

# Net Zero Logistics: the challenges ahead

Professor Alan McKinnon

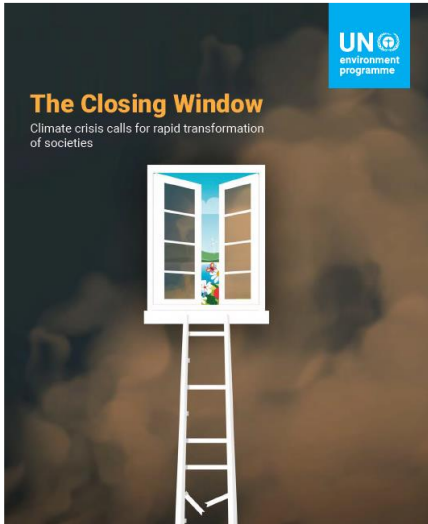
*Kühne Logistics University  
Hamburg*



15 March 2023



# Update on the Climate Emergency and the Meaning of Net Zero



<https://bit.ly/3j2y29d>

*To get on track for limiting global warming to 1.5°C, global annual greenhouse gas (GHG) emissions must be **reduced by 45 per cent ... in just eight years**, and they must continue to decline rapidly after 2030*



*'we are on a highway to climate hell with our foot on the accelerator'*

**PNAS** PERSPECTIVE OPEN ACCESS Check for updates

**Climate Endgame: Exploring catastrophic climate change scenarios**

Luke Kemp<sup>a,b,1</sup>, Chi Xu<sup>c</sup>, Joanna Depledge<sup>d</sup>, Kristie L. Ebi<sup>e</sup>, Goodwin Gibbins<sup>f</sup>, Timothy A. Kohler<sup>g,h,i</sup>, Johan Rockström<sup>j</sup>, Marten Scheffer<sup>k</sup>, Hans Joachim Schellnhuber<sup>l</sup>, Will Steffen<sup>m</sup>, and Timothy M. Lenton<sup>n</sup>

<https://www.pnas.org/doi/10.1073/pnas.2108146119>

*'There are ample reasons to suspect that climate change could result in a global catastrophe.'*



**RACE TO ZERO**

Over 52 countries and regions, 8,300 businesses and 1136 cities committed to having net zero emissions by 2050 or earlier

<https://bit.ly/3f6svtD>

**Net Zero:** reduce emissions as much as possible by **mitigation** measures with any surplus balanced by the removal of CO<sub>2</sub> from the atmosphere by carbon **sequestration** processes

Concept of net zero is a dangerous trap (Dyke, Watson and Knorr, 2021) <https://bit.ly/3oRR0Tr>

*'Within a few decades, we will need to transform our civilisation from one that currently pumps out 40 billion tons of carbon dioxide into the atmosphere each year, to one that produces a net removal of tens of billions.'*

*'net zero has licensed a recklessly cavalier "burn now, pay later" approach which has seen carbon emissions continue to soar.'*

# Logistical Challenges of Carbon Sequestration

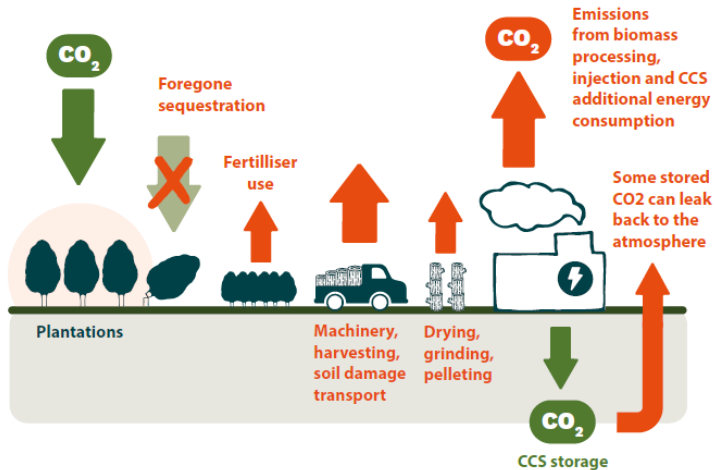
ipcc  
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Climate Change 2022  
Mitigation of Climate Change

IPCC (2022): given extent of carbon budget overshoot may need to use BECCS and DACCS to remove **360 billion tonnes of CO<sub>2</sub> between 2020 and 2100** -

almost **ten times** as much CO<sub>2</sub> as the world emitted in 2019

## Bio-energy carbon capture and storage BECCS



high supply chain emissions

supply chain emissions of 1.11 tonnes for every 1 tonne sequestered

## Direct air carbon capture and storage (DACCS)



- extremely low concentrations of CO<sub>2</sub>: *only 0.04% of atmosphere*
- at 416 ppm for CO<sub>2</sub> need to filter 1600 tonnes of air to capture 1 tonne of CO<sub>2</sub>
- very high consumption of renewable energy / high cost
- very immature technology

