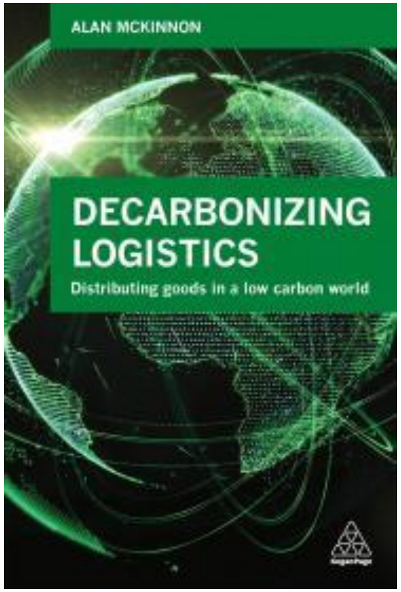
Decarbonizing Logistics:

Frameworks, Targets and Options

Professor Alan McKinnon

Kühne Logistics University

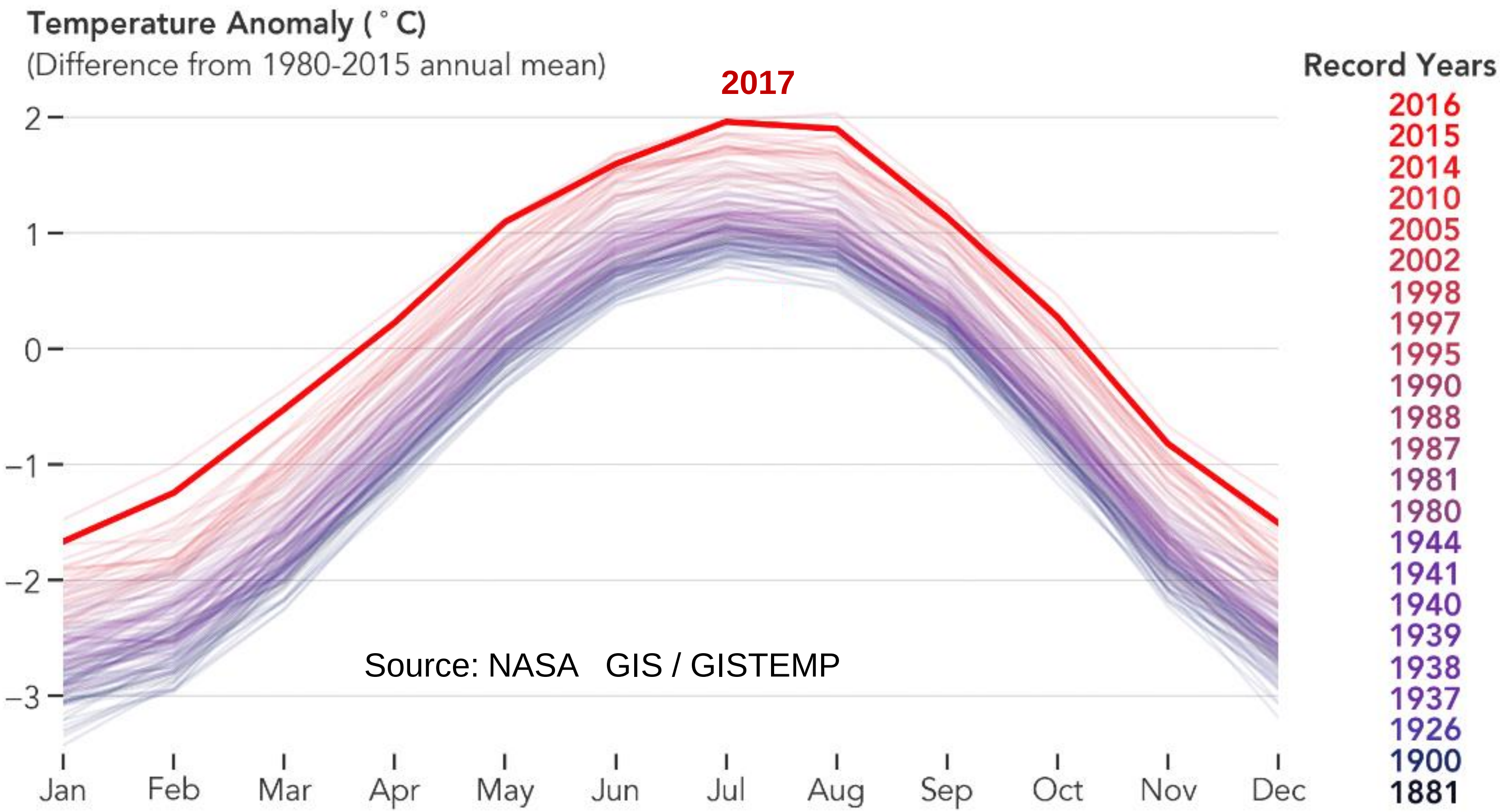


NTM Lecture

Stockholm

28th May 2018

Increase in Average Global Temperature 1881-2017

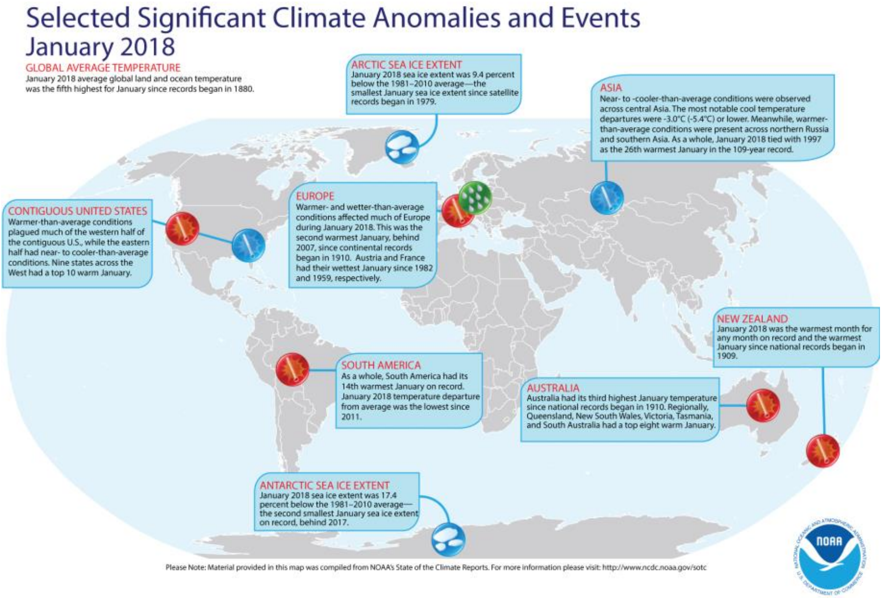


- average global temperature in 2017 was the second highest on record – after 2016
- 41st consecutive year of average global temperatures above the 20th Century mean
- Rate of increase of global average temperature unprecedented

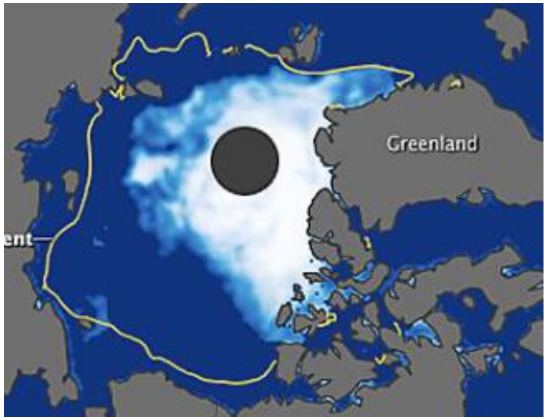
'…we are seeing remarkable changes across the planet that are challenging the limits of our understanding of the climate system. We are now in truly uncharted territory'

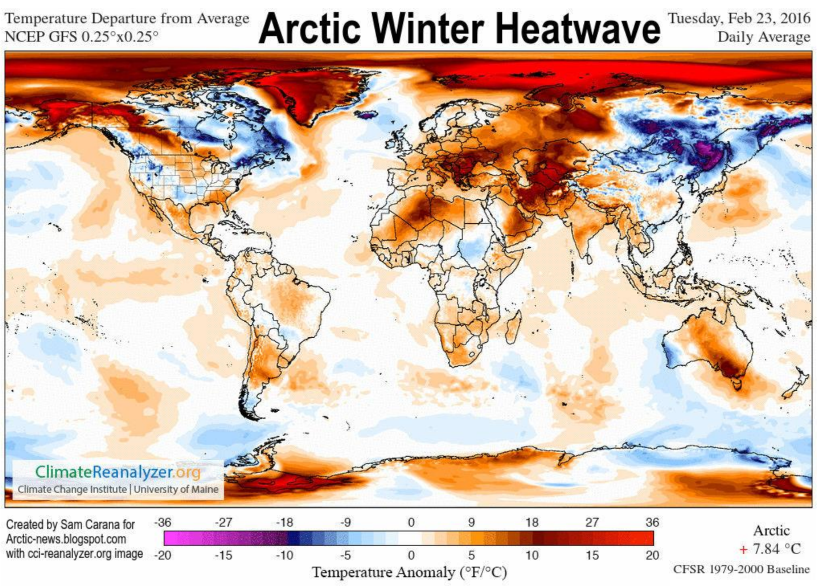
David Carlson, Director of WMO World Climate Research Program. (2017)

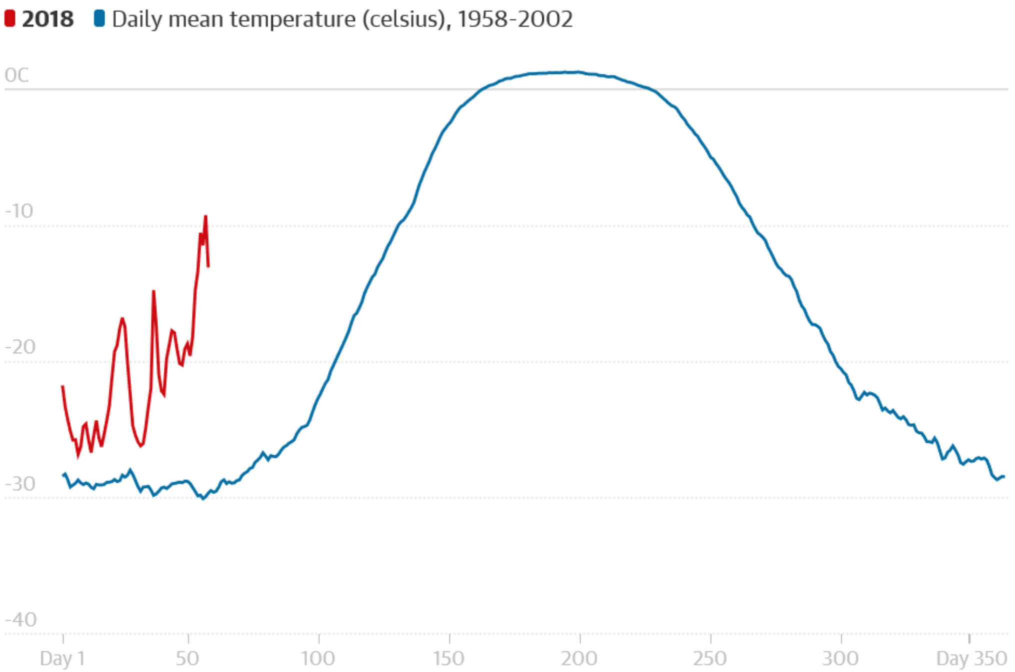
Climatic Anomalies Multiply



the Arctic Barometer







Guardian graphic | Source: Danish Meteorological Institute. Data recorded north of the 80th northern parallel

UNFCC COP 21 Conference on Climate Change
December 2015

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

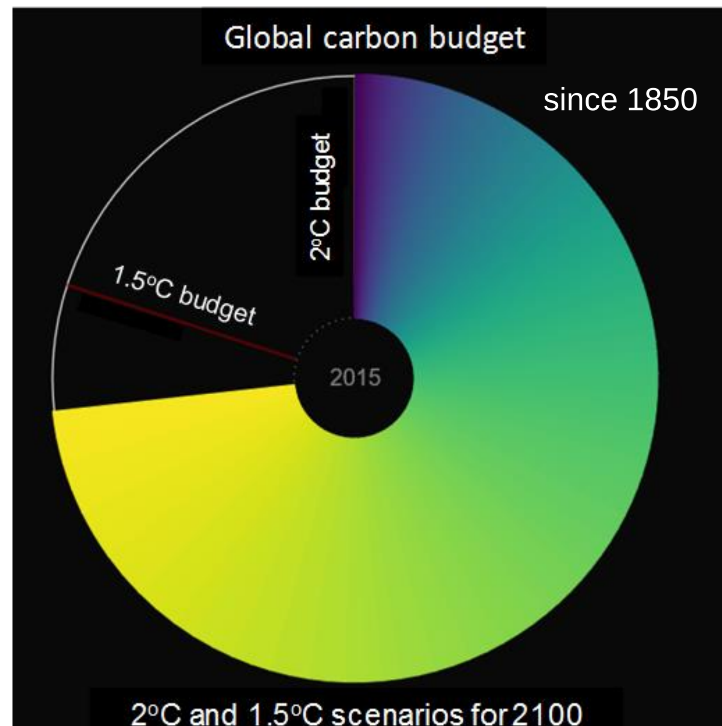
Bottom-up rather top-down approach to securing country commitments
Intended Nationally Determined Contributions (INDCs)

International agreement to keep average global temperature '*well below*' 2°C above pre-industrial times and '*endeavor to limit*' it to 1.5°C – **but already 1.1°C above 1850 temperature**

No legal sanction on countries failing to meet targets

COP21 commitments still lead to 3.4°C increase by 2100

US withdrawal from Paris Accord: *not till 2020*



Source: Ed Hawkins http://www.climatechangenews.com/2016/07/27/spiral-tastic-climate-change-in-three-animations/

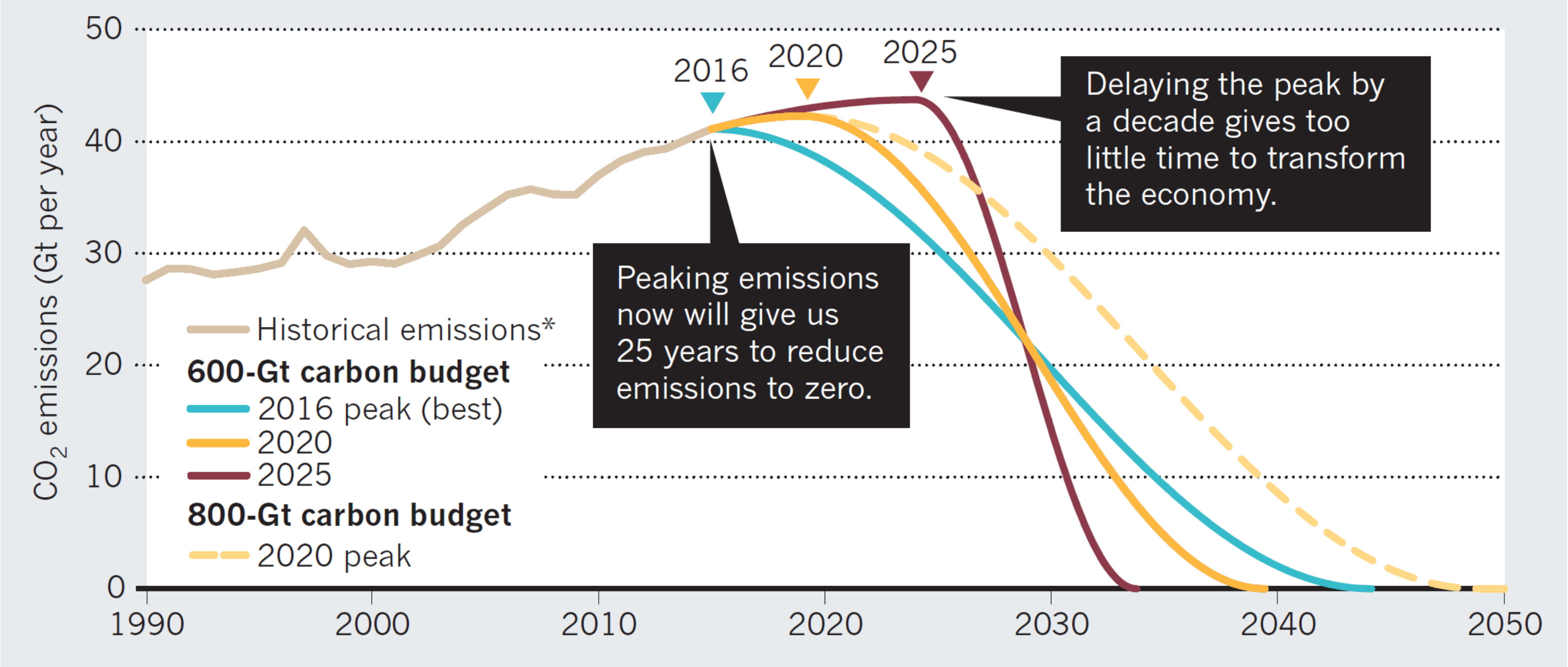
How much more GHG can we emit within COP21 temperature limits?

