ARUP

Foresight

Future of Goods Movement

November 2023

Contents

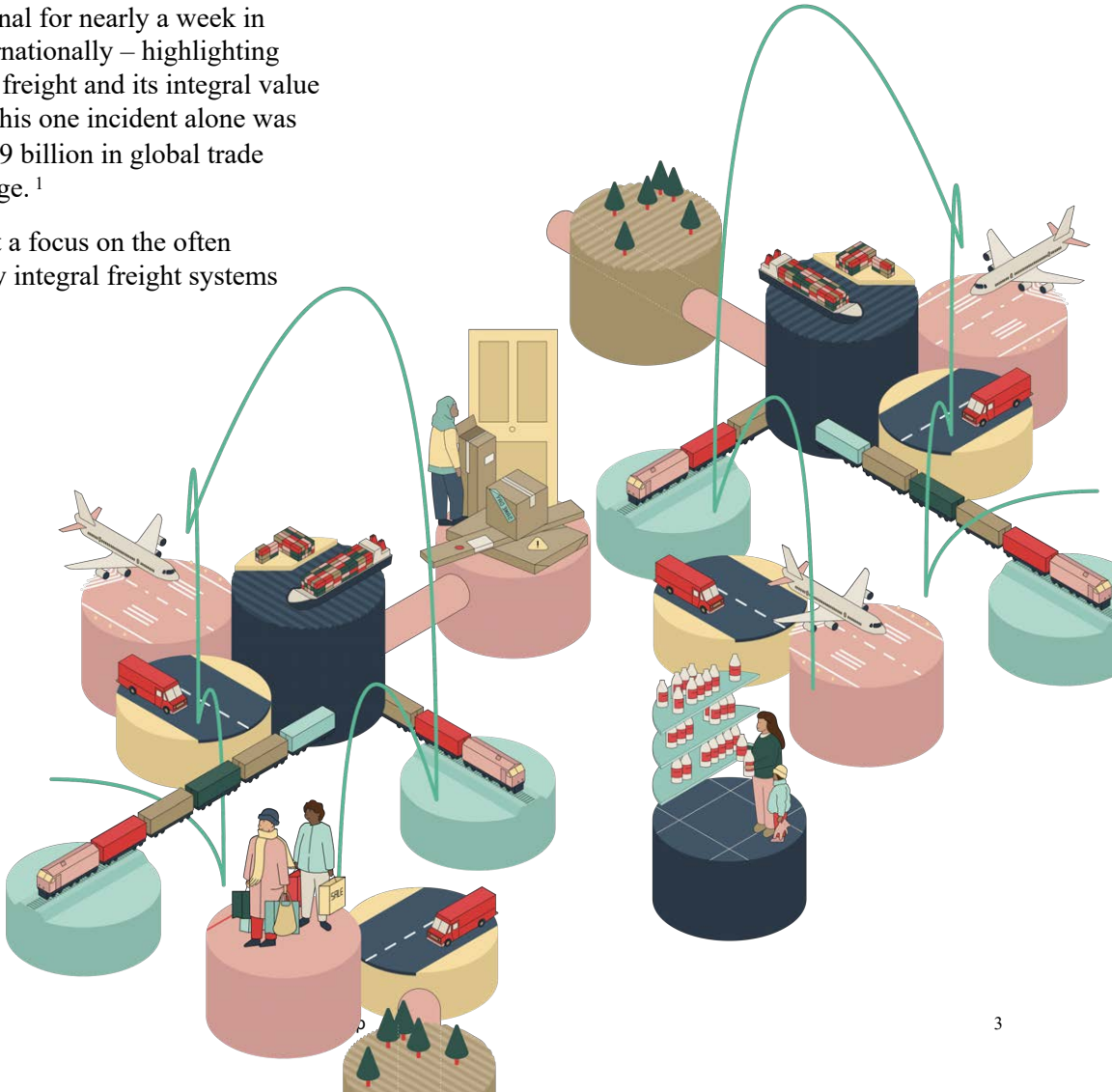
Why do we need to think about the future of goods movement?
Introduction

Every activity we engage in to sustain our lives, businesses, leisure, health, and relationships is facilitated by goods and resources – materials, products, food, fuel, energy, and assets. These goods are the end products of highly complex and largely invisible supply chain networks. Goods we consume rely on extensively coordinated operations and transport networks for their movement and delivery. Freight transport moves goods (materials, products, foods, etc.) from a location where they are available to another location where they are required.

Typically, these behind-the-scenes transport systems only gain mainstream attention when there is a critical breakdown in the network, and populations and key industries are suddenly cut off from the daily resources they otherwise expect uninterrupted access to. The ship which blocked the Suez Canal for nearly a week in 2021 earned headlines internationally – highlighting both the intricacy of global freight and its integral value to economies worldwide. This one incident alone was estimated to have held up $9 billion in global trade value per day of the blockage. [1]

In this report, we argue that a focus on the often invisible, but fundamentally integral freight systems which are responsible for delivering secure access to the goods and resources we all depend on is particularly crucial at this time.

Around 80% of the world's economy, and 77% of global greenhouse gases, are now covered by a national net zero target.[2] The world's most traded commodities are agricultural, energy, and metal products – all products which are directly subject to major transformation as a result of these committed efforts to tackle climate change and reduce greenhouse gas emissions. Understanding the changes and shifts the future of goods movement is likely to be subject to, and the priorities and processes which should be in place, will be critical to the resilience of the global economy and a more sustainable planet.



The nature of freight
Introduction

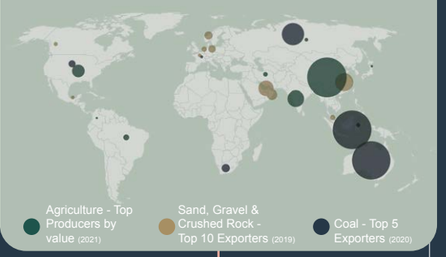
The movement of goods across long distances in most parts of the world is generally enabled through one or a combination of four main transport modes: road, shipping, aviation, and rail. Pipelines are also considered in this study, due to their role in transporting key energy products and affecting the demands on other mainstream freight modes. The relative prominence of particular transport modes in different parts of the world varies based on production, trade, geography, and precedents of investment in different systems and infrastructure. The freight system is influenced by a multitude of actors, from individual consumers ordering goods to be delivered to their homes, through to large retailers and manufacturers, to shippers, operators and infrastructure providers, and governments setting policies that shape the parameters of the freight world. In most places, the private sector dominates freight movement via every mode.