Source: FERN (2021)

<https://bit.ly/3CP0yT6>

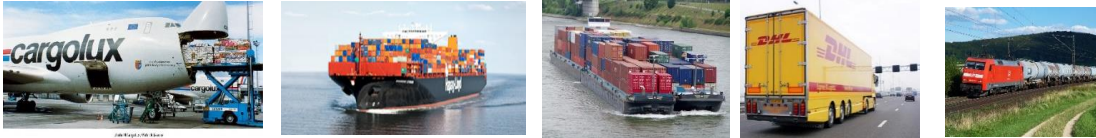
*18 plants and 10,000 tonnes captured (IEA, 2021)*

<https://bit.ly/3NiFl6t>

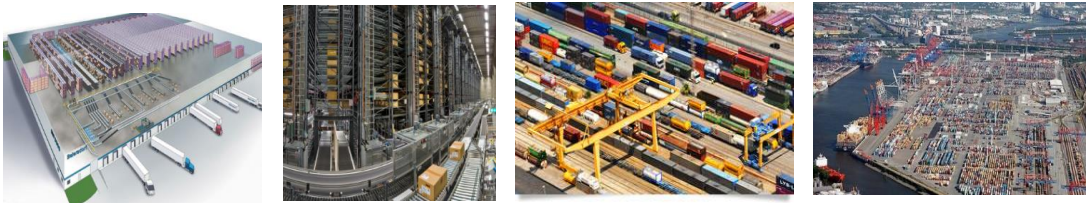
# Contribution of Logistics to Global Energy-related CO<sub>2</sub> Emissions

Logistics = 11-12% of global CO<sub>2</sub> emissions

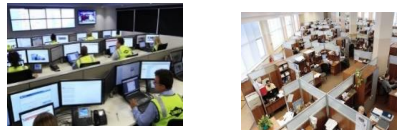
freight transport 9.6%



warehousing and terminals- 1-2%



administration / IT ?



% of emissions from refrigerated transport and storage?

refrigeration, air conditioning and heat pumps = 7-10% of GHGs

75% from energy use 25% from leakage of refrigerant gases

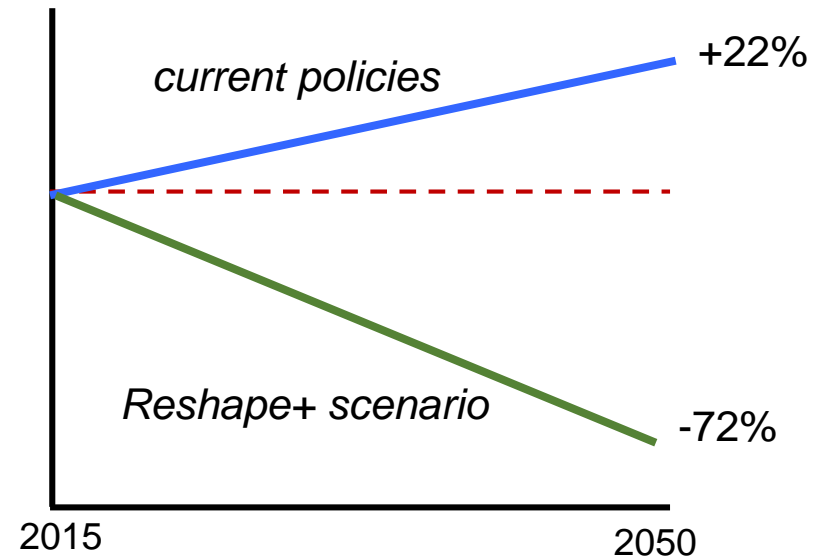
<http://bit.ly/3YWgURq>

**freight transport will be difficult activity to decarbonise**

- almost total dependence on fossil fuel
- high forecast growth of freight movement  
*2.6x increase in tonne-kms between 2015 and 2050 (ITF, 2021)*
- long life of freight assets (*typical replacement rate in years*)