66% probability of staying within 2ºC: limit total GHG emissions between 2011- 2100 to 1000Gt (Intergovernmental Panel on Climate Change)

At current emission rate (41 Gt/ann) – only 24 years to reach this limit

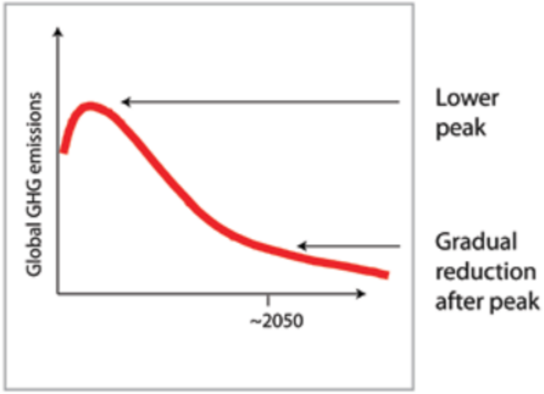
Figueres et al (2017) estimate only 600 Gt GHG capacity: *15 years of emissions at current rate*

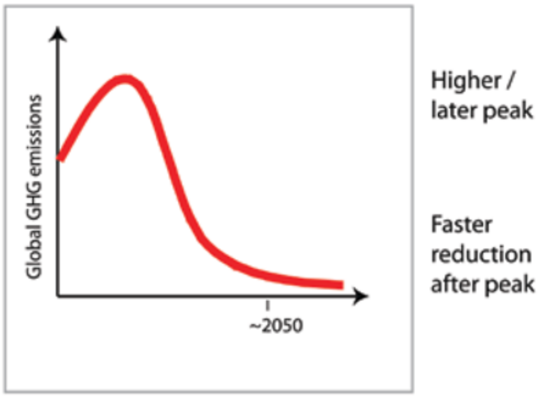
Annual emissions need to peak soon and drop sharply: *longer the delay steeper the decline*

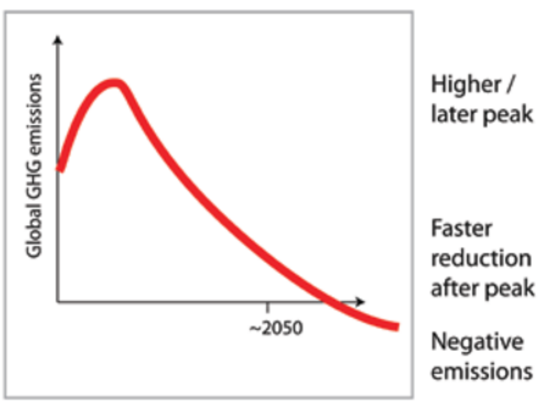


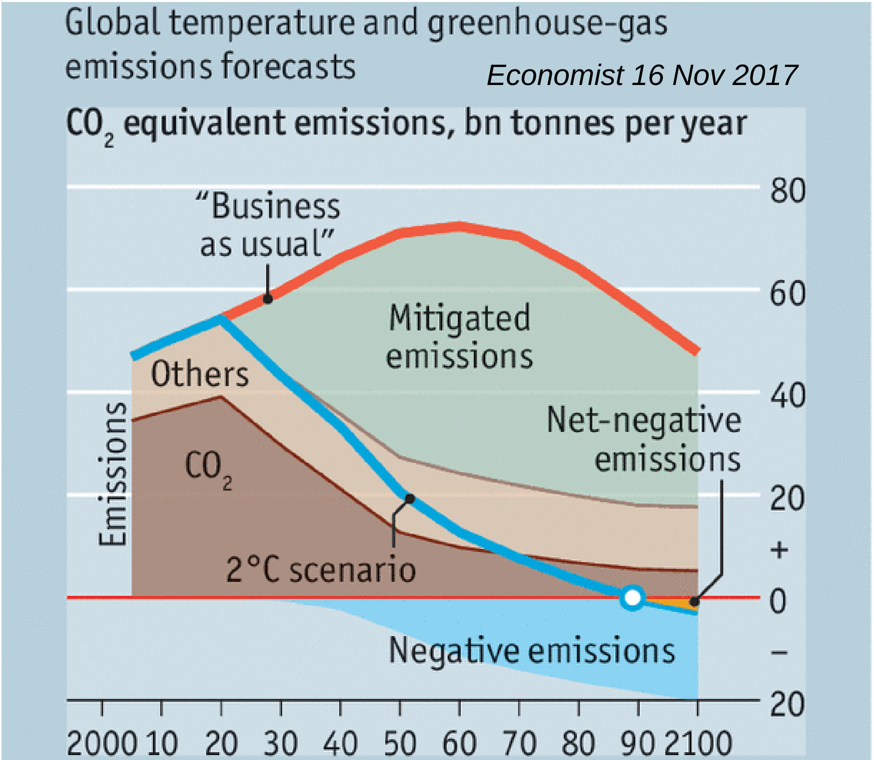
Source: Figueres et al, *Nature* June 2017

Over-shooting carbon budgets – *reliance on negative emissions*



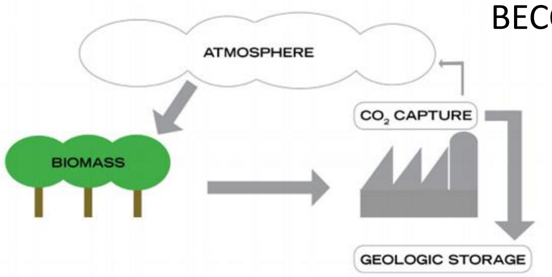






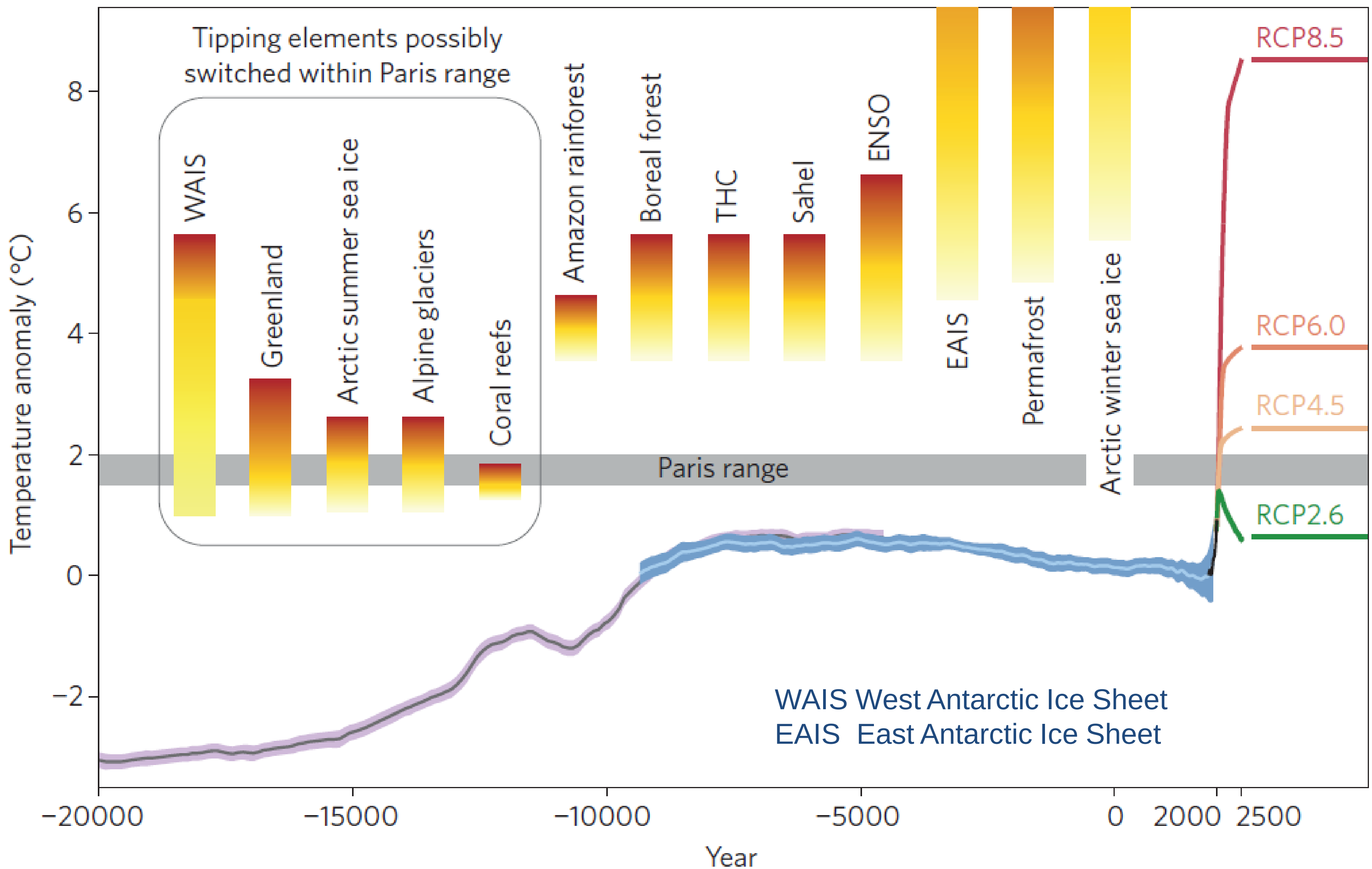
Bio-energy with carbon capture and storage

BECCS



'negative emission technologies may have a useful role to play but, on the basis of current information, not at the levels required to compensate for inadequate mitigation measures' (EASAC, 2018)

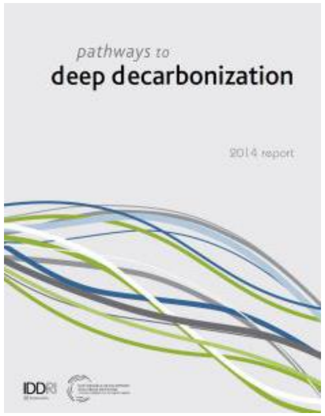
Risk of crossing climatic, geophysical and ecological tipping points as average global temperature increases

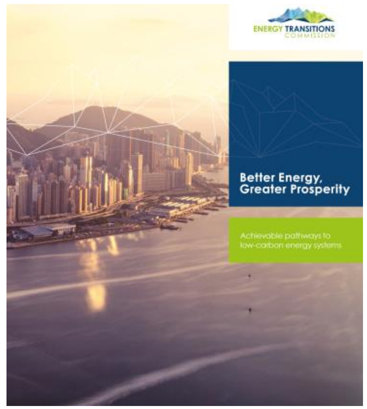


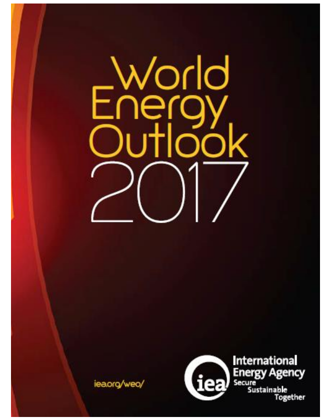
Source: Schellnhuber et al, 2016

Contribution of Logistics to Climate Change

- Freight transport 7-8% of energy-related CO_2 emissions
- Freight transport responsible for round 90% of all logistics emissions
- Little data on '*logistics buildings*' around 10-12% of logistics emissions



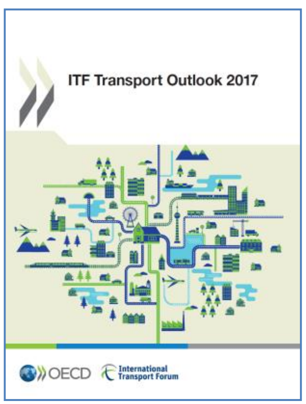




a '*hard to mitigate sector*'

Heavy dependence on fossil fuel

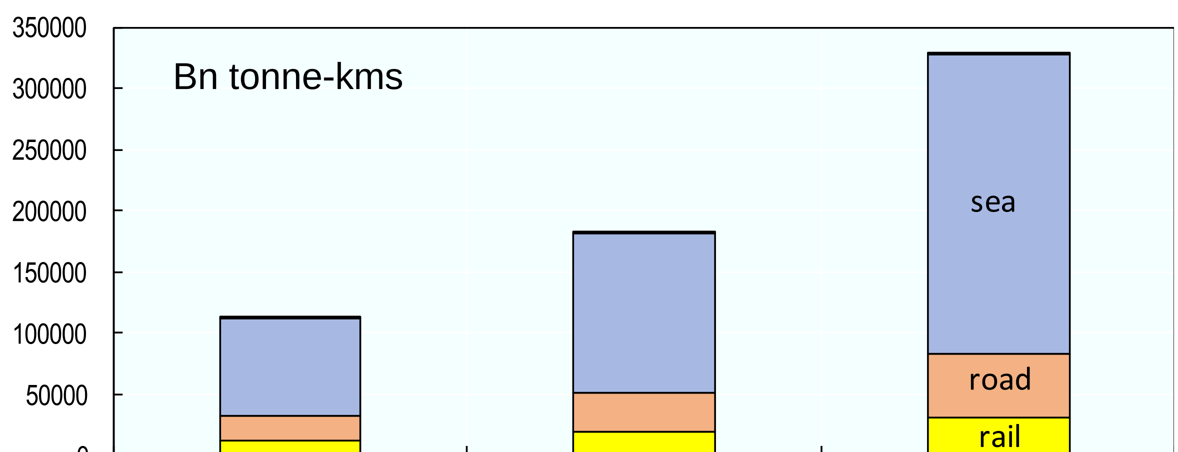
High forecast growth rate



OECD / ITF Transport Outlook (2017):

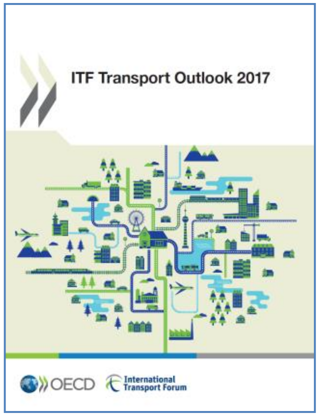
3x increase in freight tonne-km between 2015 and 2050

Freight transport emissions would rise from 3.2 to 5.7 Gt CO_{2e}

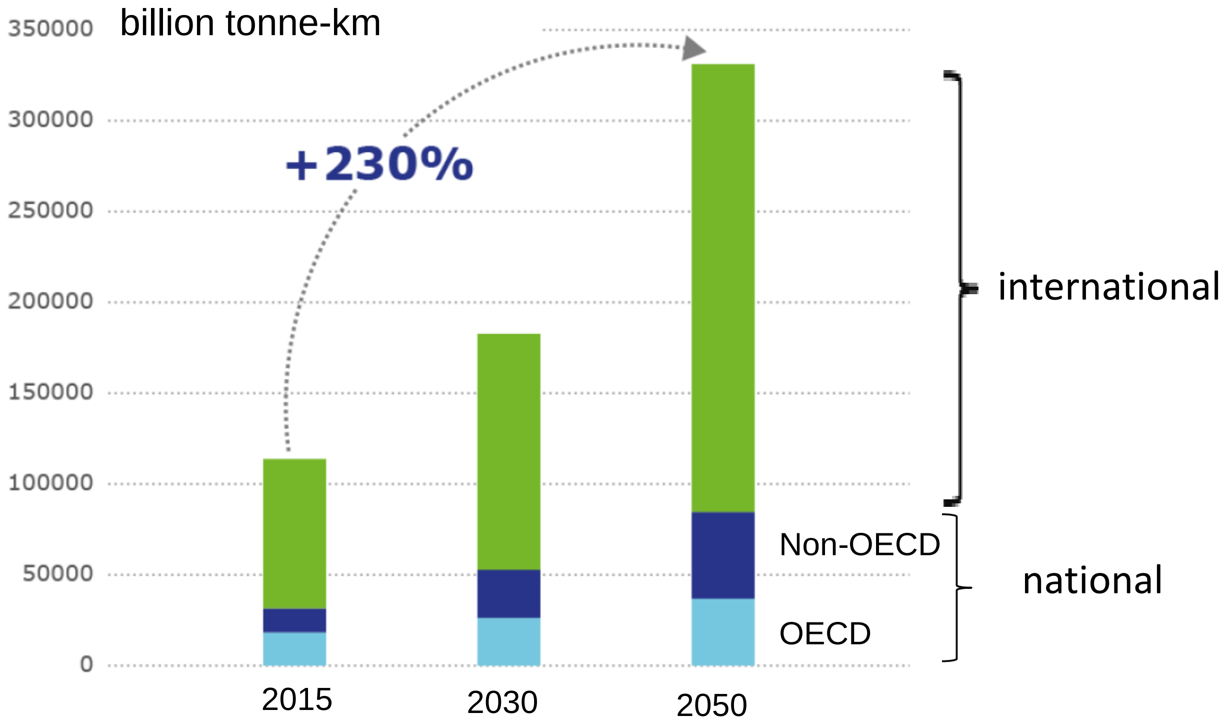


International Transport Forum Projections

Compound annual growth rates 2015-2050



Compound annual growth rate 2015-50	
GDP	2.5%
Freight demand	3.1%
Rail	2.6%
Road	2.8%
Aviation	5.4%
Sea	3.3%