Consequently, services are planned and optimised with a fragmented view (based on the individual entities which operate and plan a specific component on the freight network). To date, freight networks and services have primarily been driven by market demand, with little systemwide strategic planning and consideration of long-term implications, resilience, and risks. This has led to an overall network in most countries and regions which has developed piecemeal and organically. Over decades, this fractional development and the absence of an overarching national or regional freight strategy has arguably made the freight sector highly vulnerable to major disruption from sudden, unexpected changes. The freight network serving most regions of the world today is a highly precarious system, and under emerging future conditions it is poised to experience significant disruption with increasing frequency.

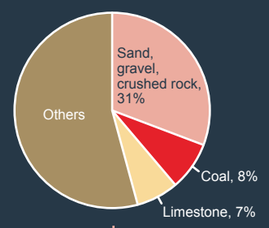
With the evident shifts in the dynamics of world trade and industry, it is necessary to consider, explore, and reimagine the future of the system which enables the movements of goods globally. Dialogue and consideration of the freight transport system must emerge from the background and into the spotlight for both private consumers and the decisionmakers planning the future of cities, regions, access to resources and infrastructure.

Future of Goods Movement

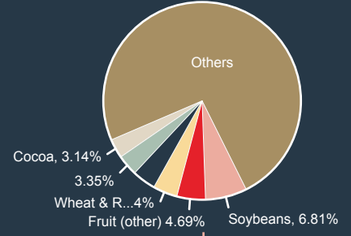
Raw Material Extraction



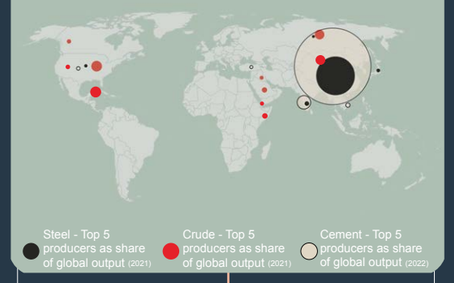
Top 10 materials extracted by share (2019)



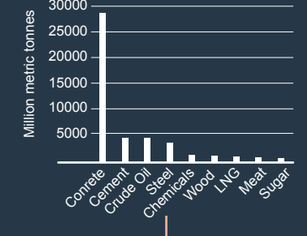
Total Trade of Agricultural Goods by value (2021)



Refined Goods

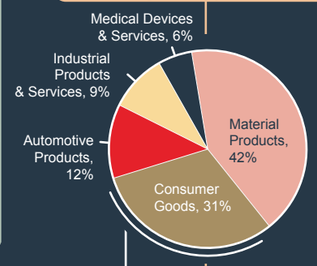


Top refining and process activities globally (2023)

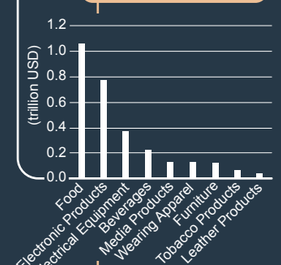


Global Manufacturing Output (2021)

Manufacturing sectors by value add (tn USD, 2022)

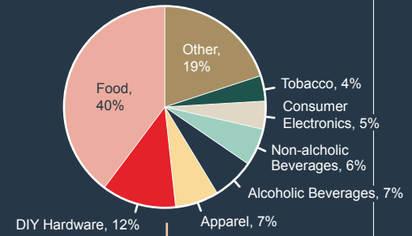


Top Consumer Goods (2023)

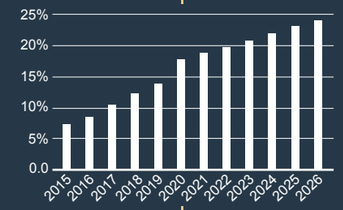


Locations of Retail Headquarters (top 15 Global Retailers by revenue, 2021)

Top 10 retail products globally (2022)

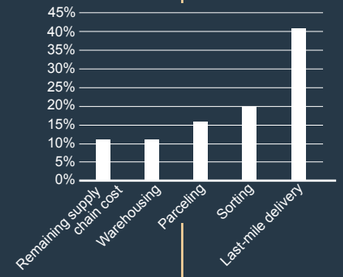


E-commerce as percentage of total retail sales worldwide from 2015 to 2026 (2023)

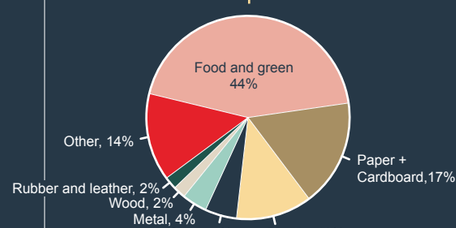


Last-mile delivery represents over 40% of total supply costs for products

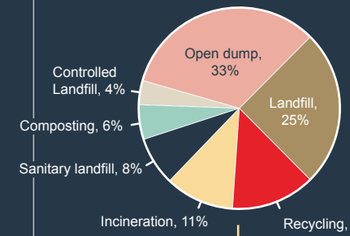
Share of total supply costs worldwide in 2018, by type of cost



Global source of 2bn tonnes of annual municipal waste (2018)



Open dumps and landfill dominate waste disposal (2018)