van	truck	locomotive	ship	plane
5-7	10-15	25-30	30	30

projected trends in freight transport CO<sub>2</sub>



source: International Transport Forum 2021 <https://bit.ly/3fQ42YE>

# Five Decarbonisation Levers: *past record of mitigating carbon emissions from trucks in EU*

5 Sets of Freight Decarbonisation Option:

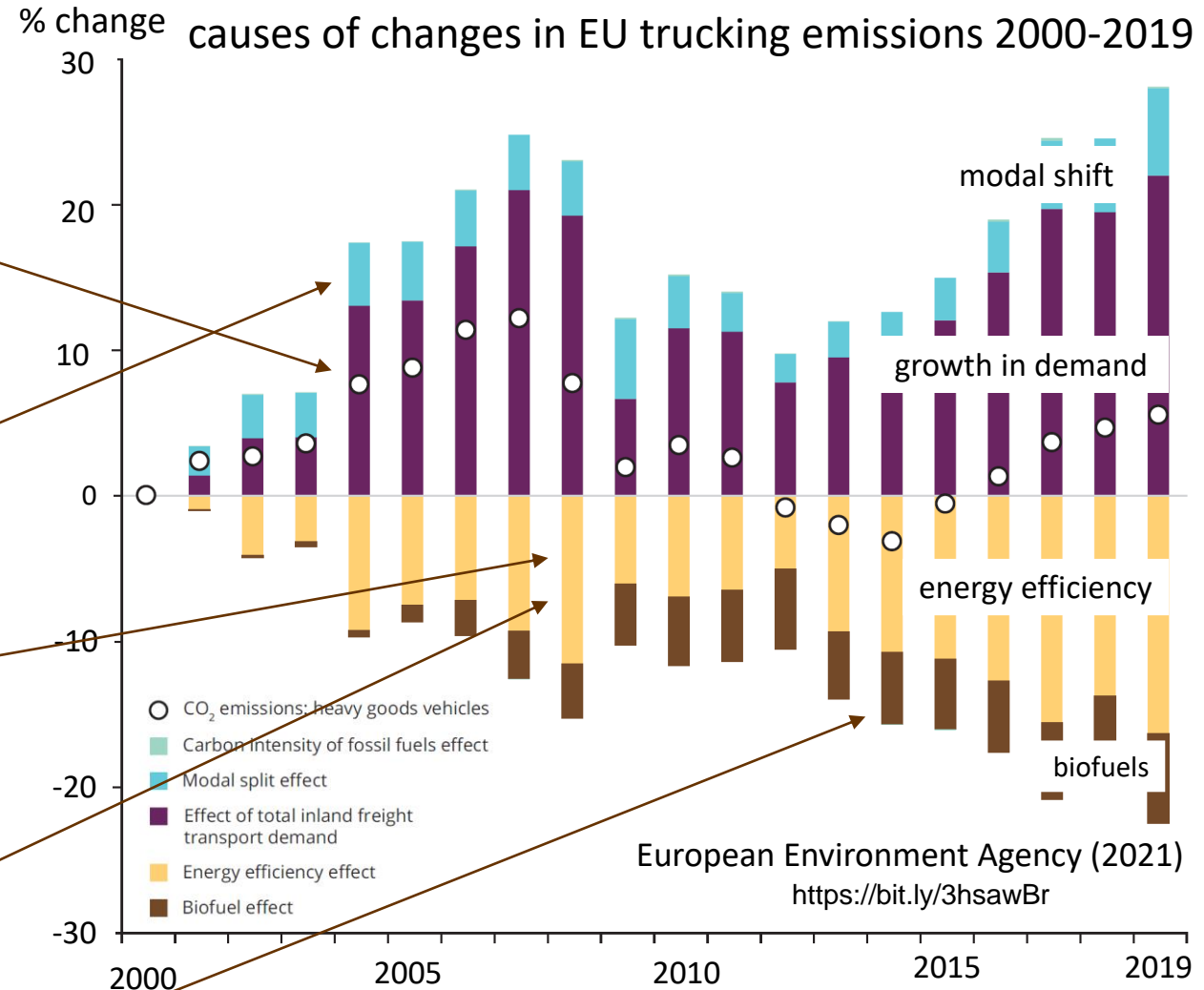
1. Reduce the total amount of freight movement

2. Shift freight to lower carbon transport modes

3. Optimise utilization of logistics assets

4. Improve energy efficiency of logistics operations

5. Cut carbon content of energy used by logistics



rising transport demand + modal shift offset by improving energy efficiency and increasing use of biofuels

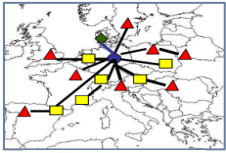
much smaller biofuel GHG reduction on a life-cycle / WtW basis



# 1. Reduce the Amount of Freight Movement

## restructure supply chains

- reshore / near-shore manufacturing
- localize sourcing
- decentralize production & inventory