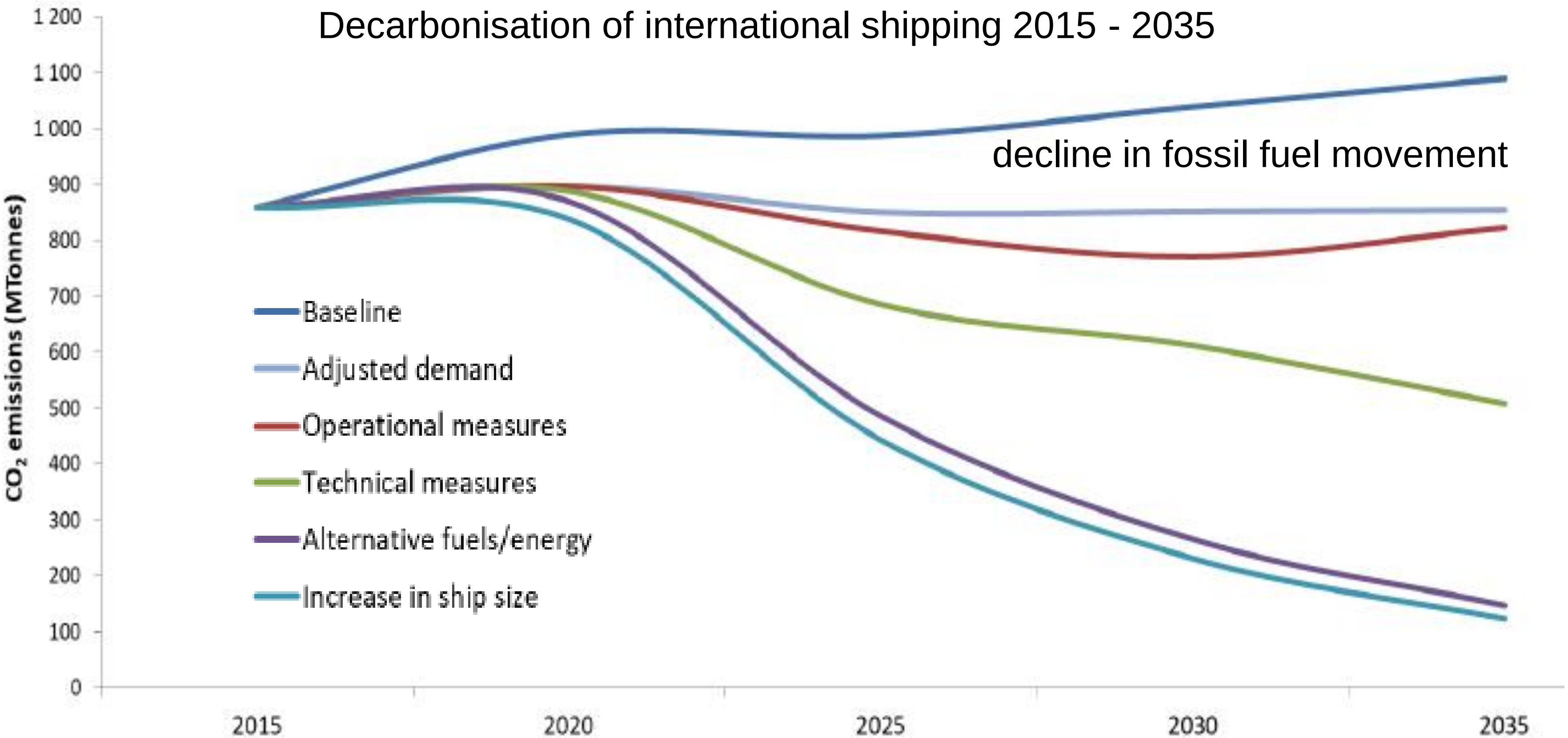
Source: ITF (2017) Transport Outlook

IMO Targets for Reducing GHG Emissions from Shipping

50% reduction in GHG emissions between 2008 and 2050

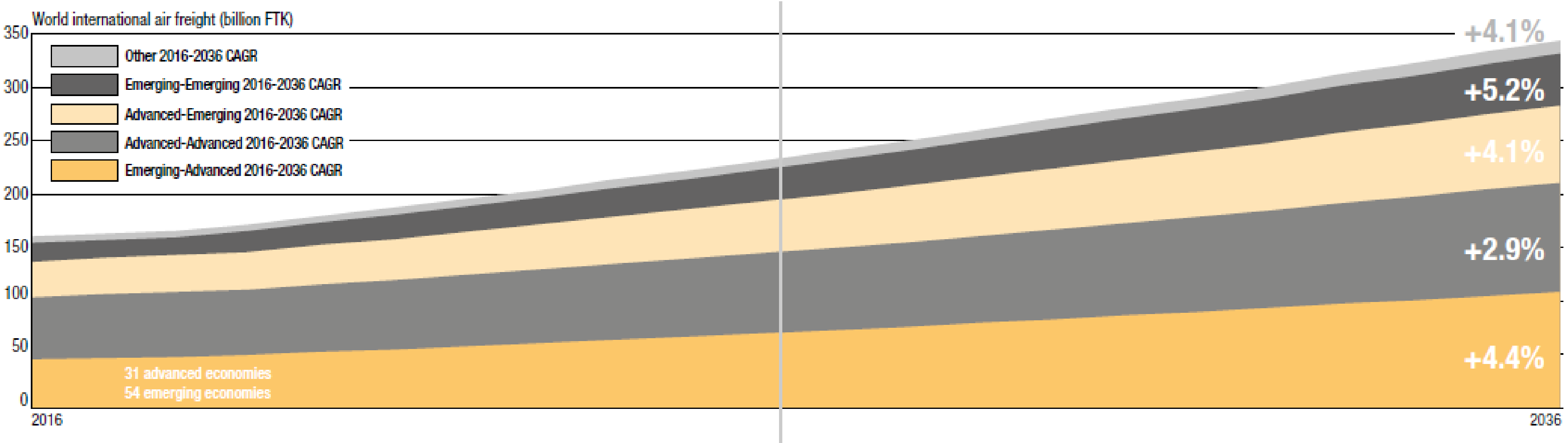
70% reduction in '*CO_2 emissions per transport work*'

'phase them out, as soon as possible in this century'.



Source: ITF (2018)

Forecast growth in air freight



Airbus (2017): Global Market Forecast 2017-2036

3.8% per annum growth in air cargo traffic (freight tonne-kms) between 2016 and 2036

Air cargo in the bellyholds of passenger aircraft to rise from 52% (2016) to 61% (2036)

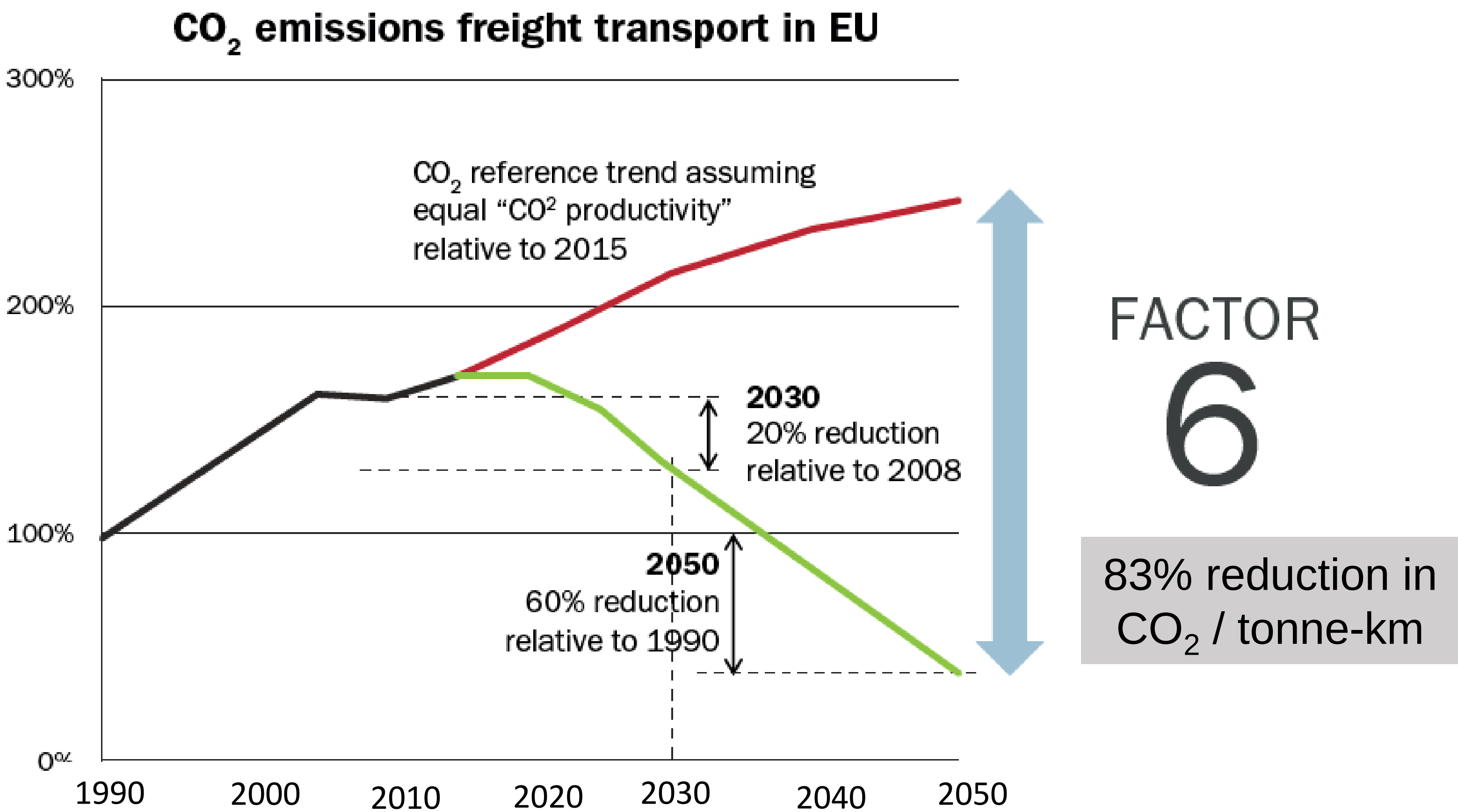
CO_2 emissions at high altitude 2-4 times more damaging (radiative forcing)

Aviation is exempt from fuel taxes

ICAO (2016): Carbon neutral air traffic growth after 2020 – mainly by carbon offsetting

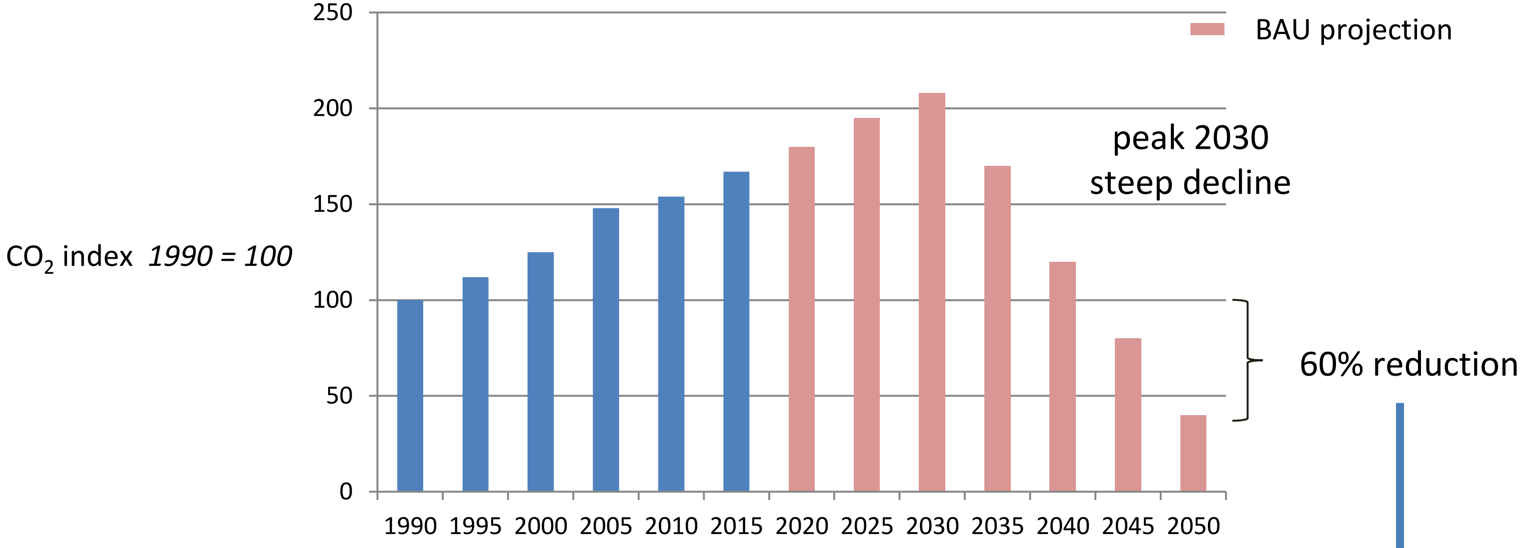
Meeting EU 2011 Transport White Paper CO_2 Target for 2050

Reduction in carbon intensity need to achieve 60% cut in total freight-related emissions

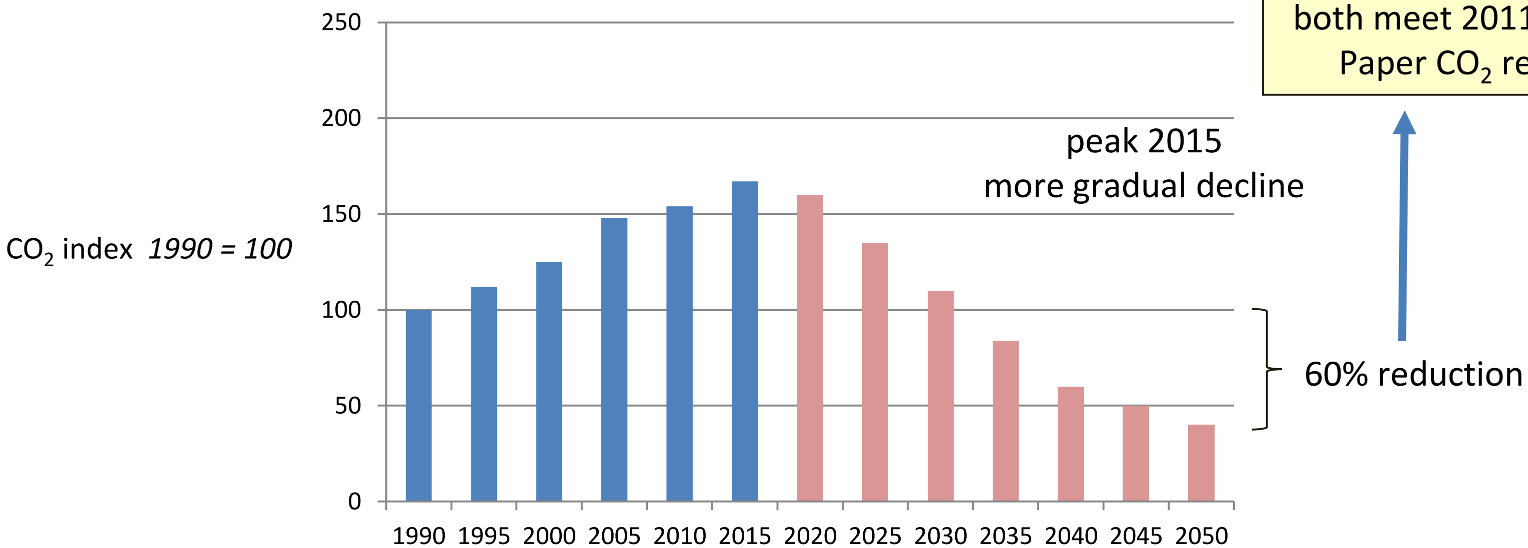


Source: Smokers et al. (2017). *Decarbonising Commercial Road Transport*. Delft: TNO.

CO_2 emission reduction profiles for European freight transport



both meet 2011 Transport White Paper CO_2 reduction target



cumulative emissions 2015-2050: 34% lower

Deriving carbon reduction targets for logistics

corporate carbon intensity targets vs governmental absolute carbon reduction targets

SCIENCE BASED TARGETS
DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

Freight is in the residual 'Other transport' category

14% TRANSPORT

Other transport	Other transport
Aviation	Aviation
Rail passenger transport	Rail passenger transport
Heavy road passenger transport	Heavy road passenger transport
Light road passenger transport	Light road passenger transport

SBT team could find '*no activity information*' for freight in the IPCC and IEA reports – relied on monetary surrogates

Definition of Trucking
'*Companies providing primarily goods and passenger land transportation Includes vehicle rental and taxi firms.*'

Need ambitious short, medium and long term targets

Preferably based on bottom-up, time-phased analysis

Deutsche Post DHL Group commits to zero emissions logistics by 2050

- Ambitious interim goals for carbon efficiency, local emissions, green customer solutions and employee engagement by 2025
- Previous climate protection target achieved ahead of schedule
- Frank Appel: "The decisions we make today will determine how our children live 30 years down the line."