Raw Material extraction

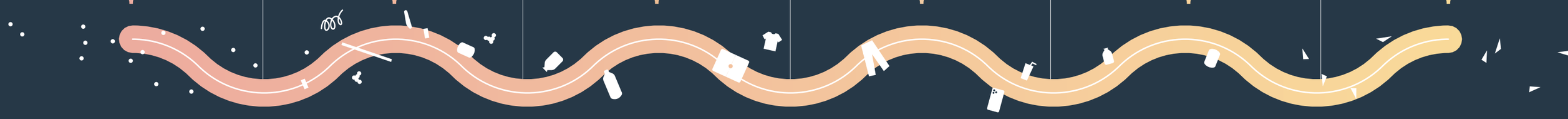
Processing / Refining

Distributed to manufacturers for different products

Distributed to retailers

Distributed to individual customers

Waste

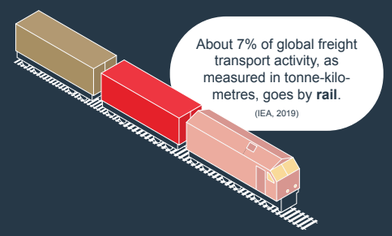


Shipping is estimated to account for about 80% of goods movement globally

(Statista, 2023)

Air freight is estimated to account for less than one percent of global volumes transported – but more than 30% of the value of goods transported.

(IEA, 2018)



About 7% of global freight transport activity, as measured in tonne-kilo-metres, goes by **rail**.

(IEA, 2019)

Road freight represents 15% of total freight activity but emits 44% of the sector s CO2

(ITF, 2021)

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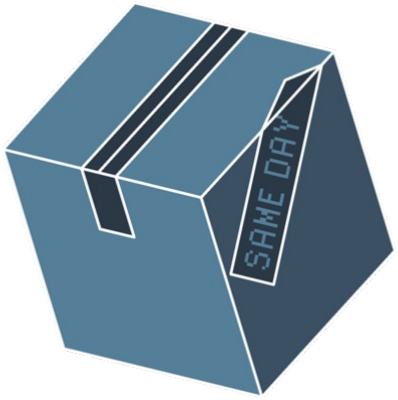


1
Future drivers of change

In studying the wider social, technological, economic, environmental, and political trends on the horizon today, we argue that five major shifts will have a core impact on how goods move in the future:

1

The transition to net zero emissions and the need to transform management of overconsumption and waste.

2

The need to prioritise resilience against growing environmental, social, and economic risks.

3

The changing nature of global economic power and the role of different nations in consumption and production.

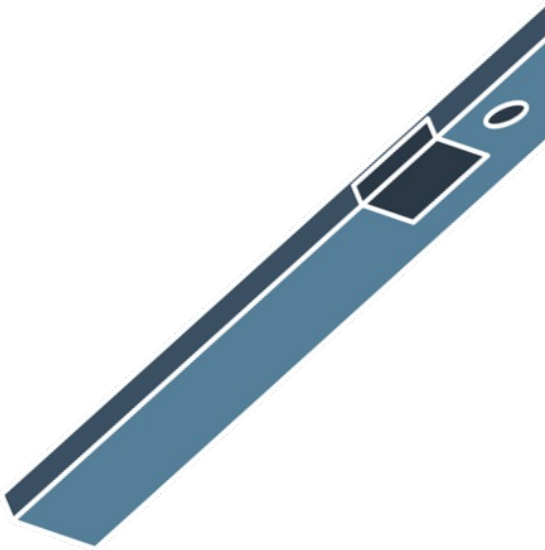
4

New technology and changes in supply chains, consumer preferences, and retail business models.

5

The energy and industrial materials transition.

The fifth shift, centred on the energy transition, is closely related to the first shift, the need to achieve net zero emissions and reduce overconsumption and waste. We focus on energy and materials separately due to the direct implications this will have for the goods and volumes which need to be transported in the future.



1.1 Net zero and managing overconsumption and waste

Climate change is having an irreversible impact on the earth, and the need to get to net zero is widely acknowledged by all major countries worldwide. The net zero agenda poses fundamental shifts for the movement of goods. Actions to meet net zero targets will affect how goods move (the infrastructure, systems, and technology), where goods come from and are taken to, and what is transported. The major changes which will affect the movement of goods due to the need to get to net zero emissions globally include:

The onset of a more circular economy globally

A shift to net zero will mean prioritising reuse, repair, design and manufacturing practices which maximise product life, and continually recycling materials and products to eliminate waste. The resources and materials which feed into industry and markets, where they come from, and how they are transported are positioned to fundamentally shift as a response to this transformation towards a low-carbon and circular world.

Changing consumer preferences and increasing environmental awareness

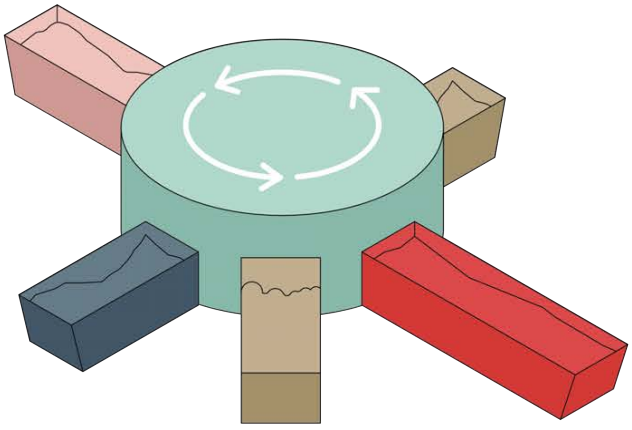
Individuals are becoming more conscious of their impact on the environment and how their personal choices can influence companies. A survey across 60 countries found that 55% of online consumers consider a company's environmental and social commitment when deciding where to shop and will accept higher prices for sustainable products.[3]

Environmental impact reporting and carbon taxation

According to the World Bank, 23% of global greenhouse gas emissions are already covered by a large number of different carbon pricing schemes.[4] However, carbon prices are currently considered too low to have a major impact. A more powerful worldwide carbon tax scheme on imports could have a major impact on where goods are produced, how they are transported, consumed, and handled at the end of their life.

Implications for goods movement

- Expectations on how long people are willing to wait for goods and associated costs can change
- The things we consume and what we need to transport will drastically change.
- Pressure on decreasing transport-related carbon will increase.