## Reduce the amount stuff to be moved



**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, simplified supply chains*



phasing out fossil fuel – 30% of tonne-kms in 2020

## Future freight traffic growth sectors

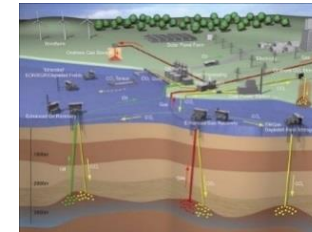
renewable energy infrastructure



air conditioning / cold chain



carbon capture and storage



carbon dioxide removal



climate change adaptation



population resettlement

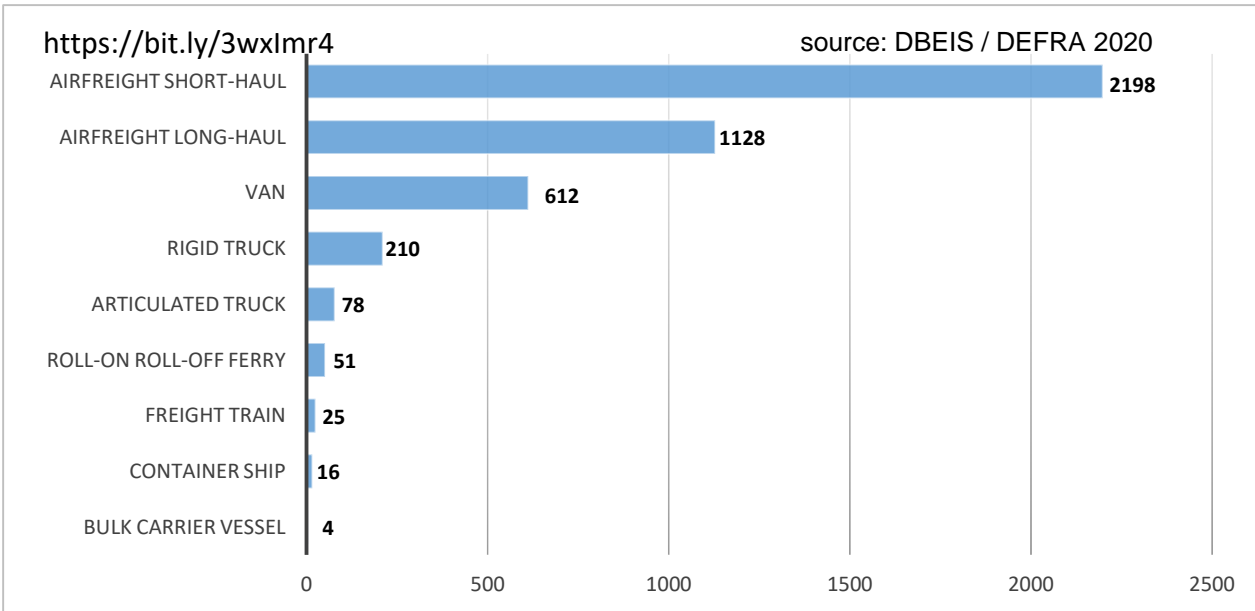


Source: Malo, 2017

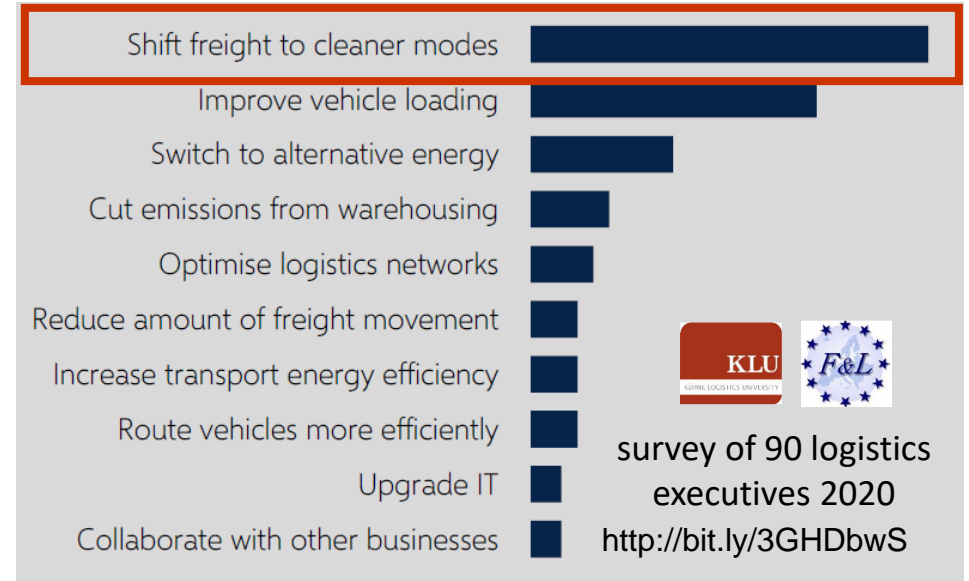
THE SEASTADING INSTITUTE

## 2. Shift Freight to Lower Carbon Transport Modes

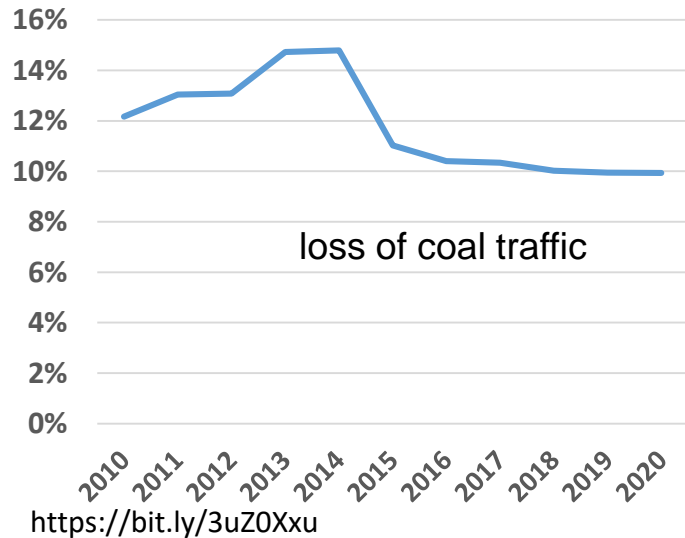
average carbon intensity of freight transport modes:  $gCO_2 / tonne-km$