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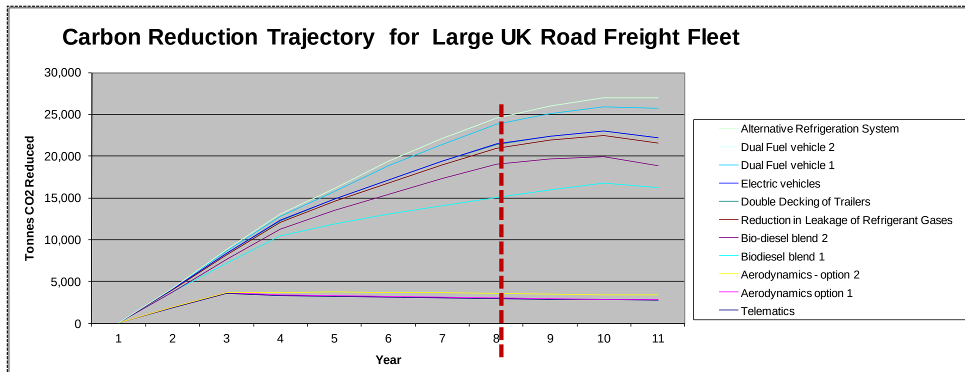
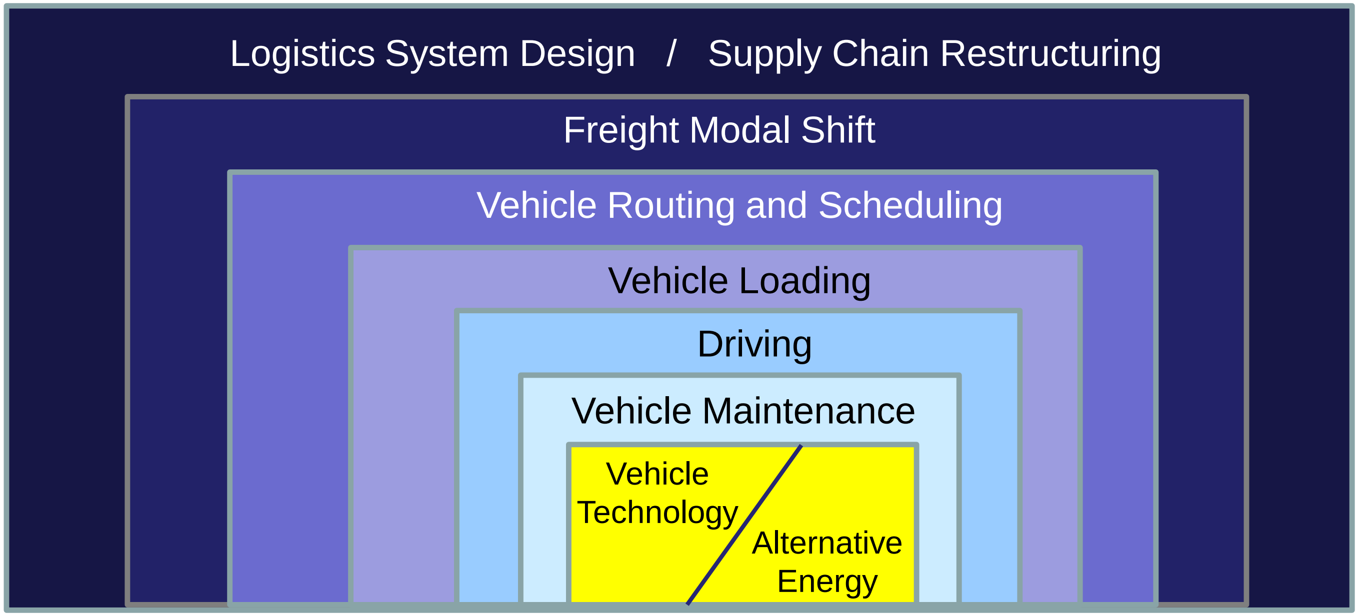
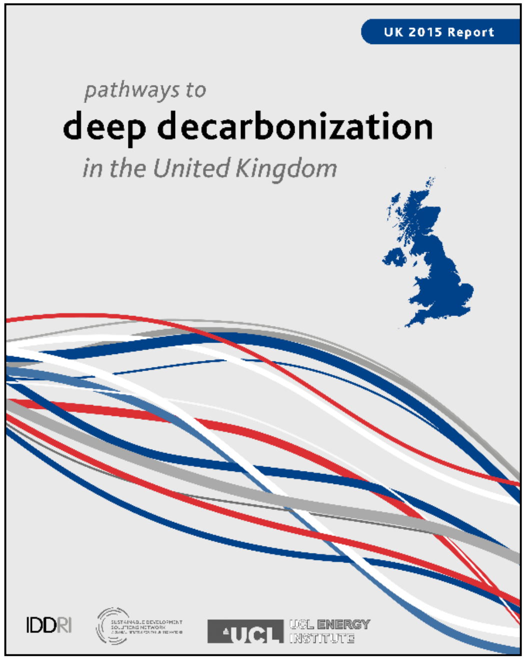
Deutsche Post DHL Group, the world's



Beware: not all decarbonisation measures are mutually-reinforcing and cumulative

Scoping the Decarbonisation of Freight Transport

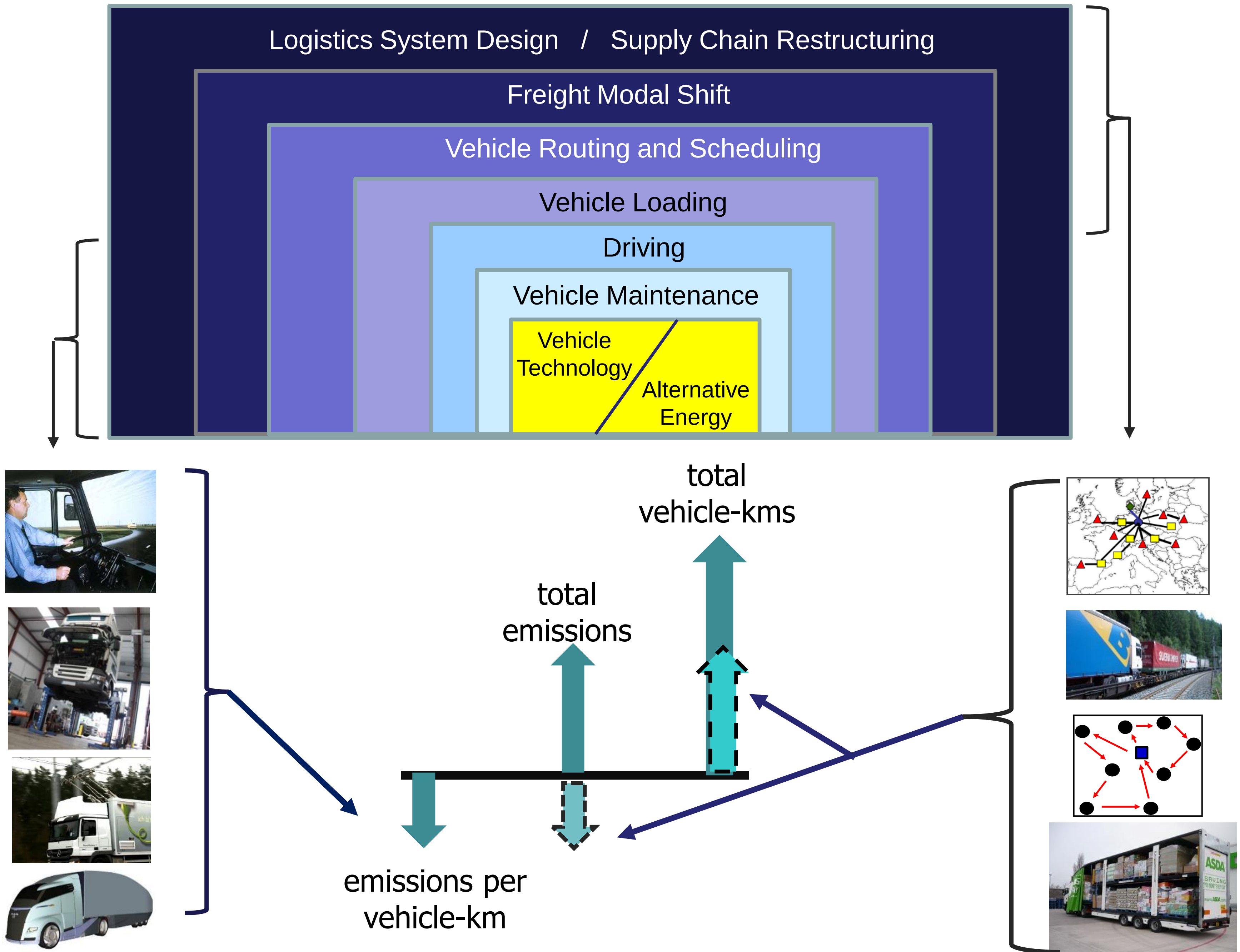




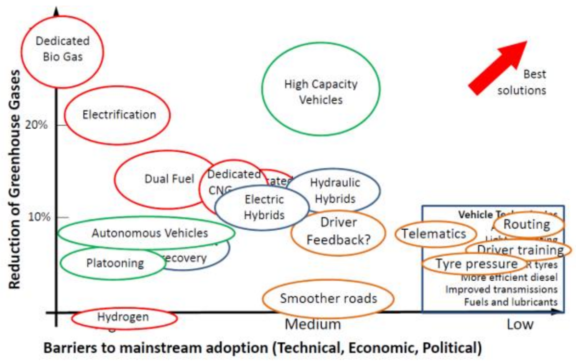
decarbonisation of UK road freight to be ‘*based on a shift to hydrogen-fuelled vehicles in the long term, with compressed natural gas (CNG) vehicles playing an important transitioning role*’.

vehicle and fuel school of logistics decarbonisation

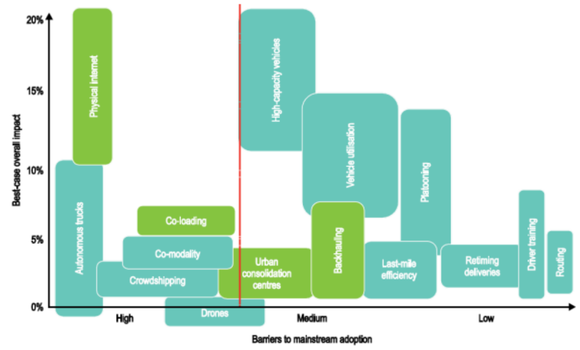
Scoping the Decarbonisation of Freight Transport



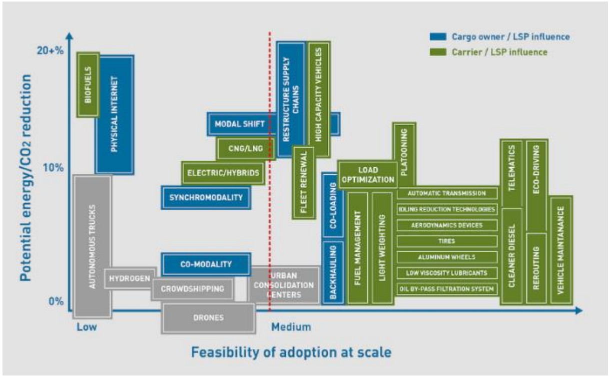
Road freight decarbonisation measures: *abatement – implementation graphs*