1.2 Resilience

The increasing recognition of the need for resilience under unexpected and disruptive circumstances has been brought into focus with the recent COVID-19 pandemic and the Russia-Ukraine War. Climate change is already increasing the observed frequency of extreme weather events and natural disasters. With increasing political, environmental, and economic strains, nations are beginning to prioritise the need for resilient, steady, and secure access to critical goods for the wellbeing of their populations and economies. Key changes to prioritise resilience which will lead to major shifts in the movement of goods include:

Rethinking the race towards supply chain optimisation

Surveys suggest that just one lengthy shock can wipe out 30% to 50% of annual earnings for businesses.[5] Companies are now starting to think about diversifying their sourcing or manufacturing bases, obtaining a greater degree of transparency across their supply chains, and embedding in redundancies – by stockpiling, and identifying alternative pathways for sourcing, processing, and transporting.

Increased frequency of natural disasters and extreme events due to climate change

One of the most destructive results of global climate change is the resulting increase in frequency and severity of natural disasters. Natural disasters can either be of low intensity and occur frequently, or they can be one-off catastrophic events. In the US in the 1980s there were, on average, three natural disasters per year that caused damage of over $1 billion. This number has risen rapidly, and there were 20 such disasters in 2021 alone.[6]

More protectionism, stronger close-knit trade coalitions, and a little less globalisation

A rise in international warfare could lead to conflicting countries further blocking trade and the movement of goods across their borders. The risk of escalated conflict is potentially worsening due to the stresses sharpened by climate change and growing economic inequality. Conflicts are wide ranging and include civil war, criminal violence, sectarian violence, territorial disputes, and transnational terrorism.

Implications for goods movement

- Priority corridors for trade and goods movement will emerge and look different from those we see today.
- Redundancy in operational routes, storage for critical goods, and systematic management of risk and resilience on key goods movement corridors will gain greater importance.

1.3 Role of different nations in manufacturing and consumption

The spread of economic and political power globally is changing, alongside lifestyle choices of populations across the world. The global push to net zero emissions, the advancement in technology and data, and rising incomes coupled with rapid growth in the East and Global South will all disrupt and transform the distribution of manufacturing, trade, and consumption across geographic regions.

The rise and power of emerging economies

Emerging economies such as China, Hong Kong, Indonesia, Singapore, and more have accounted for almost two thirds of the world's GDP growth and more than half of new consumption over the past 15 years.[7] The OECD has projected GDP growth to 2060, and the top five countries are all located in either Asia or Africa.[8] While countries like the US, UK, Germany and Japan will remain as some of the world's largest economies, growth is forecast to slow down. Rapid growth, and economic and urban development could imply a change in the global roles and relationship between the East, South and the West, particularly in terms of investment, production, and consumption.

Changing distribution of foreign investment

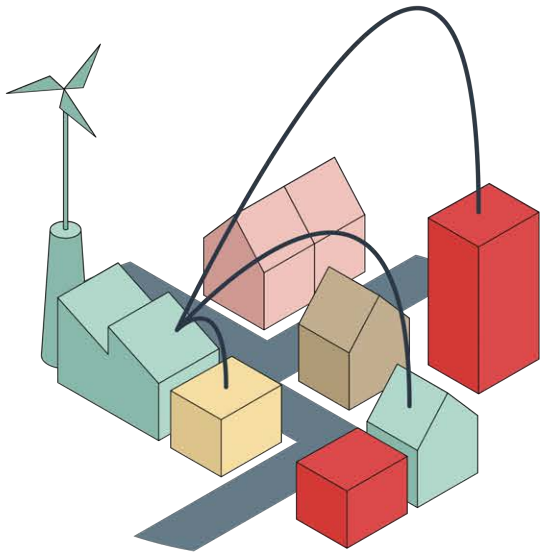
The influence of foreign direct investment (FDI) in the world economy is growing – rising from 22% in the early 2000s to now accounting for 35% of global GDP.[9] While the US is currently the top destination for the world's FDI, there has been a continual shift in the global FDI landscape, with emerging market economies (EMEs) playing a larger role both as a source of and as a destination for investment.

Making things locally – reshoring

Two in five UK-based small businesses are considering a switch to UK manufacturers as rising shipping costs bite into margins and threaten growth, according to a survey of 750 firms by logistics platform ShipBob.[10] Offshoring of manufacturing in the late 20th century was mainly driven by cost economics, with labour being significantly cheaper in developing countries. Now, not only is the wage gap between countries closing, but manufacturing is also not as labour intensive as it once was due to factories embracing automation.

Implications for goods movement

- Patterns around where goods and services are produced and consumed are set to change from what we observe today.



1.4 Technology and changing business and consumption models

Technological innovation affecting everything from access to information which shapes decision making, operations, and consumption choices, to the actual devices and vehicles used to transport goods will continue to disrupt the movement of goods.

Increasing automation

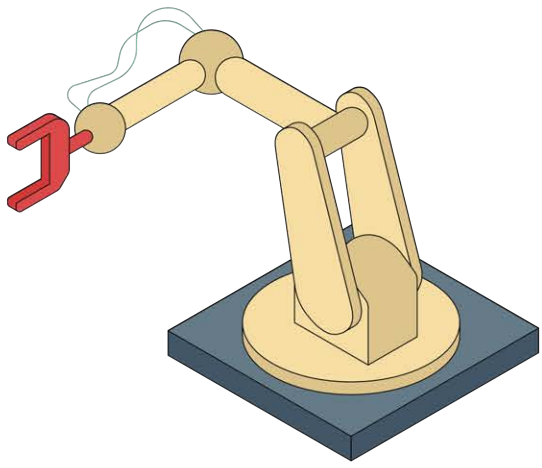
The potential onset of artificial intelligence and robotics, combined with an ageing population, could increase the likelihood of and accelerate the push towards automation. Automation of road or rail transport could significantly reduce operating costs associated with these modes – changing the competitive landscape between modes from a cost perspective. Optimisation enabled through automation of manufacturing and processing facilities could also shift the costs associated with different types of goods production and resulting market demand.