most cost-effective methods of decarbonising logistics



rail share of UK road + rail tonne-kms



- fossil fuel phase-out – a core traffic for rail: *hard to replace with manufactured goods*
- difficult to reverse past modal shift trend: *few countries have achieved it*
- long term logistical 'lock-in' to trucking: *critical importance of intermodality*

rail: *minimal share of refrigerated freight market*

new opportunities?



Tesco rail reefer service

<https://bit.ly/3ySmHwN>

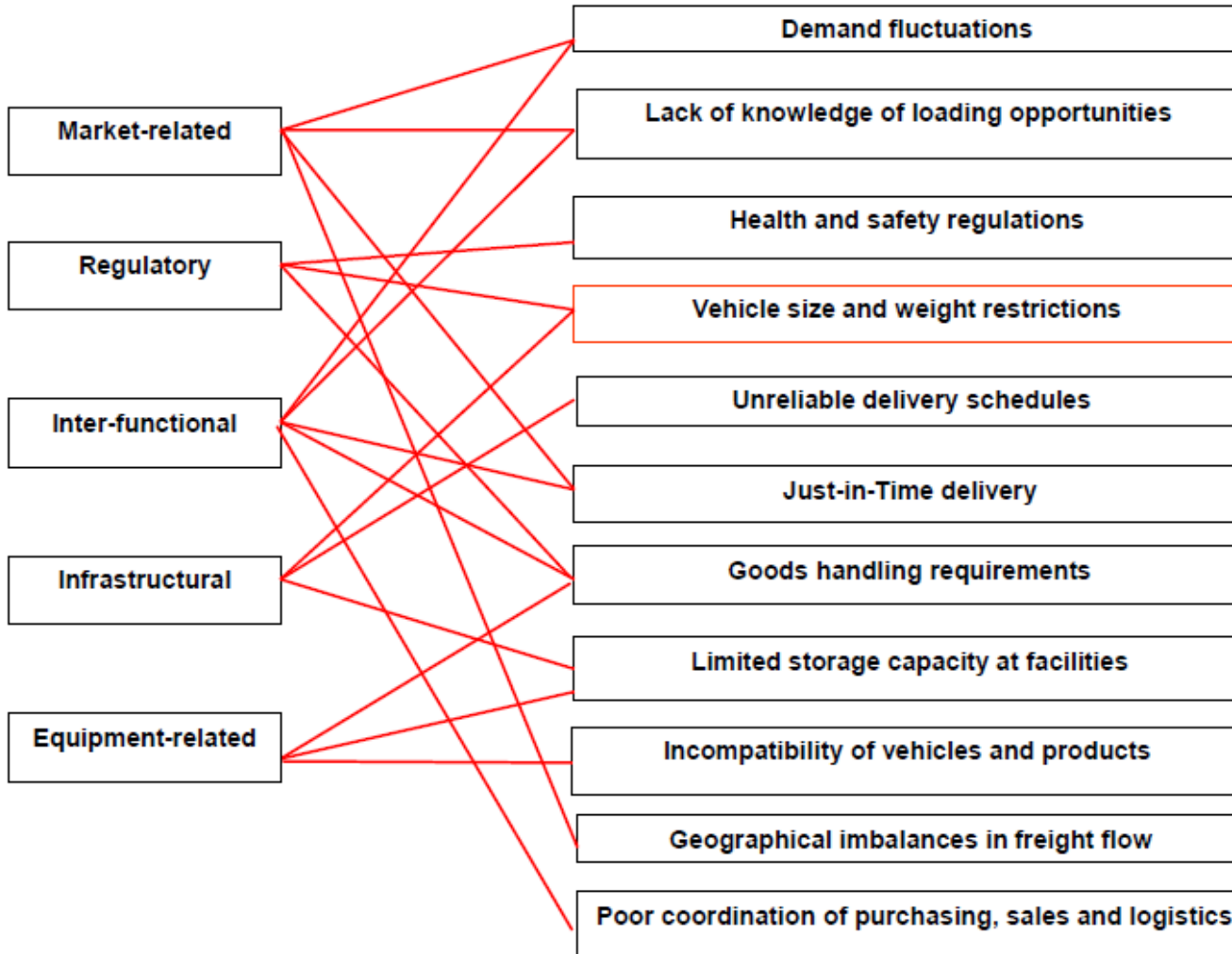
### 3. Optimise the Utilisation of Logistics Assets

large potential CO<sub>2</sub> savings

low or negative carbon mitigation costs

short-medium term implementation

#### classification of factors constraining vehicle utilisation



#### ways of raising vehicle load factors



Logistical collaboration



Digitalisation



High capacity transport



Relaxation of JIT ?



