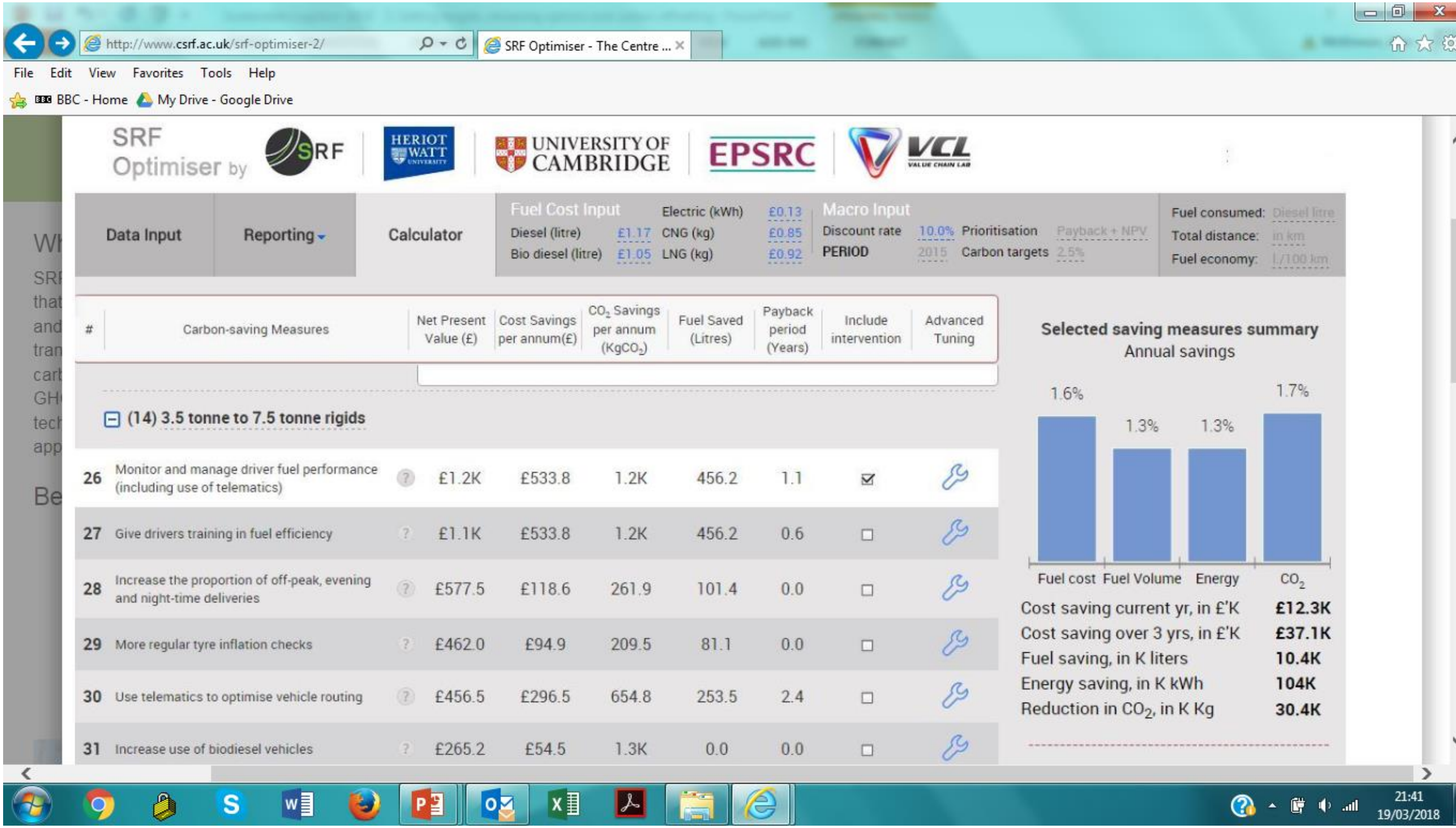
Decarbonising road freight

Future of Mobility: Evidence Review

Foresight, Government Office for Science



Sustainable Road Freight (SRF) Optimiser



#	Carbon-saving Measures	Net Present Value (£)	Cost Savings per annum(£)	CO_2 Savings per annum ($KgCO_2$)	Fuel Saved (Litres)	Payback period (Years)	Include intervention	Advanced Tuning
26	Monitor and manage driver fuel performance (including use of telematics)	£1.2K	£533.8	1.2K	456.2	1.1	☑	
27	Give drivers training in fuel efficiency	£1.1K	£533.8	1.2K	456.2	0.6	☐	
28	Increase the proportion of off-peak, evening and night-time deliveries	£577.5	£118.6	261.9	101.4	0.0	☐	
29	More regular tyre inflation checks	£462.0	£94.9	209.5	81.1	0.0	☐	
30	Use telematics to optimise vehicle routing	£456.5	£296.5	654.8	253.5	2.4	☐	
31	Increase use of biodiesel vehicles	£265.2	£54.5	1.3K	0.0	0.0	☐	

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

Source: Centre for Sustainable Road Freight

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