Changing role of e-commerce

E-commerce is on the rise and has already disrupted logistics in major cities - it now accounts for between 16% and 20% of UK commerce by revenue, second only to China.[11] Rapid growth of e-commerce is facilitated by online payments becoming more secure, deliveries becoming faster, tailored marketing to consumers to maximise convenience, and a greater share of companies growing their digital presence.

From ‘mass production’ to ‘mass personalisation’

There is speculation that industry is moving from a ‘mass production’ model – where more generic products suitable to the average consumer are made at high volumes and mass distributed – towards a ‘mass personalisation’ model, where products can be personalised to meet individual customer preferences.[12] There is a strong desire for customisation of products, and some research suggests that businesses which do not incorporate an element of personalisation into their products and services will risk losing customers. According to recent research, one in five consumers who expressed an interested in personalised products or services are willing to pay a 20% premium, and 48% said they are willing to wait longer for a personalised product or service. [13]



1.4 Technology and changing business and consumption models *continued*

Emerging supply chain innovations

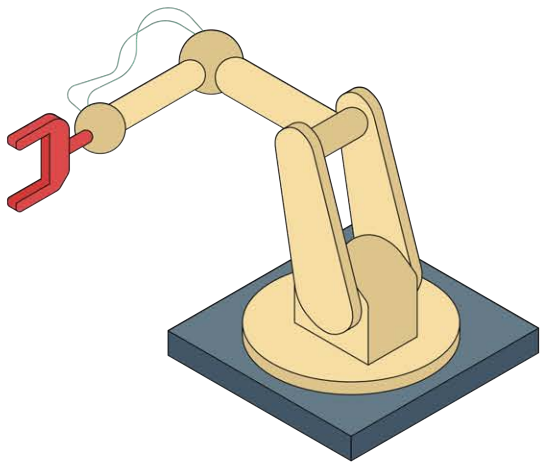
A consumer product company's supply chain on average accounts for 80% of greenhouse gases associated with the product.[14] Innovations to increase the transparency and traceability of supply chains are rising as a result of market and regulatory pressure on companies to manage emissions. Development of multiparty systems such as blockchain, distributed ledger, and tokenization, improve companies' ability to track resource use, sourcing, compliance and fraud prevention, and help in reducing the emissions in their supply chains.

Implications for goods movement

- Lower cost and more capacity for freight on the transport network.
- More policy control over e-commerce.
- Transformation of existing processing and distribution systems.
- Changing volumes of consumed products, waste, and turnover.

More utility and less ownership

In a product-as-a-service (PaaS) model, the customer pays for access and use of a product for a period of time (as one would pay to use a given amount of a utility such as energy or water), alongside due maintenance, rather than paying a fixed fee for permanent ownership of the product. This business model has risen in popularity in recent years and continues gaining traction from a sustainability perspective, as it incentivises businesses to design products with a 'whole life' view and durability in mind. It also makes businesses accountable and better positioned to manage products at the end of their life, as they can reuse parts and components in the design of new products.



1.5 Energy and industrial materials transition

Measured in tonne-kilometres (tkm), energy products made up 36% of global seaborne trade in 2021, and with seaborne trade[15] making up 80% of global freight[16], this represents a significant portion of the global movement of goods. The energy sector is set to see major transformation in the decades ahead. Emissions from energy used in various sectors account for nearly 75% of global greenhouse gas emissions.[17] Alternative clean sources of energy to fossil fuel are fundamental to achieving net zero emissions globally. New low or zero carbon materials to create products and build infrastructure and buildings will also have a major impact on the types of goods which require transporting across the world. However, this is a space of significant uncertainty, rapid innovation, and political volatility. The shape of the energy and materials transition will impact the actual goods and volumes which need to be delivered, how transport systems are powered, key new emerging technologies, and which transport modes become more and less dominant over long distance routes or to carry heavy goods.

Coal

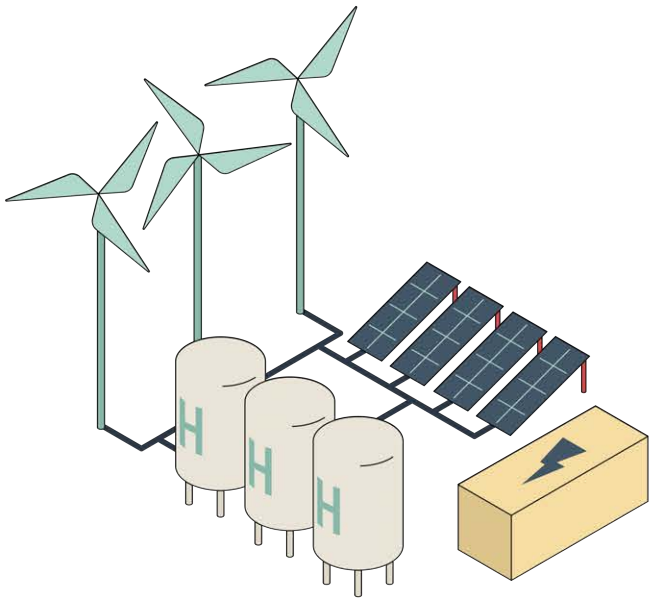
Many countries still have vast coal reserves and some estimates suggest that in the next 20 years energy consumption could increase by 60% and coal will remain the major source of power generation.[18] Global coal production is still trending upwards despite mining decreasing in Europe and the United States due to increased activity in Asia, particularly China which produced 3,969 Mt of coal in 2021 alone. [19]

Natural Gas

Natural gas accounted for a quarter of global electricity generation in 2021, though its level of use varies significantly between nations. It is beginning to be phased out as a source of domestic energy in mature markets, being replaced with air heat source pumps or other clean sources of heat.

While it is projected to see some decline, natural gas is still widely seen as a transitionary fuel likely to play a major role in regions of the world still dependent on coal for electricity, even under the net zero transition.

Conflicts and political instability around the globe remain a factor in the natural gas market, with countries seeking to purchase gas from trusted partners to maintain security of supply. Such a shift includes the importing of liquified natural gas (LNG), with countries building new import terminals to increase their import capacity.