Physical Internet

<https://bit.ly/3xakzB0>



# 4. Increase the Energy Efficiency of Logistics Operations

longer term

short term

uptake of new technologies

retrofitting fuel saving devices

vehicle operation: *IT, training, monitoring*



platooning

automation



eco-driver training



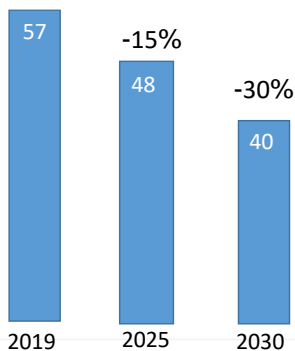
telematic monitoring

fuel economy standards: *applied to trucks and ships*

enhanced vehicle maintenance

changes to business practice: e.g. *deceleration*

EU fuel / CO<sub>2</sub> standards for new trucks

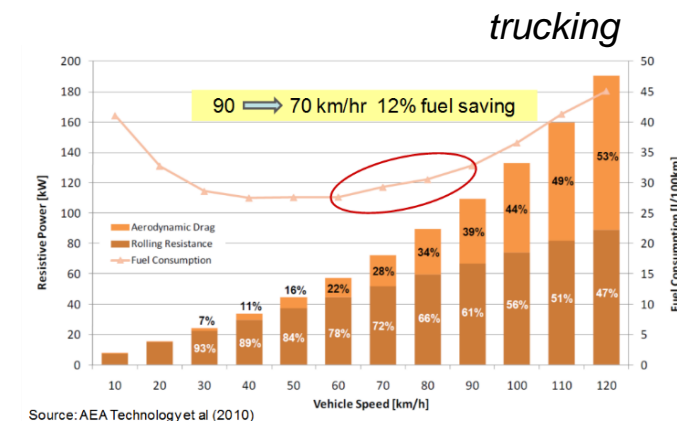
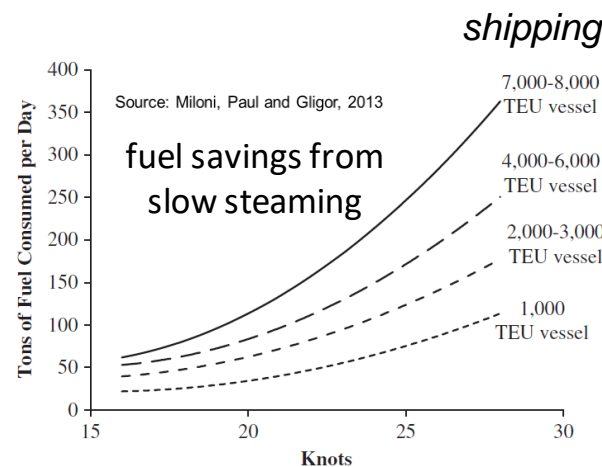


75% of new trucks sold in 2021 in countries with fuel economy standards (IEA, 2022)

<https://bit.ly/3ECn3Mf>



ship energy efficiency ratings  
EEDI for new vessels  
EEXI for existing vessels



# 5. Cut the Carbon Content of Energy Used by Logistics

Several low-carbon energy options for each freight mode: *uncertainty and disagreement about future energy mix*



short haul road	long haul road	rail	shipping	airfreight
battery	battery	catenary	e-methanol	biofuel
hydrogen	hydrogen	battery	green ammonia	e-kerosene
	e-highway	hydrogen	hydrogen	hydrogen
	biogas		battery	battery
	HVO		wind	

heavy dependence on direct or indirect **electrification** of the freight transport system

slow transition

coordinating the development of **transport and energy infrastructures** with the **manufacture of new low carbon vehicles** and **operators' fleet replacement cycles**.