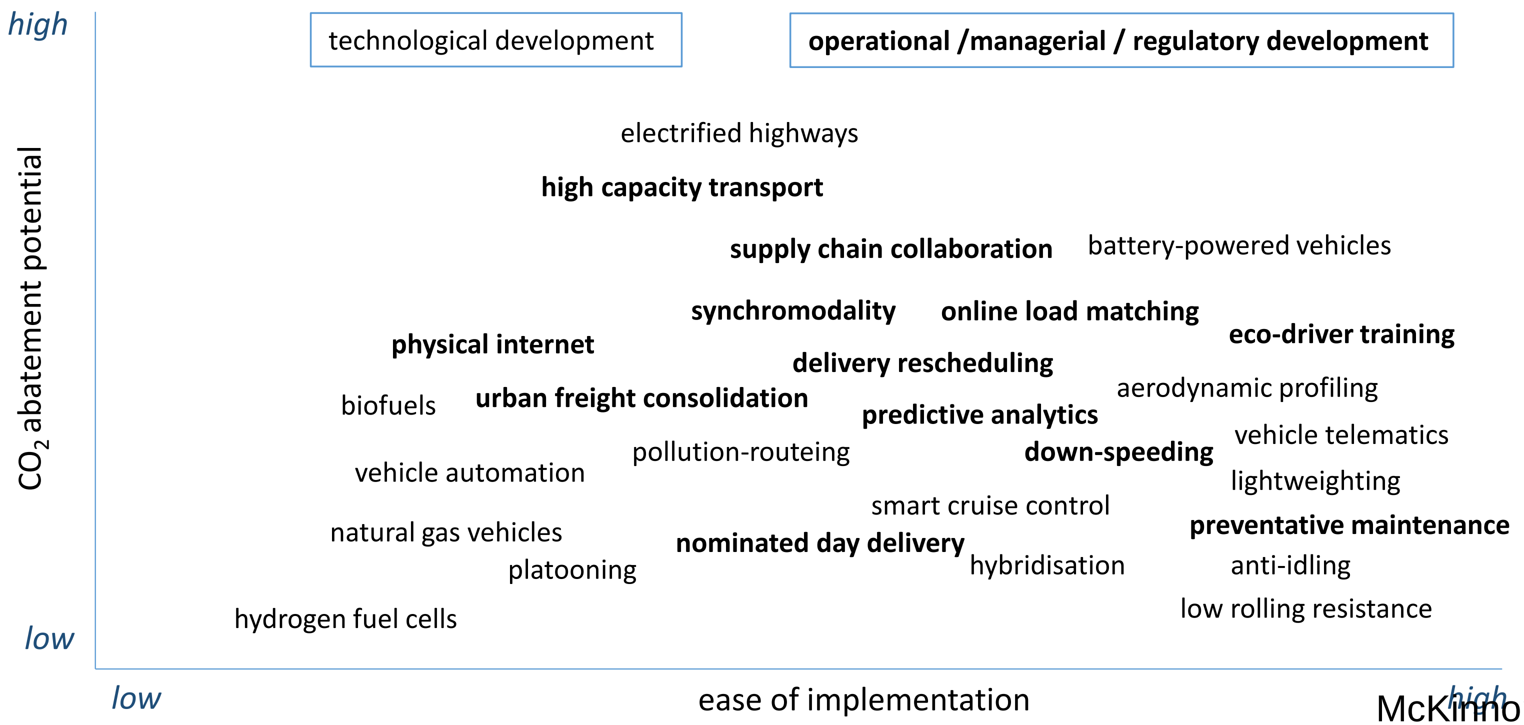
Professor Cebon



International Energy Agency

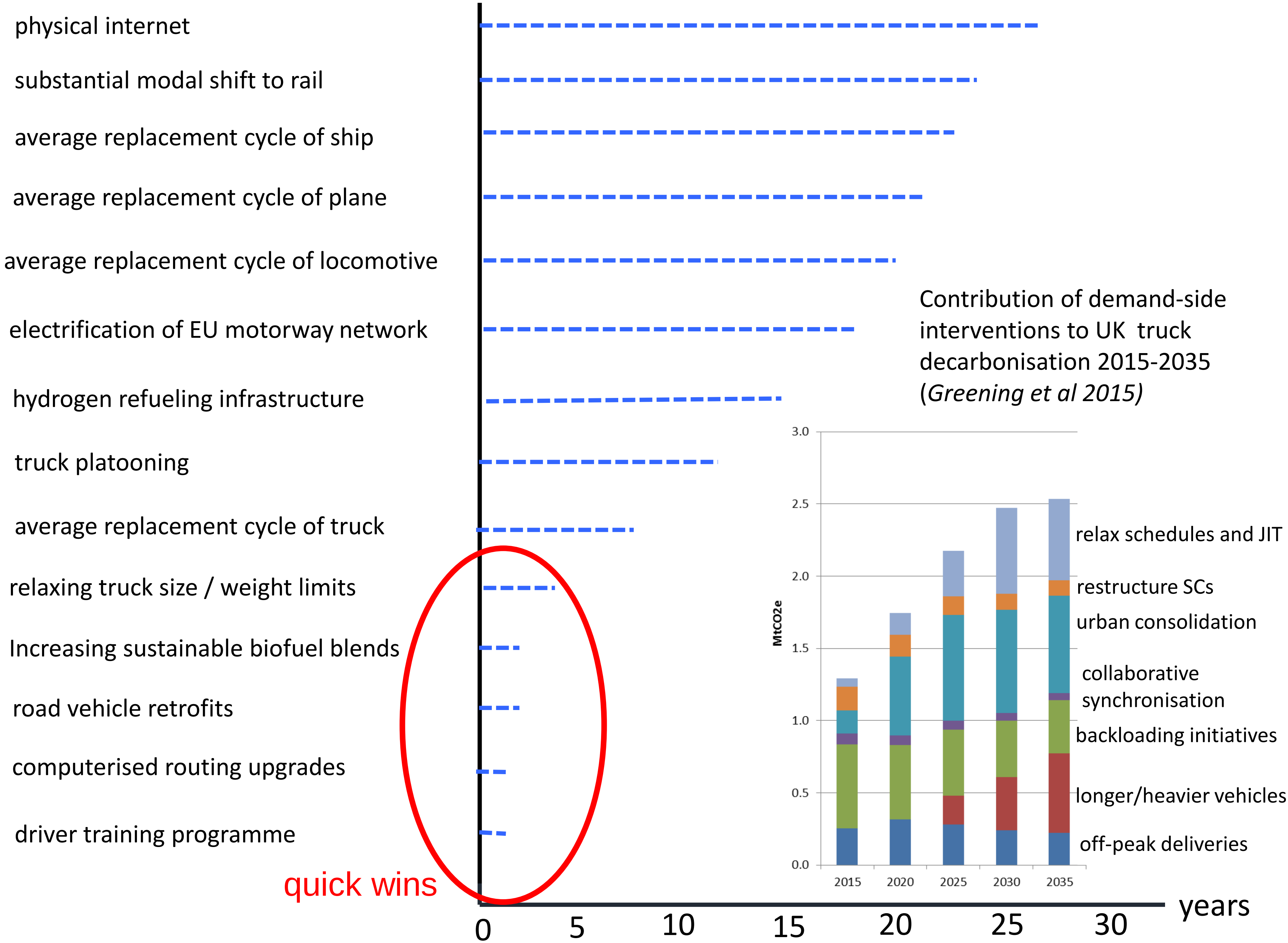


Smart Freight Centre



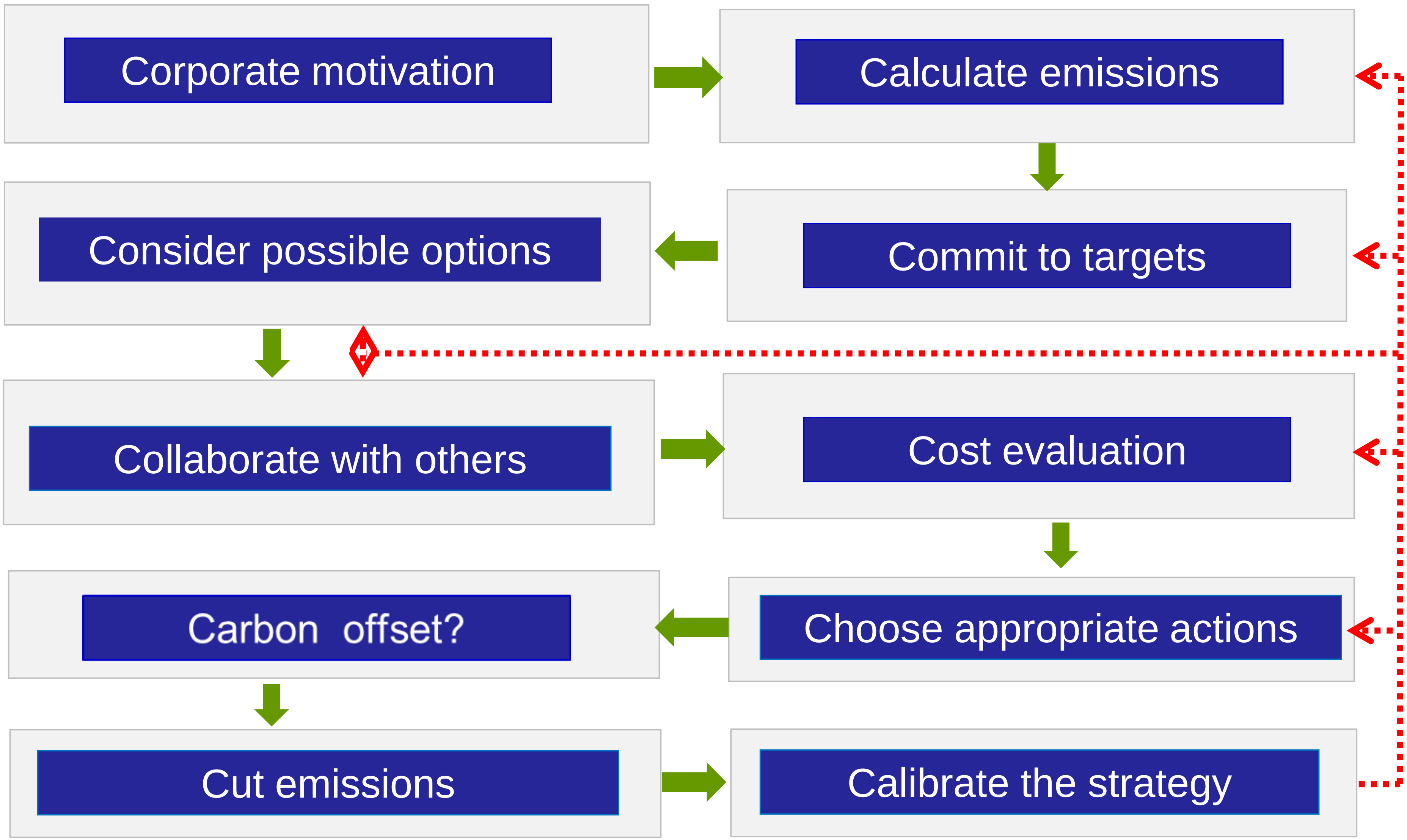
McKinnon (2018)

Time Dimension in Logistics Decarbonisation



Developing a Decarbonisation Strategy for Logistics

10 C approach



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

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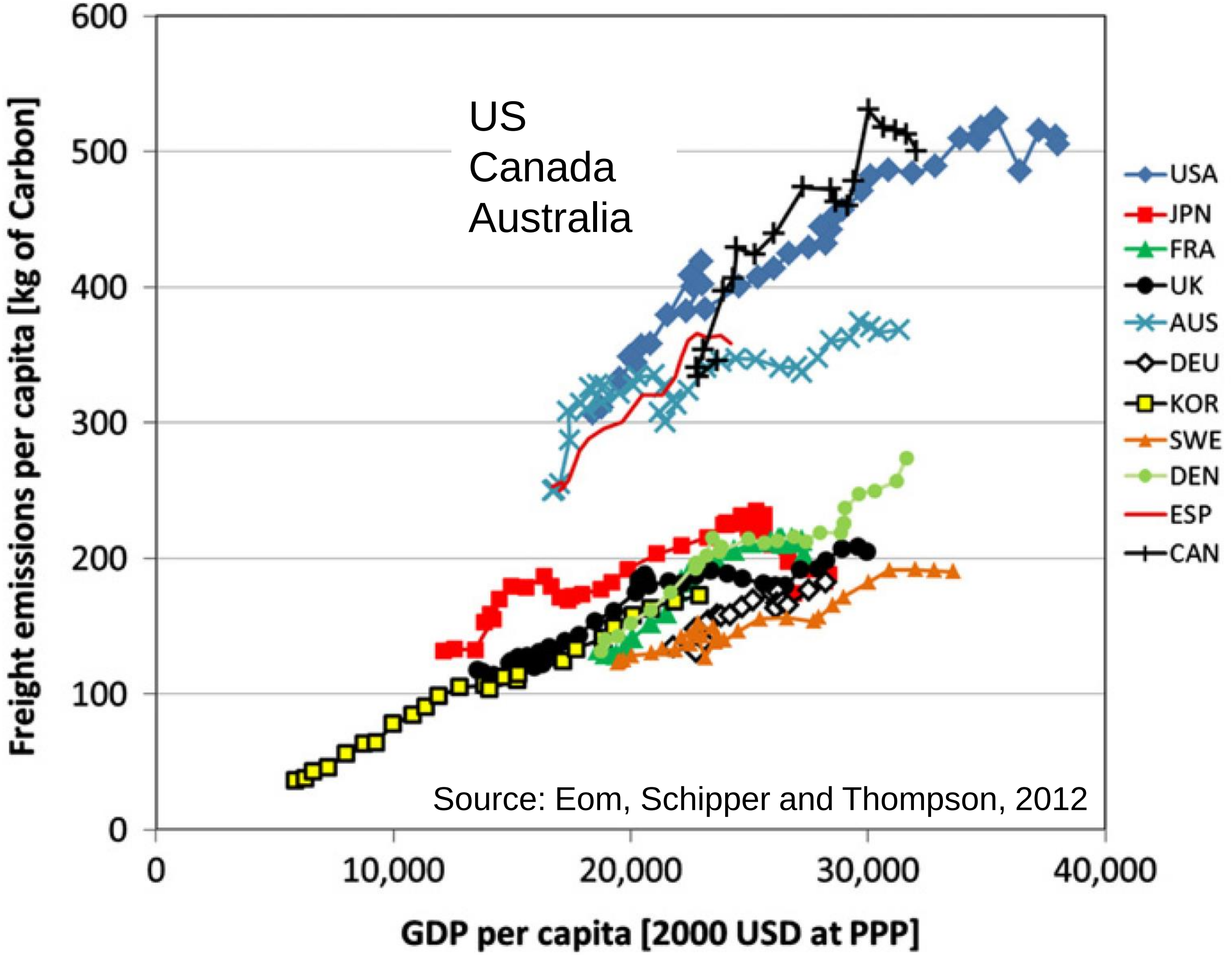
Economic Growth Increases Freight Transport Emissions per Capita



Global population projected to rise from 7 to 9 billion between 2010 and 2050

Restrain the Growth in Demand for Freight Transport

‘De-growth’ – reaching ‘*peak stuff*’?

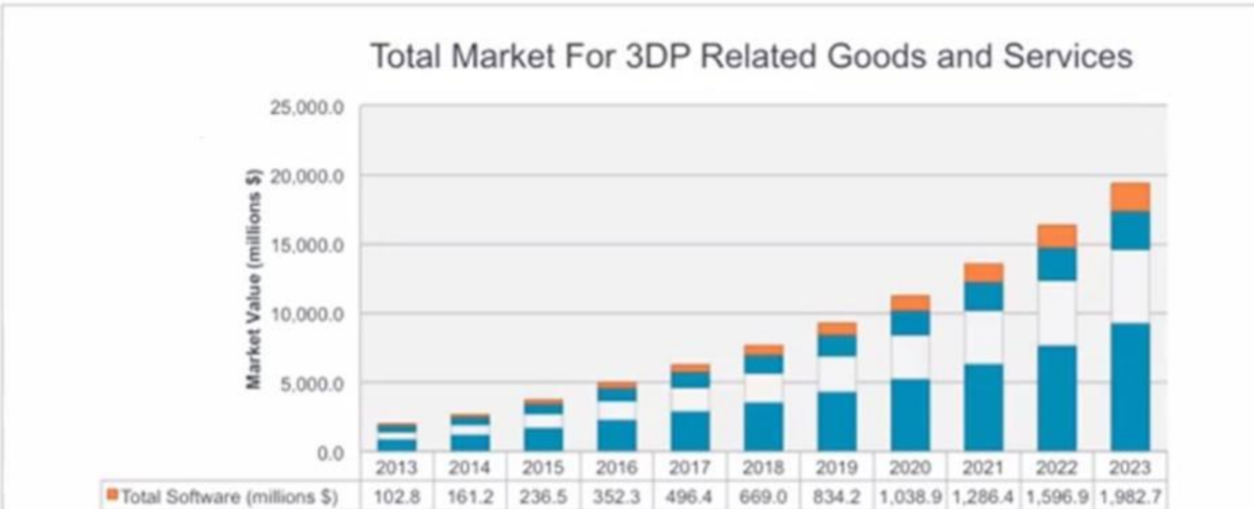
– substitute experiences for physical goods

– need to constrain consumption?

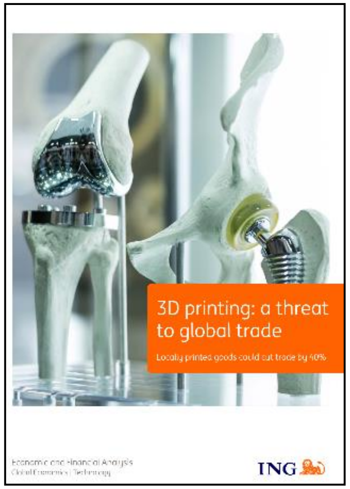
Dematerialisation: improve ‘*material efficiency*’:

- Increase modularisation and remanufacturing: *circular economy*
- Digitisation of physical products: *consignments to electrons*
- Designing products with less material: *miniaturisation, lightweighting*
- 3D Printing: *less material, less wastage, eliminating supply chain links*

3D Printing – supply chain impacts?



Adidas to mass customise soles of training shoes using 3D printing in German factory



Scenario 1: by 2040
50% of manufacturing
25% less world trade

Scenario 2: by 2060
50% of manufacturing
25% less world trade

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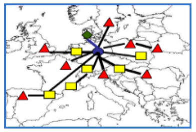
Restructuring of supply chains



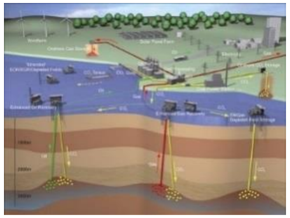
- relocalize production / sourcing
- decentralize inventory
- reversal of key business trends
- high carbon-mitigation costs

Fossil fuel phase-out

- 60% of trade in raw materials
- G7 fossil-fuel free by 2100
- Constructing renewable energy infrastructure is material- and transport-intensive

New freight growth sectors?

carbon capture and storage



air conditioning

adaptation of infrastructure to climate change

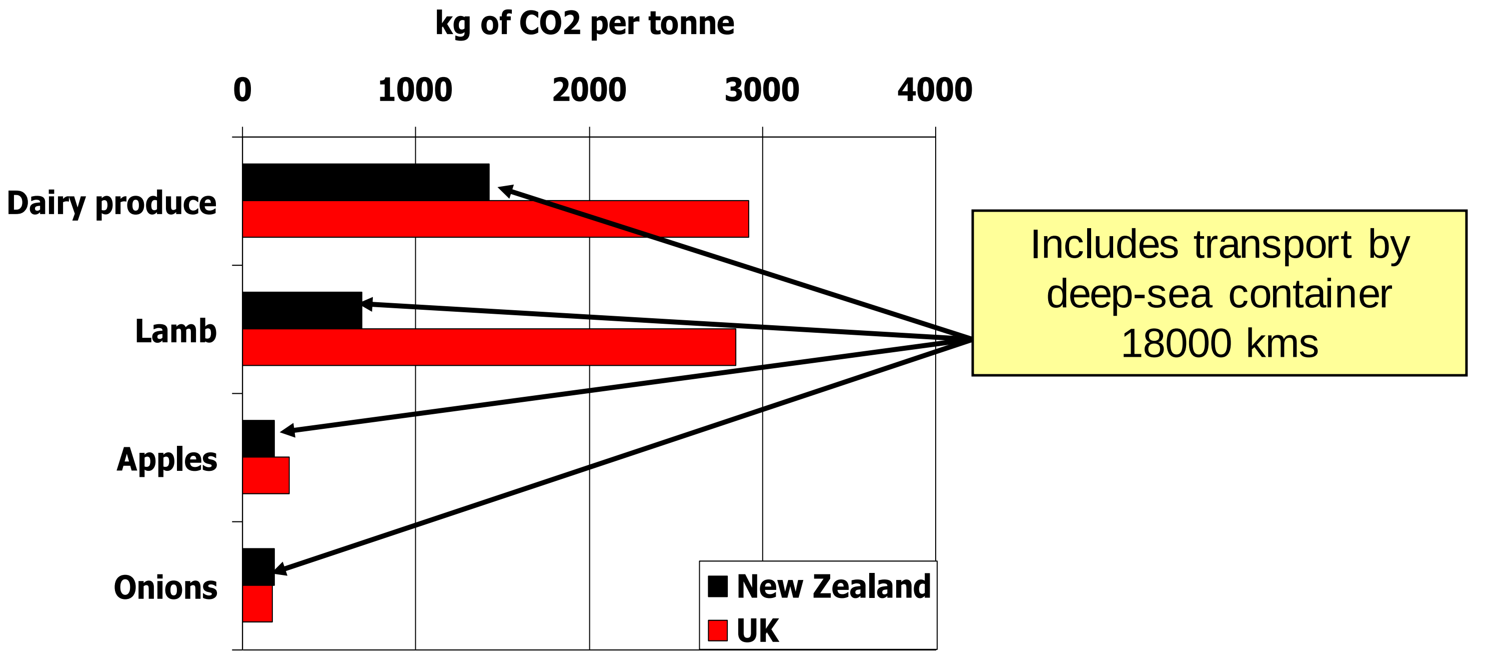
resettlement of populations

Reversing globalisation for environmental reasons?

- Negative effect on economic development, especially in emerging markets
- May not yield environmental benefits:

Local sourcing of food from UK or importing it from New Zealand?

New Zealand agriculture emits less greenhouse gas per tonne of product



Source: Saunders, Barber and Taylor, 2006

Minimising distances freight is moved will not necessarily minimise environmental impacts on a full life cycle basis

Objective is not to decouple freight volumes from GDP but rather to decouple freight-related externalities from GDP

To Cut Carbon Emissions Should We Return to Decentralised Warehousing?