1.5 Energy and industrial materials transition *continued*

Hydrogen

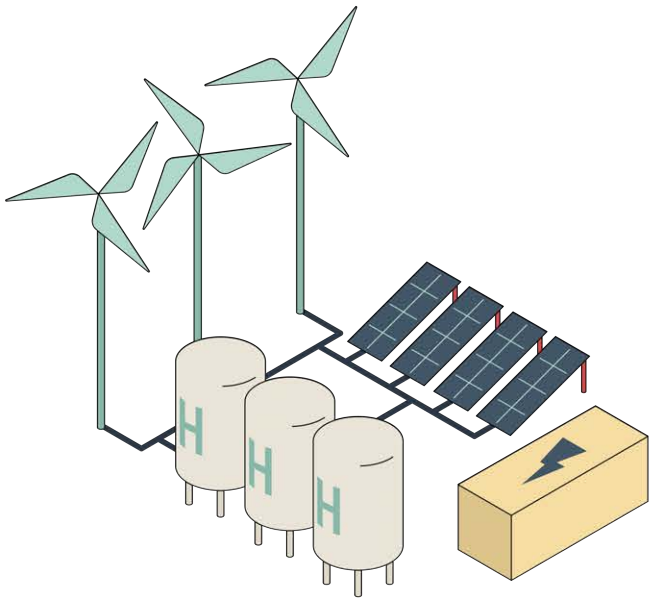
Demand for hydrogen in transport, industrial heat and power grew by 60% in 2021, while still only comprising a fraction of overall global demand for hydrogen.[20] Most of the increase in hydrogen demand has been spurred by road transport and accelerated deployment of fuel cell heavy duty trucks in China. Public R&D funding for hydrogen rose by 35% in 2021 over the previous year - its largest ever annual increase.[21]

Steel

Steel has an enormous impact on global development through its pivotal role in buildings and infrastructure. In the US, structural steel has a 46% market share in non-residential and multi-storey residential buildings.[22] Most crude steel is produced by reducing iron or using coal and is extremely carbon intensive. Europe was once a net exporter of steel products, but since 2016 it has been a net importer with net imports reaching 3 million tons in 2020.[23] The increasing influence of China and the volatility of raw materials make forward outlooks uncertain for the steel industry in other parts of the world. With the pressure to decarbonise spurring innovation and changing centres for demand due to accelerating growth in construction in Asia and Africa, the future of the steel industry or the emergence of any unknown breakthrough materials which compete with steel will have major implications for the world of trade and future goods movement.

Glass

The high temperatures required to melt sand and other materials make the glass industry one of the most energy-intensive industries in the manufacturing sector. Glass remains a key material in packaging, construction, transportation, telecommunication, and electronics. The five biggest glass exporters are mainland China, Germany, United States of America, France and Hong Kong.[24] These countries collectively generated almost half (48.1%) of overall international sales for glass as a material plus glassware products during 2021.[25] China alone accounts for almost 20% of the current global market share.[26]



1.5 Energy and industrial materials transition *continued*

Cement

Cement is the second most consumed product globally after potable water and is used in almost every part of construction.[27] It is also, however, one of the biggest contributors to global carbon emissions and is facing an uncertain future in which there is significant pressure on the industry to decarbonise. Cement production is likely to increase in India and other developing countries in Asia and Africa as these regions undertake significant infrastructure development and growth.[28]

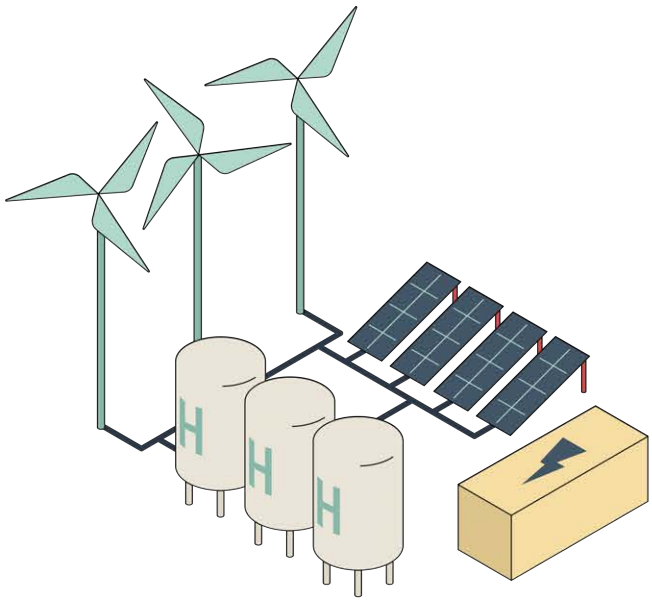
The global shortage of sand[29] and the carbon-intensity of cement production mean that alternative materials and carbon capture technologies are critical for the future of construction. The cement industry is poised for major disruption in the coming future.

Critical Rare Earth Metals

Historically key in the production of catalysts and magnets, critical rare earth elements have seen demand surge in recent years following the widespread adoption of mobile devices and other electronic gadgets. Rare earth elements are crucial in the production of EVs and offshore wind turbines. The IEA expects demand for rare earth metals to increase by between three to seven times current levels by 2040.[30] Production and refining of such metals is highly concentrated, with China responsible for 60% of production and 87% of refining globally – raising concerns over the security of supply.[31] To meet growing demand, mining companies have expanded operations with previously untapped resources such as sub-Saharan Africa. [32]

Implications for goods movement

- Fluctuating volumes of demand for major bulk energy products
- New nodes for production and distribution of key materials