# Speed and nature of the transition to fossil-free trucking

<http://bit.ly/3eIQwzx>

<https://bit.ly/3nRtGk6>



**MoU of 15 countries (including UK)**  
all **new** trucks must be zero emission:

- by 2035 for vehicles <26 tonnes
- by 2040 for vehicles >26 tonnes

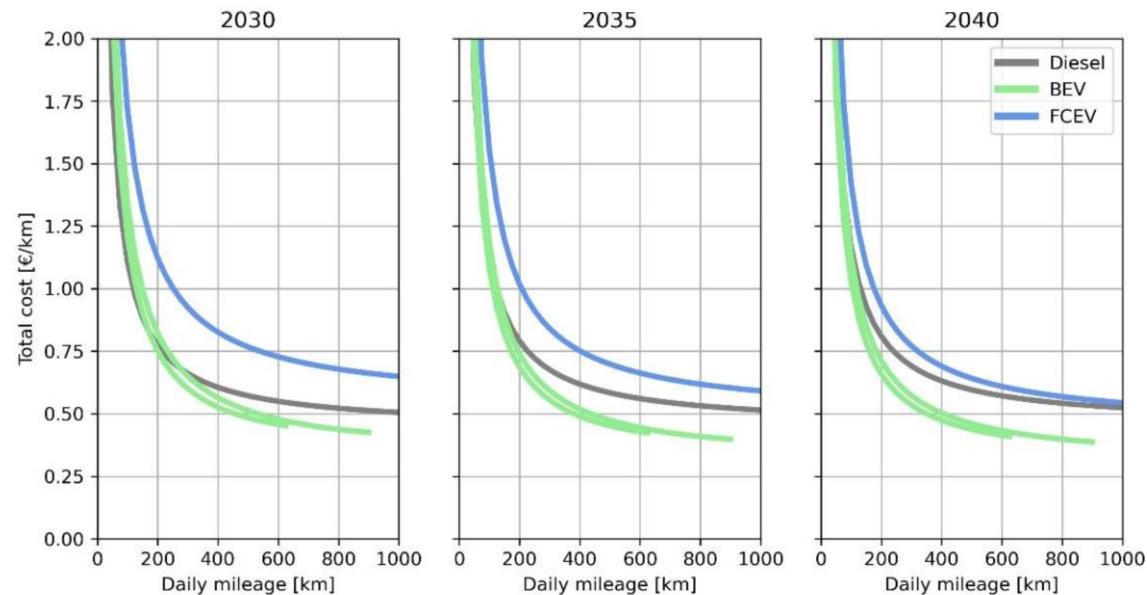
**COP27 12 more countries sign MoU incl. US**

EU 6.1 million medium and heavy duty trucks (2019)

361K new MDV and HDV sales (2019)

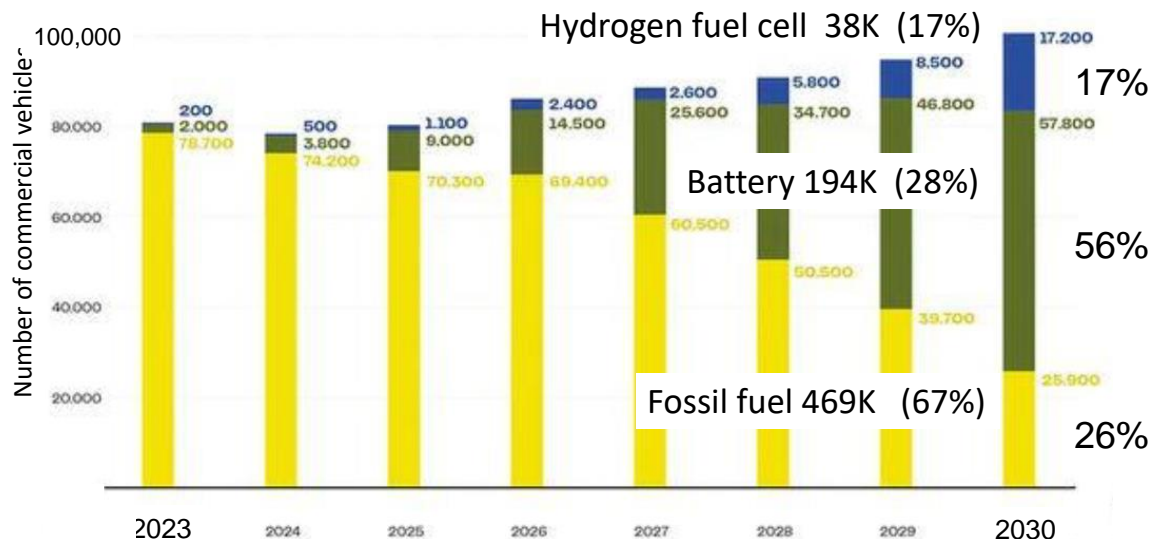
17 years to replace the EU27 fleet

TCO curves for diesel BEV and FCEV (TNO)



BMDV forecast composition of German truck sales (2023-2030)

<http://bit.ly/3hRxsu6>



Electric Road Systems (ERS)  
to supplement static with dynamic charging of trucks

[bit.ly/3FphW22](http://bit.ly/3FphW22)