Potential CO_2 Benefits from Inventory Centralisation:

Lower inventory levels:

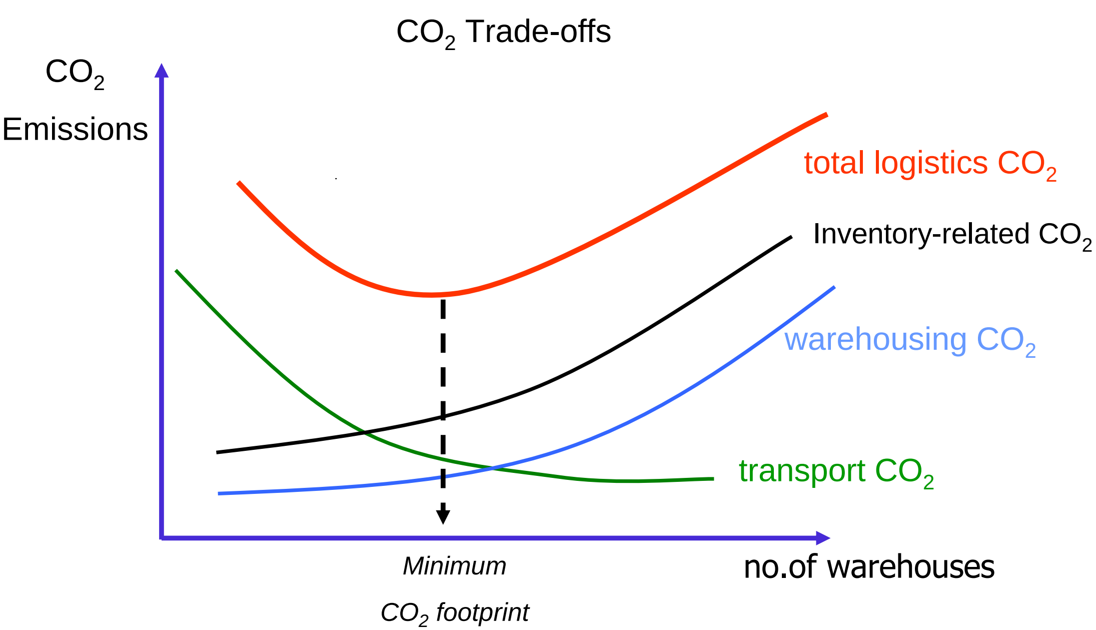
- *less energy use in storage*
- *less wastage of product*

Less warehouse space required:

- *less CO_2 in construction, operation and maintenance*

Larger warehouses can be more energy efficient:

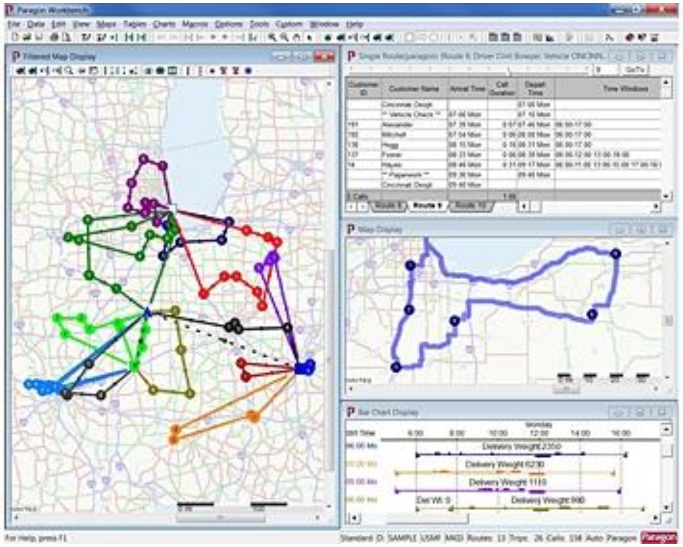
- *emit less CO_2 per unit of throughput*



ultra-low / zero carbon

warehousing and materials handling equipment by 2030?

Optimising Vehicle Routeing



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

Yields economic and environmental benefits – *‘win – win’ option*

No adverse impact on economic development

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

Widely adopted technology in developed countries but low levels of market penetration in emerging markets

CVRS being upgraded as vehicles becoming more intelligent and connected – *dynamic re-routing of vehicles*

Big Data and use of predictive analytics enabling carriers like UPS to increase efficiency of delivery
– customer service, cost and service benefits

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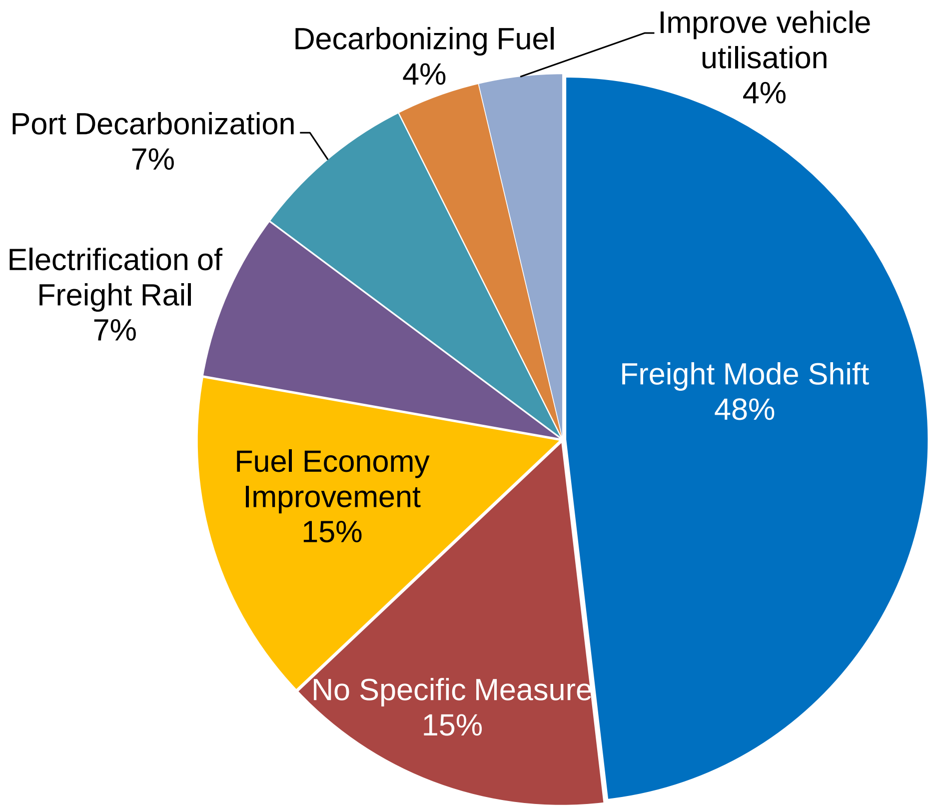
Climate Change Mitigation Measures Specified for Freight in INDCs

Content of 158 INDCs for185 countries analysed
43% explicitly refer to passenger transport
13% explicitly refer to freight transport

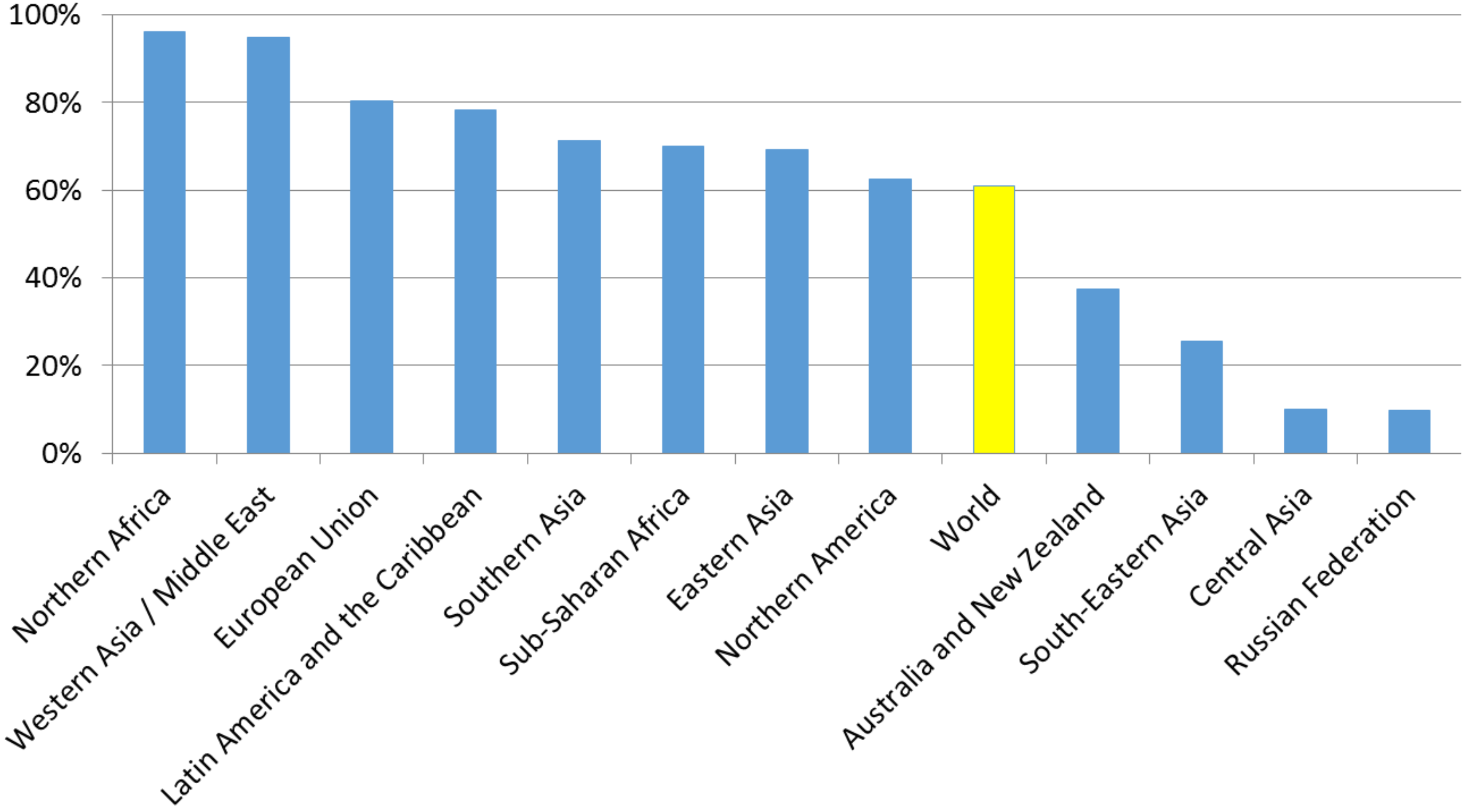
Analysis by Sudhir Gota

% of INDCs specifying particular green freight measures



Under-estimating potential for decarbonising road freight and the inter-relationship between road efficiency gains and modal split

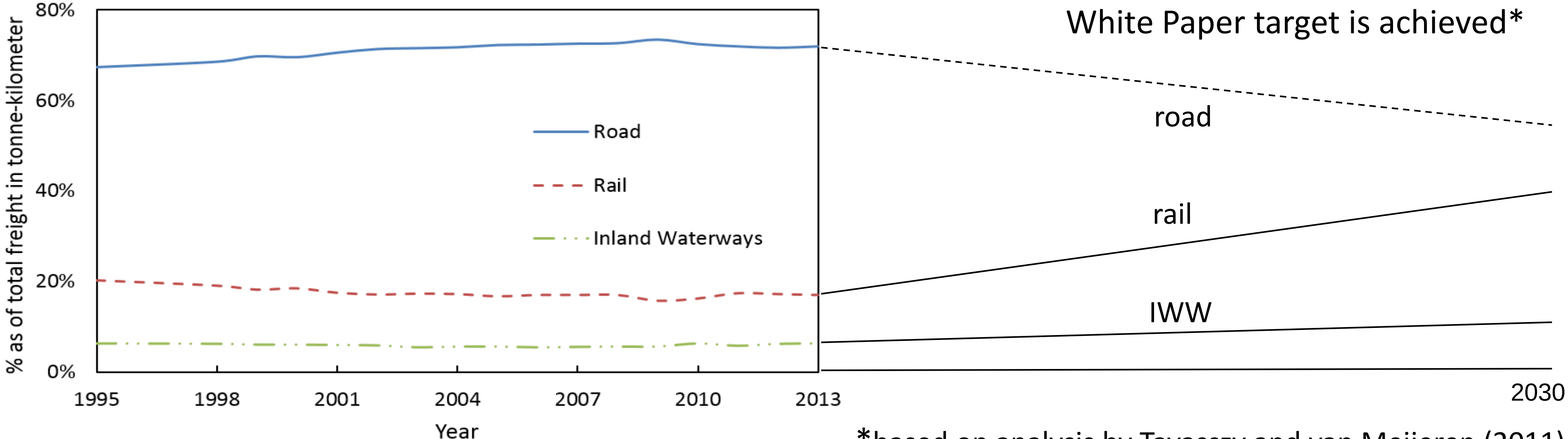
International variation in surface freight modal split:
road share of road-rail freight tonne-kms



Source: UN Statistics Division (2017)

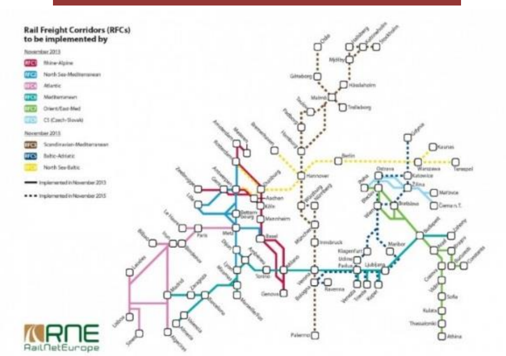
Prospects of a Major Modal Shift in Europe?

2030 modal shares if EU 2011 White Paper target is achieved*



*based on analysis by Tavasszy and van Meijeren (2011)

strategic corridors



intermodal hubs

Synchromodal scheduling

	Location	Cost	Travel time	Distance	Transportmode
1	Karlsruhe Industriegebiet	0.00	10:16	0.0	TM_ROAD
2	Wörth am Rhein Hafen	63.00	10:58	29.5	LOAD_ROAD_RAIL
3	Wörth am Rhein Hafen	63.00	2 16:00	29.5	TM_TTN_RAIL
4	Hamburg CTB Burchardkai	301.00	3 14:15	722.5	LOAD_RAIL_SHORTSEA
5	Hamburg CTB Burchardkai	301.00	7 17:00	722.5	TM_TTN_SHORTSEA
6	Moss Container Terminal	400.00	10 09:00	1,564.5	LOAD_SHORTSEA_ROAD
7	Moss Container Terminal	400.00	10 09:30	1,564.5	TM_ROAD

Wider supply chain application of synchromodality principle

Decline in coal and oil traffic

Change in rail freight commodity mix

Need to redefine modal shift target: *choice of metrics*

differing rates of modal decarbonisation

reducing the carbon benefits of switching mode?

Five Sets of Decarbonisation Initiatives for Freight Transport

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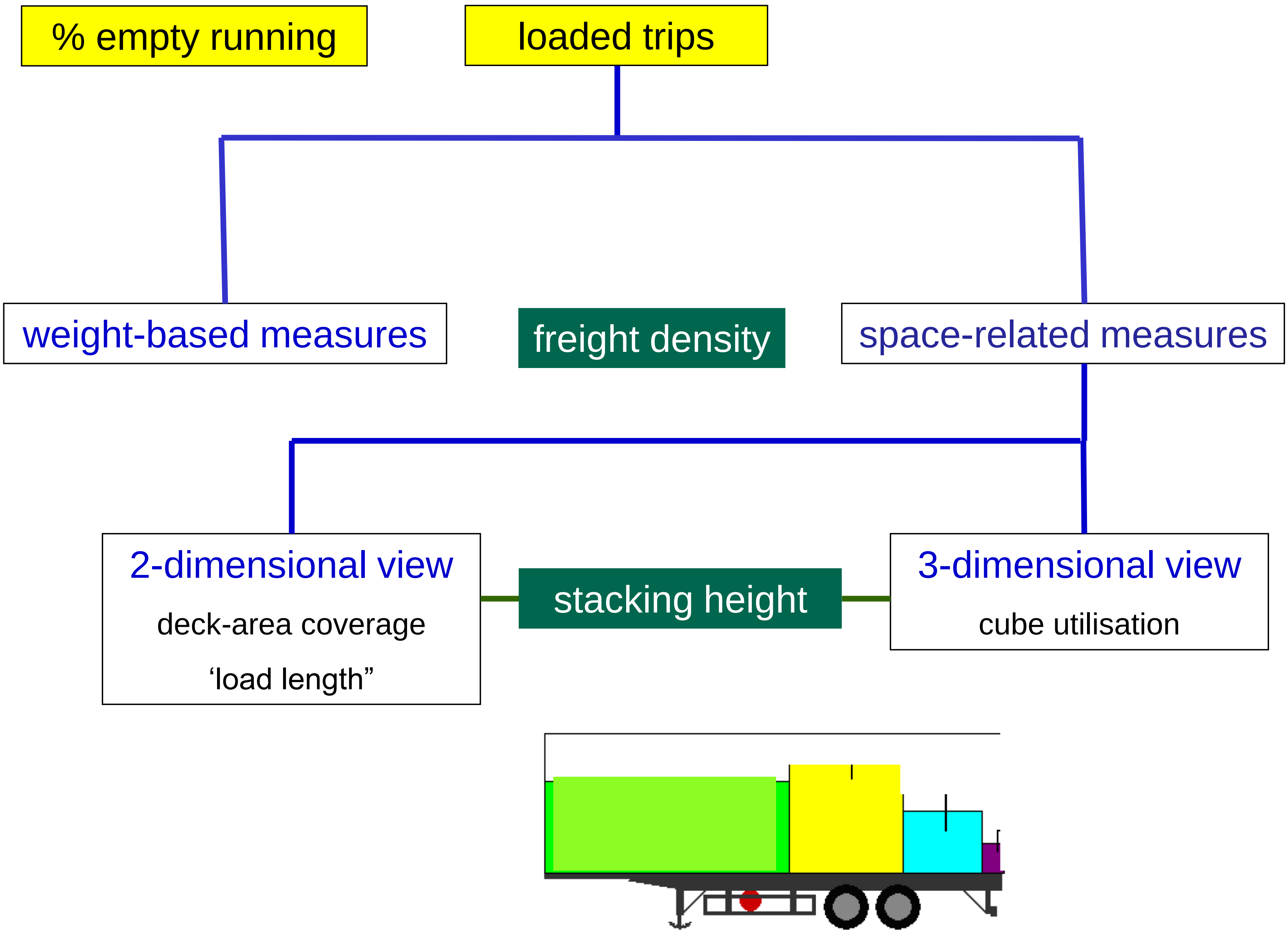
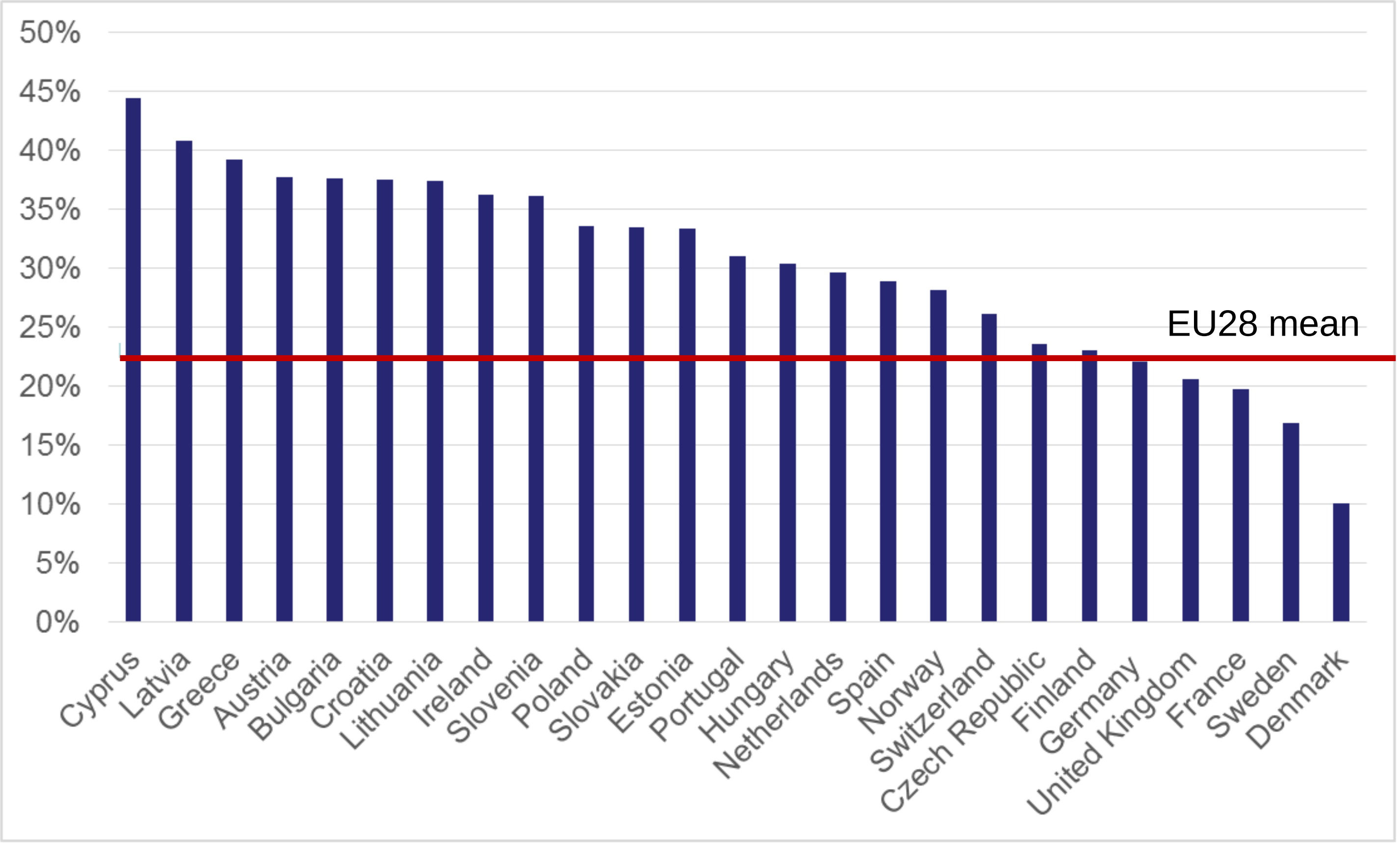
- Reduce the Carbon Content of Freight Transport Energy