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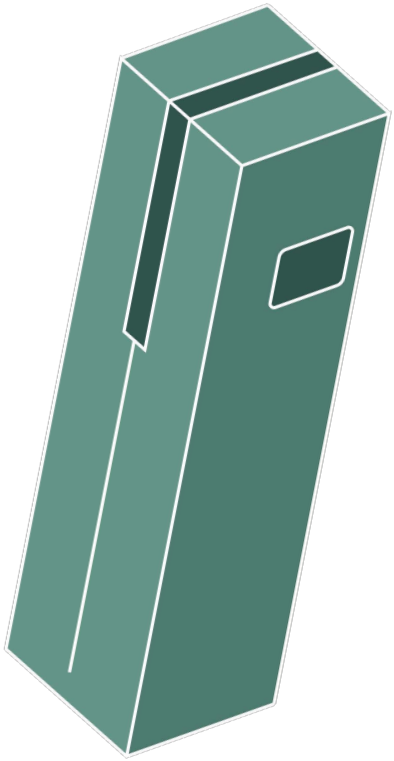
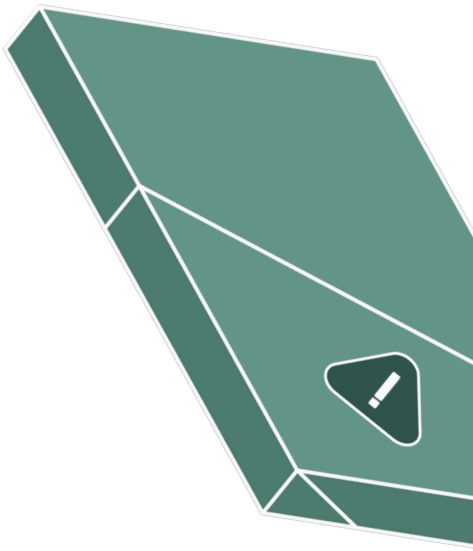
Future mode-specific considerations



On an individual mode level, the underlying strengths and suitable roles of different transport modes will still hold true in most cases under any future scenario – whether it is one which continues to be oriented around high growth or one that is more consumption conscious. Basic strengths of different modes – for example, for ships to travel long distances with heavy goods, or for aeroplanes to provide secure and fast access to critical products – will likely continue to differentiate them and dictate their roles in a changing market. The key consideration for freight operators will still be about offering reliability, resilience, and cost-effectiveness with high quality access to goods for industry and consumers.

However, what will happen with a changing context – such as the implementation of high carbon pricing or the availability of low-carbon aviation fuel at scale – is that some transport modes could start to gain a competitive edge for new use cases. We highlight some of the key opportunities and considerations that emerge for the different major modes of freight transport as a result of key contextual changes we have highlighted as probable.



2.1 What are the prospects for shipping?

Sea shipping is likely to remain the most common way to move large volumes of freight over significant distances between global regions, but there may be a reduction in the volume of demand for sea shipping given the potential future scenarios described earlier. Short sea and inland shipping can be expected to see a relatively higher proportion of freight tonnage (where navigable routes are exist or are viable) as it gains traction in competing with road and rail freight due to both its flexibility in deploying capacity/service as needed, and relatively lower carbon intensity. In some areas, including the UK and parts of northern Europe, there will be significant growth in shipping traffic to construct, maintain, renew and service offshore power generation and transport hydrogen produced by these facilities.

Key considerations, risks and opportunities for future rail, based on our study are as follows:

1
Shipping decarbonisation to reach global net zero targets by 2050.

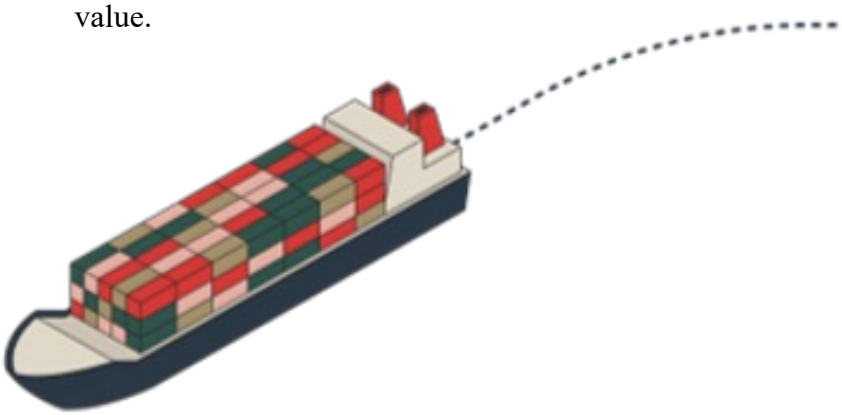
2
More inland and short sea shipping due to its energy efficiency.

3
Global variation in demand for bulk shipping and more localised trade.

4
Future energy products and enabling access to hydrogen or other zero-carbon fuels at scale.

5
Resilient and connected ports for sustainable and undisrupted goods distribution.

6
Repurposing existing infrastructure to identify opportunities for underutilised assets to generate value.



2.1 What are the prospects for rail?

The prominence and suitability of rail in the wider freight ecosystem is subject to significant variation under future contextual shifts (i.e., what is transported, how high the volumes are, where goods are coming from and going to), and therefore the role of rail in transporting goods will be highly dependent on coordinated industry, transport, and land use policy and planning. Rail's primary strength in moving large volumes of goods over medium and long distances will continue to be relevant in the face of ongoing shifts. Rail transport will also likely continue being the best option for adding major increases in transport capacity on highly congested routes. Rail will continue to play a major role in transporting goods along corridors where freight rail network offer strong service and where demand for transporting bulk commodities, such as staple agricultural products and clean fuels, continues to be in place or experiences growth.

Existing rail freight routes in some parts of the world will also see some reductions in demand, most critically in the case of a decarbonisation and circular economy-oriented world from reduced use of fossil fuels and extracted raw materials such as iron ore. In such cases, planners and developers can repurpose facilities and relocate new industries requiring the transport of heavy goods to places where increasingly underutilised, but functioning rail infrastructure sits.

Key considerations, risks and opportunities for future rail, based on our study are as follows:

1
Better balancing the prioritisation of freight and passenger rail to ensure adequate rail freight services.

2
Expanding emphasis on express & mixed passenger/freight rail.

3
New sources of bulk goods to be transported by rail under a circular economy which repositions industry, waste, and resource circulation.