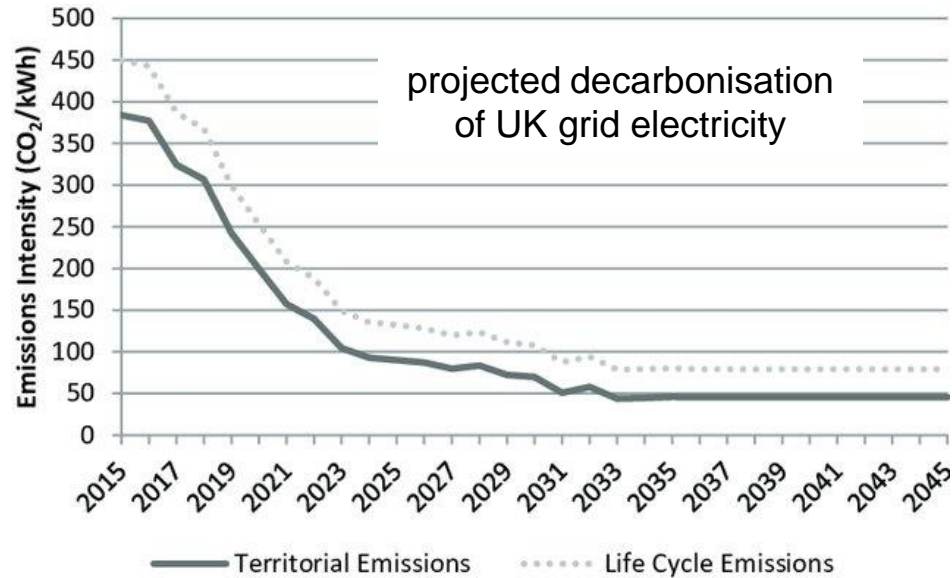
- reducing battery size, weight and cost
- reducing required static charging capacity
- carbon efficient powering of refrigeration

German studies: *most cost effective way of decarbonising trucking*  
@ €2-3 million per km for one lane in each direction



# Reliance on the Decarbonisation of Grid Electricity, Batteries and Micro-generation

*'There seems to be an implicit assumption around cooling...that much of the heavy lifting of emissions reductions will be achieved through decarbonisation of electricity'*  
(*'Doing Cold Smarter'* report) <https://bit.ly/2EJv0CX>



**competing with other sectors for low carbon electricity**

**securing adequate and reliable supply of battery materials**

**intensifying use of scarce battery materials in the road fleet**

**metric: CO<sub>2</sub> savings / kg of battery material / day**

## micro-generation of renewable energy

A high-resolution geospatial assessment of the rooftop solar photovoltaic potential in the European Union

Katalin Bódis<sup>a</sup>, Ioannis Kougias<sup>a,\*</sup>, Arnulf Jäger-Waldau<sup>a</sup>, Nigel Taylor<sup>a</sup>, Sándor Szabó<sup>b</sup>

<https://bit.ly/3Jokb6n>

*rooftop solar: could be 25% of EU electricity*



world's most environmentally-friendly commercial building  
Rhenus Logistics, Tilburg

<http://bit.ly/3ZWIgJS>

Article

**Decarbonizing the Cold Chain: Long-Haul Refrigerated Deliveries with On-Board Photovoltaic Energy Integration**

<https://www.mdpi.com/2071-1050/13/15/8506>



13kg CO<sub>2e</sub> saving on 1350km tour relative to diesel refrigeration  
*4 year payback reducing*

Project ZERO



<https://bit.ly/3YUGC98>



# Sequestration Side of Net Zero Logistics

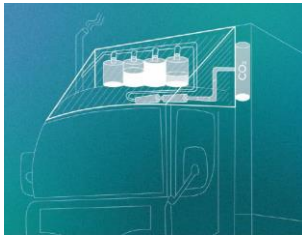
Applying the net zero concept at a corporate or sectoral level: few *carbon sinks* in the logistics sector

opportunities for carbon removal **within** the logistics sector:

capturing logistics emissions onboard vehicles / vessels



Remora



Qaptis

**aramco** : if every heavy duty truck in world had mobile CC technology onboard: 708m tons of CO<sub>2</sub> saved per annum (2x UK total in 2021)

<https://bit.ly/3F9j4VZ>

**Norwegian Project to Research Carbon Capture and Storage on Ships**



CCS onboard vessels to cut net maritime emissions

<https://bit.ly/3jNLXNE>

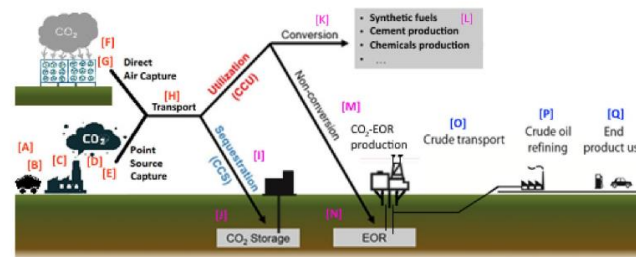
critical role for logistics in capture, movement and storage of CO<sub>2</sub> from the atmosphere



nature-based



engineered



carbon capture, utilisation and storage

**CCUS value chains**

future business opportunity for logistics companies?

*entitlement to negative emission credits?*

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