Measurement of Vehicle Utilisation: *key parameters*



% of Truck-kms Run Empty in EU Countries, 2016



Source: Eurostat, 2017

Improving Vehicle Utilisation

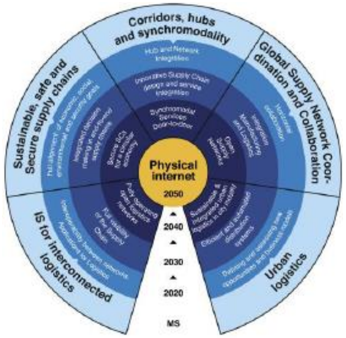
Constraints on loading

- **Demand fluctuations**
- **Uncertainty about transport requirements**
- **Geographical imbalances in freight flows**
- **Limited knowledge of backloading opportunities**
- **Vehicle size and weight restrictions**
- **Unreliable delivery schedules**
- **Just-in-Time delivery**
- **Nature and size of packaging / handling equipment**
- **Limited storage capacity at destination**
- **Incompatibility of vehicles and products for backloading**
- **Poor coordination of purchasing, sales and logistics**

Online freight procurement

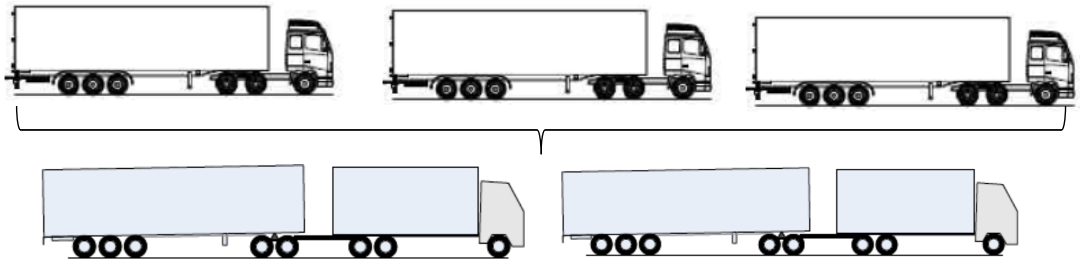
High capacity transport

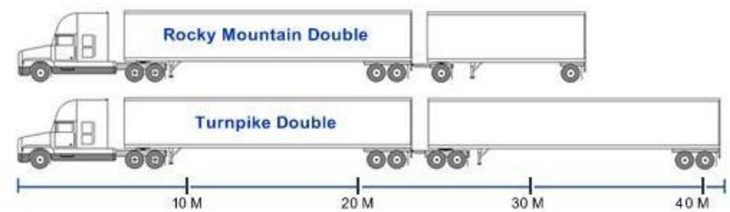
Logistical collaboration



Physical internet

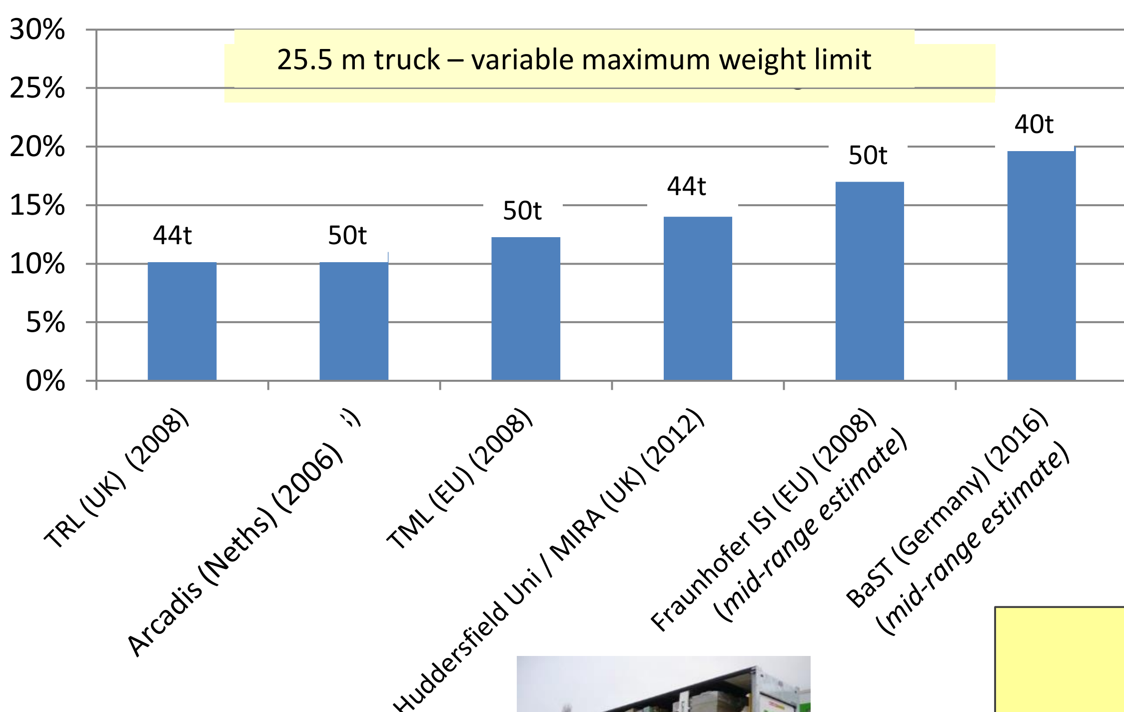
Raise Truck Size and Weight Limits – *within infrastructural constraints*

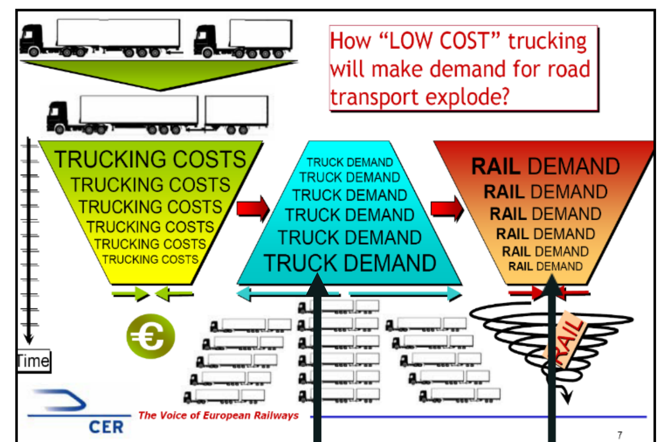




2 truck for 3 substitution: load consolidation → reduced energy use and emissions per tonne-km

% reduction in carbon intensity against baseline vehicle





assumed modal and cross-modal price elasticities?

freight modal shift
versus
road freight efficiency improvement

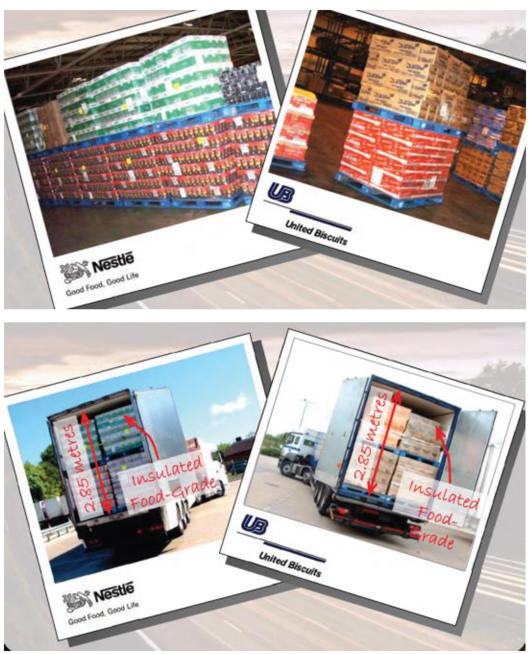
Conflict between freight decarbonisation strategies

Supply Chain Collaboration

examples

P&G and Tupperware (EU)

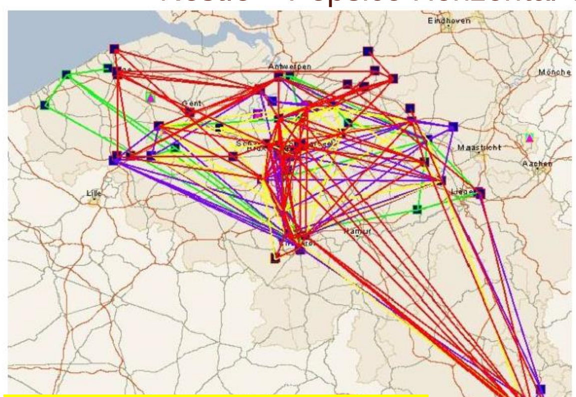
Nestle-United Biscuits (UK)

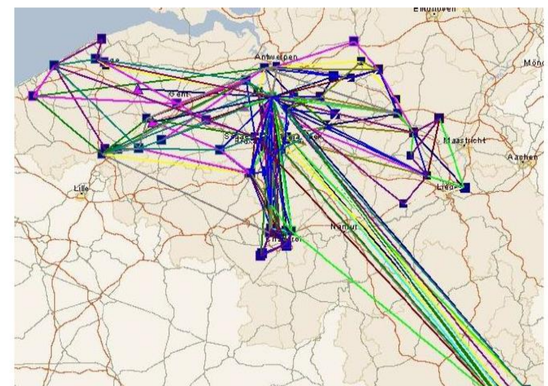


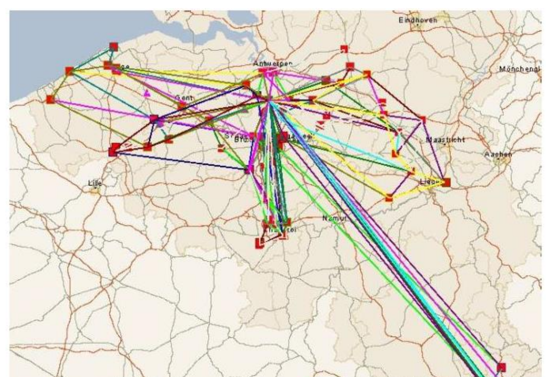
Deep decarbonisation of freight transport will require much greater sharing of logistics assets

- 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

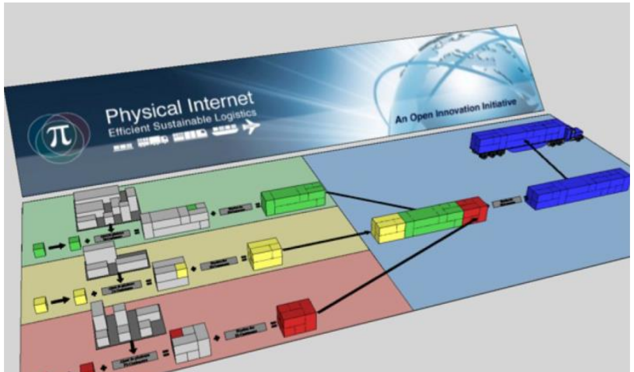

3. Collaborative synchronisation

	Kg CO_2 / tonne
1. Separate delivery	43.8
2. Groupage	27.3
3. Collaborative synchronisation	20.3

EU project: CO3

Source: Jacobs et al 2014

The Physical Internet



Source: Montreuil, 2012

applying the networking of principles of the internet to the physical movement of freight
Open, collaborative network with full visibility and incentivized asset sharing
'*Physical encapulation*' of goods in a new generation of modularised containers'

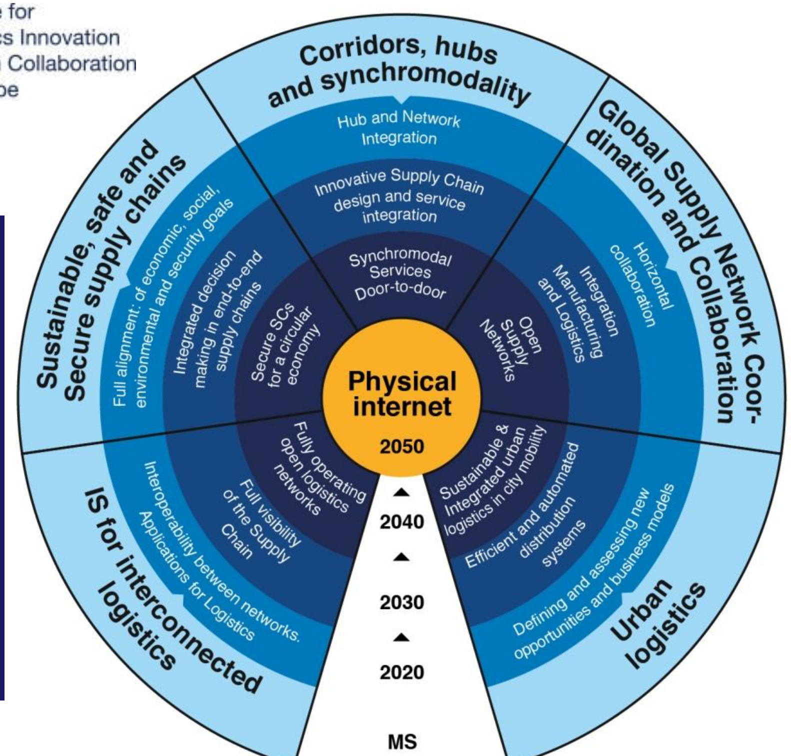
Physical Internet
Efficient Sustainable Logistics

alice | Alliance for Logistics Innovation through Collaboration in Europe

Vision for the future of logistics

Potentially large efficiency gains and CO_2 savings

Is it likely to be realized in time to meet carbon reduction targets?



Five Sets of Decarbonisation Initiatives for Freight Transport

Reduce Demand for Freight Transport

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Reduce the Carbon Content of Freight Transport Energy

Improve Energy Efficiency in the Freight Transport Sector

vehicle design: *new build + retrofits*

vehicle operation: *IT , training, monitoring*

eco-driver training

telematic monitoring

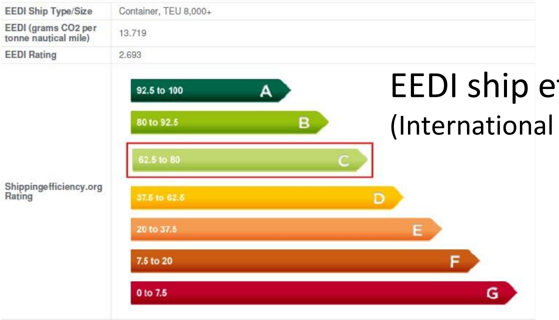
platooning

automation

fuel economy standards: *applied to trucks and ships*

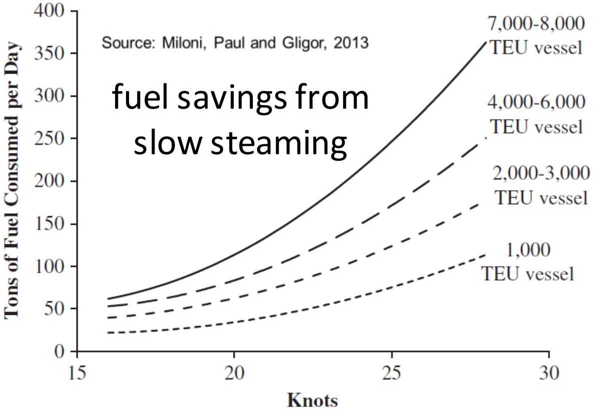
Fuel Economy Standards for Heavy Duty Vehicles

Source: ICCT (2015)



EEDI ship efficiency ratings
(International Maritime Organisation)

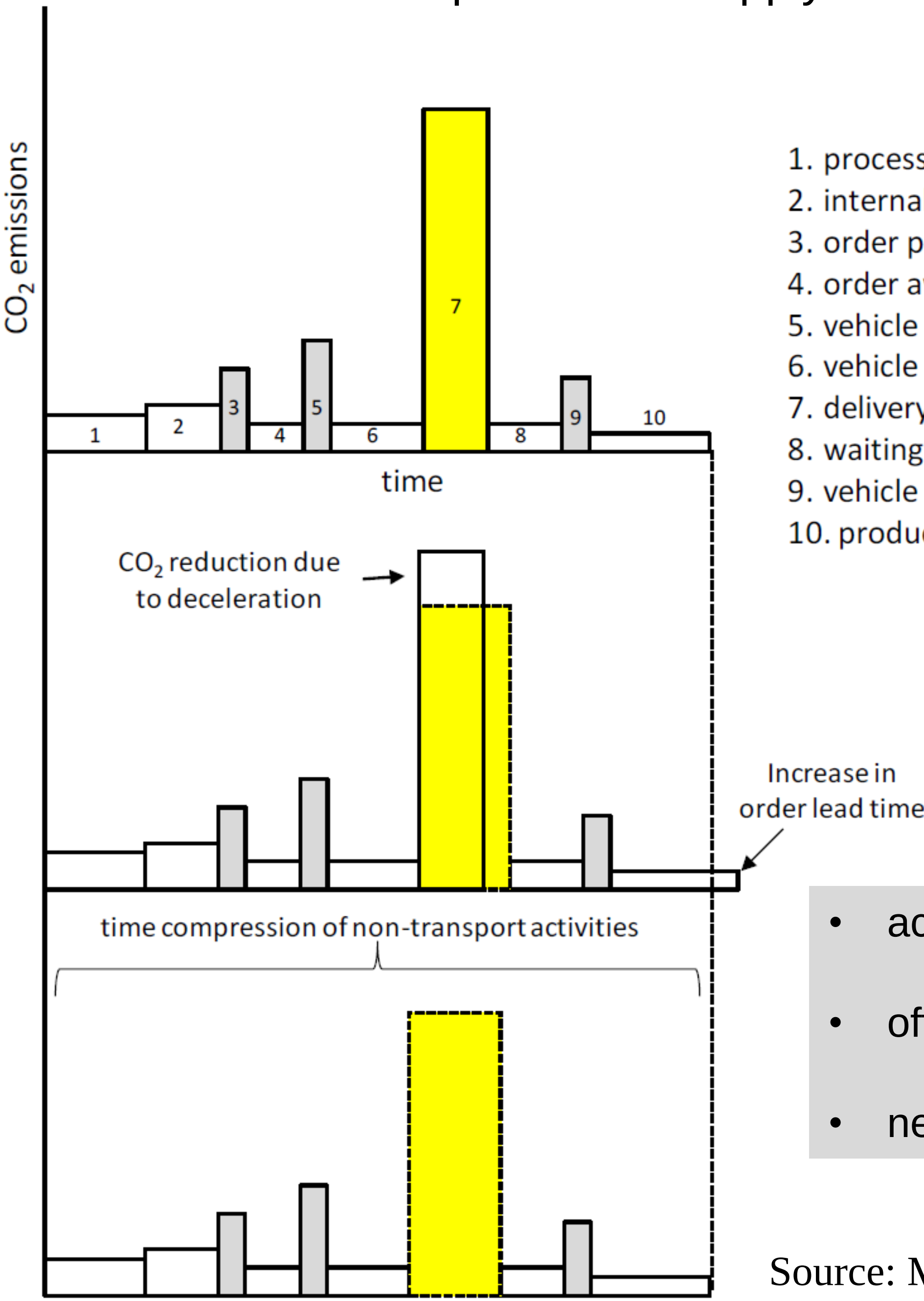
business practice: e.g. *deceleration*



fuel savings from slow steaming

Wider case for transport deceleration ?

Relationship between Supply Chain CO_2 Emissions and Time



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

Source: McKinnon (2016) *Transport Reviews*

Five Sets of Decarbonisation Initiatives for Freight Transport

Reduce Demand for Freight Transport

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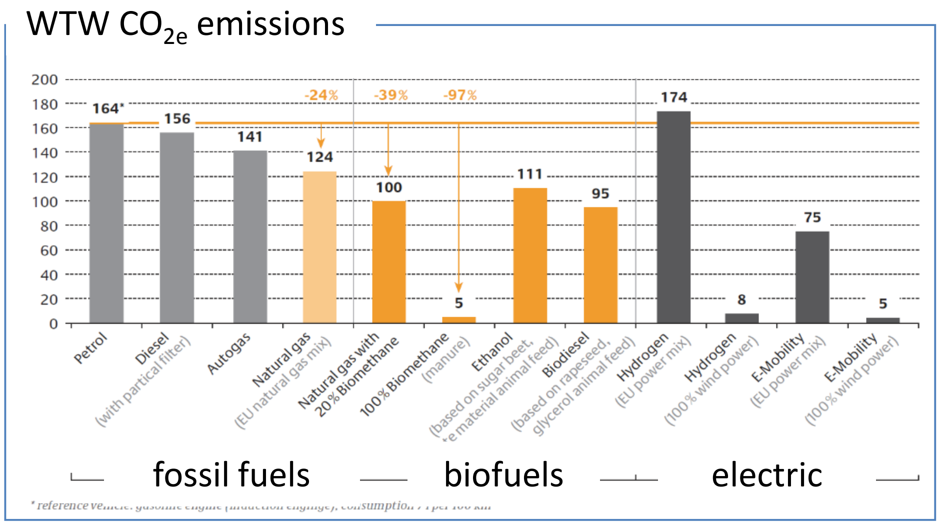
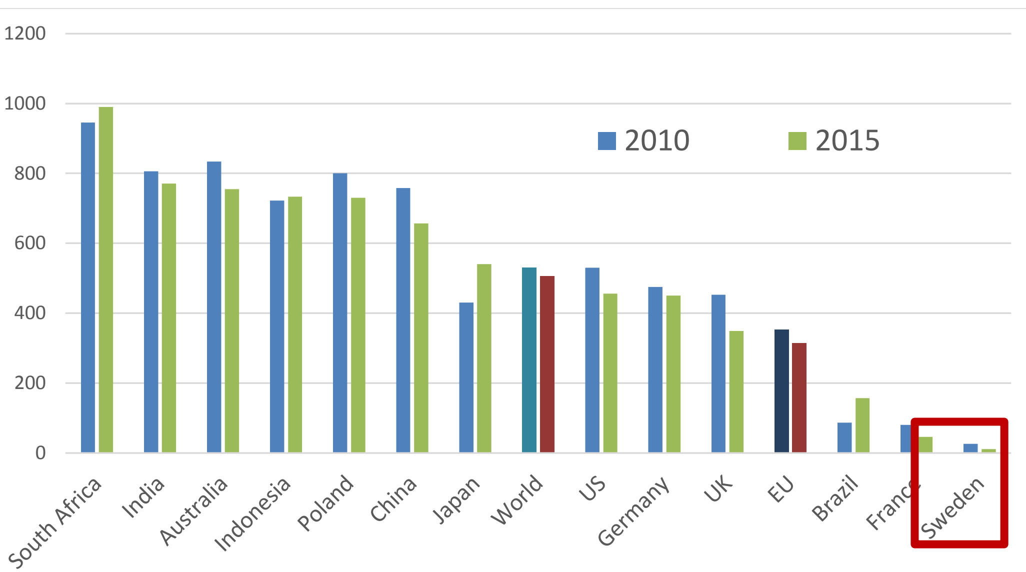
Switch to Cleaner, Low Carbon Energy



biofuel fuels: *slow uptake*

- uncertainty about net GHG impact
- limited supply of sustainable biofuels
- inter-sectoral competition for supplies
- lack of refuelling infrastructure
- '*methane slip*' problem

CO_2 benefits of freight electrification?



Carbon intensity of electricity generation (gCO_2 / kWh)

Short-term: *electrified rail*
local road delivery

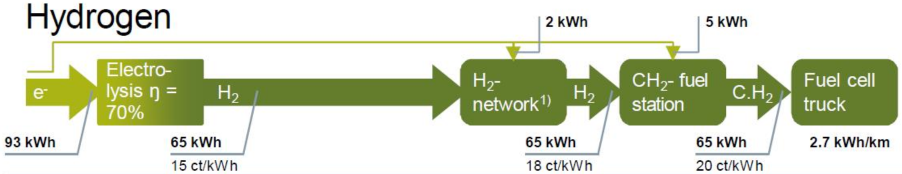
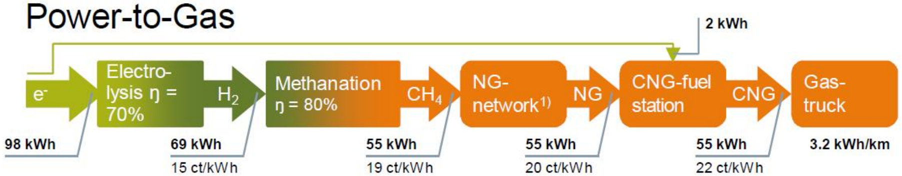
- recharging infrastructure
- future battery performance
- E- vehicle price differential

Long-term:

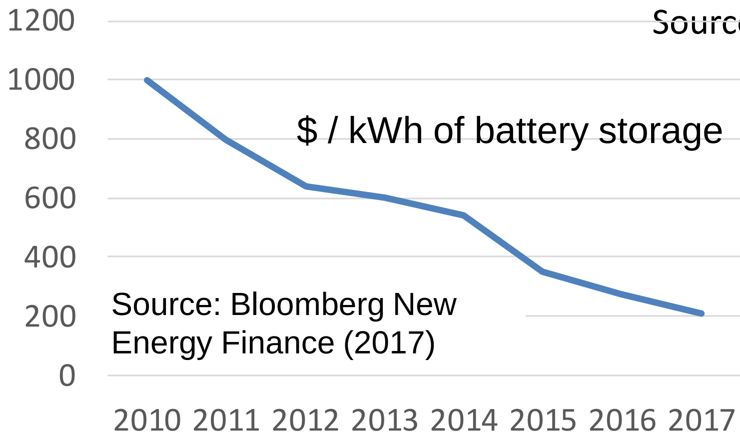
cold ironing of ships in port

electrified roads: Trials in Sweden, Germany and the US

Energy Efficiency and Cost of Different Methods of Electrifying Long Haul Road Freight

Pathway — 100 kWh 6c / kWh		Range Cost per km	Efficiency WTW	Example vehicle
Electric Road Systems		**60 km** 19 ct/km	77%	
Battery		**48 km** 20 ct/km	62%	
Hydrogen		**24 km** 55 ct/km	29%	
Power-to-Gas		**17 km** 70 ct/km	20%	

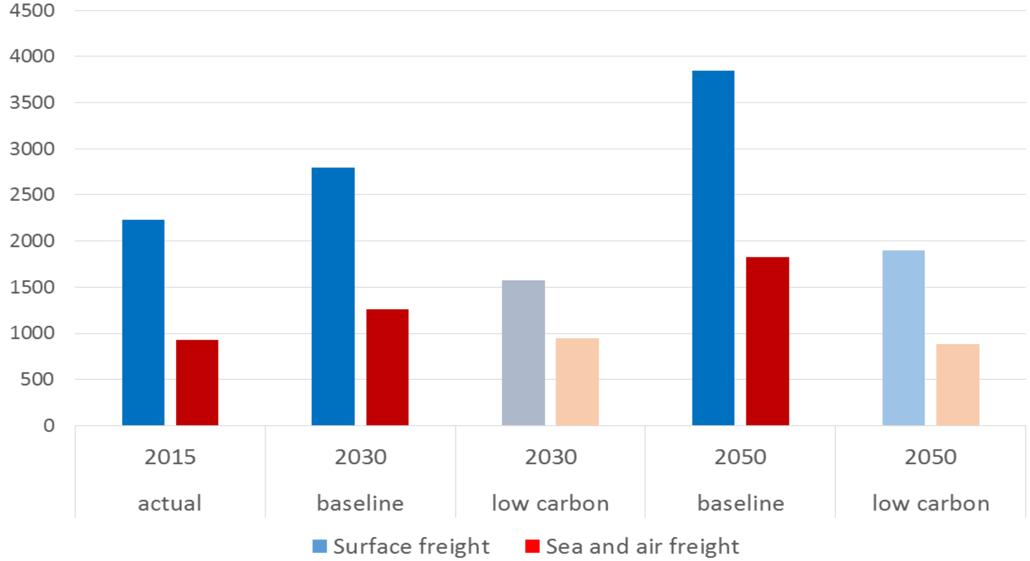
Source: German Ministry of Environment (quoted by Akermann, 2016)



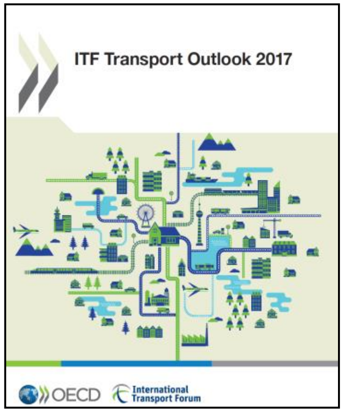
TESLA gamechanger?

500 mile battery range
fast charging
autonomous
platooning-ready

Potential CO_2 reductions from freight transport: *grounds for optimism*?



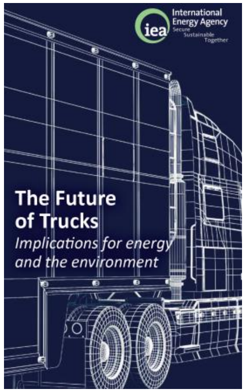
CO_2 emissions from freight transport: baseline trend vs low carbon scenario



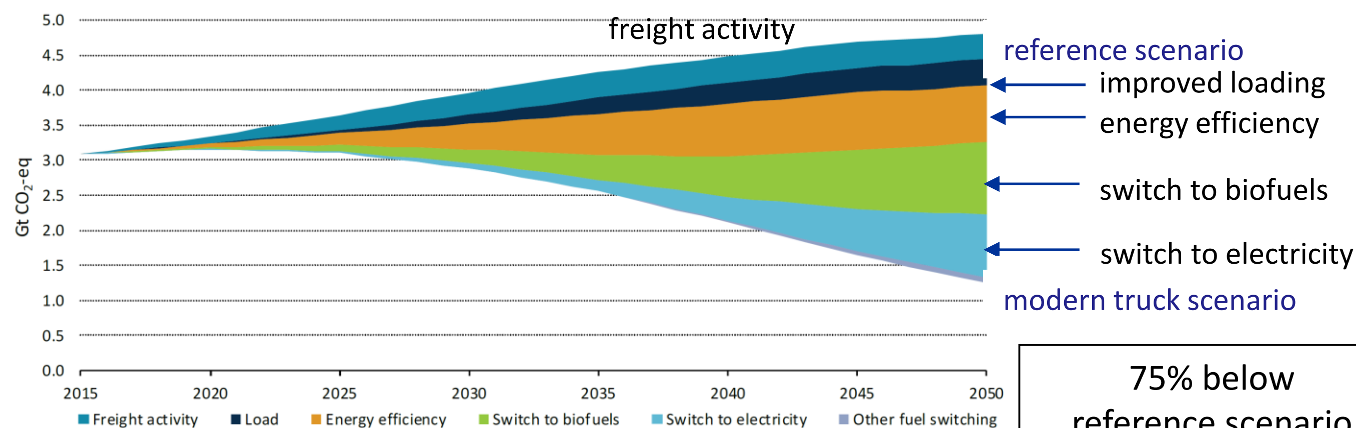
Reducing global average carbon intensity of freight transport from **28 gCO_2/tonne-km** to **8 gCO_2/tonne-km**

But total freight-related emissions in 2050 on **14% lower** than in 2015

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



source: IEA (2017)



75% below reference scenario

Leveraging the 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

↓

83% reduction in carbon intensity

Factor 6

achievable in 20-30 years ?

may need to restrain growth in demand for freight transport

EU wants to avoid '*curbing mobility*'

Professor Alan McKinnon

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