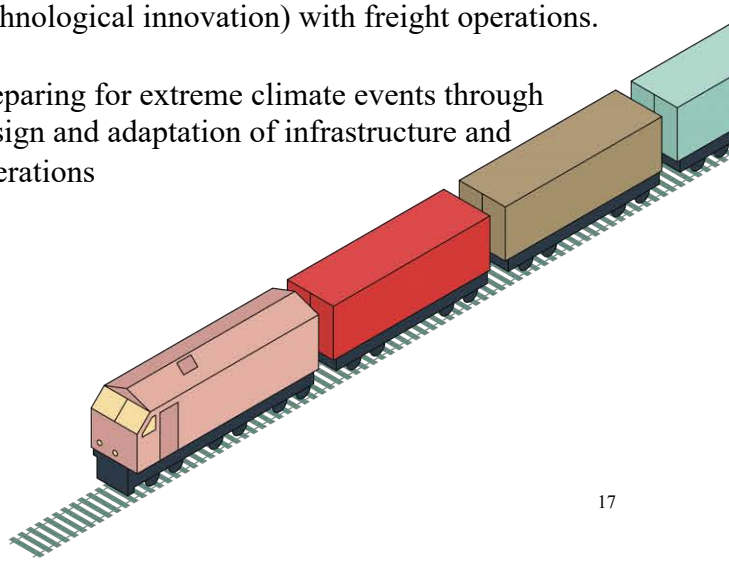
4
Ensuring provision of integrated multimodal freight hubs to ensure optimal utilisation of rail infrastructure.

5
Harnessing potential for sustainable freight by rail in high-growth markets on the cusp of major population and economic booms.

6
Keeping up in decarbonisation efforts with other transport modes

7
Ensuring compatibility of new evolving rail systems (as a result of the energy transition and technological innovation) with freight operations.

8
Preparing for extreme climate events through design and adaptation of infrastructure and operations



2.1 What are the prospects for road freight (HGVs/LGVs)?

Road transport is and will likely remain a dominant form of freight transport across the world owing to its flexibility, ability to deliver last mile, connectivity arising from existing infrastructure, and the ability to carry smaller loads relatively economically when compared with other modes.

Key considerations, risks and opportunities for future road transport based on our study are as follows:

1
Continue as a means of highly flexible transport capacity as demand to transport goods shifts.

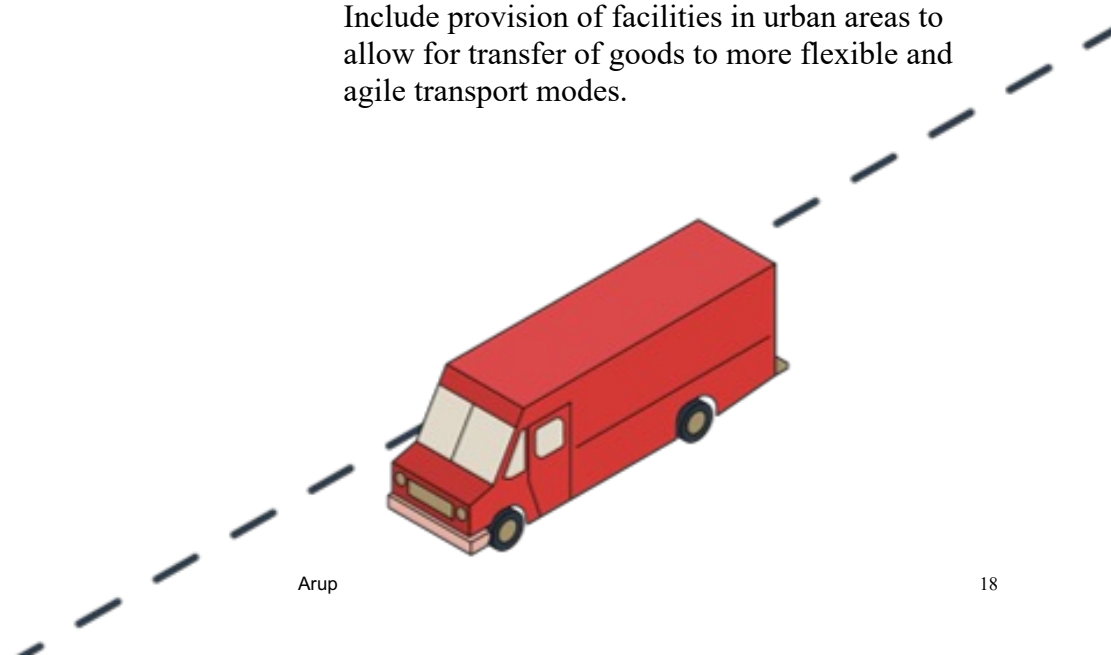
2
Coordinated policy and implementation to align with net zero commitments and enable adequate provision of the infrastructure required for hydrogen/EVs.

3
Enhancing resilience through focus on routes, labour (drivers), and energy sources.

4
Navigating competitive landscape against new and rising lower carbon transport alternatives.

5
Sharing information and deploying technology to maximise vehicle load factors.

6
Include provision of facilities in urban areas to allow for transfer of goods to more flexible and agile transport modes.



2.1 What are the prospects for aviation?

The aviation industry's ability to connect the world at the speed, comfort, and affordability attained to date is undeniably attractive for the world's economy, for collaboration, and for its ability to provide access to both remote places and goods. Due to aviation's focus on light but high value goods, its economic role is far more significant than the volumes it carries would suggest. In a world oriented around sustainability and consumption consciousness, the role for aviation in the movement of goods over the coming decades is likely to continue to be limited to time-sensitive, critical goods, and, if anything, in lower quantities on average than previously seen.

Over the long term (the next 50 - 70 years) such a scenario could imply reduced viability for some freight only and passenger-freight services. In a more high-growth future world, potentially with some breakthrough in sustainable aviation fuels at scale, the quantities of freight transported via air could expand to some degree – but given that the cost of travel via air is likely to remain higher than other modes, air freight in the future will most likely continue to be limited to high value and time sensitive goods.

Key considerations, risks and opportunities for future aviation based on our study are as follows:

1
Prioritising innovation towards net zero aviation

2
Reassessing demand for air freight in a low consumption world

2.1 What are the prospects for pipelines?

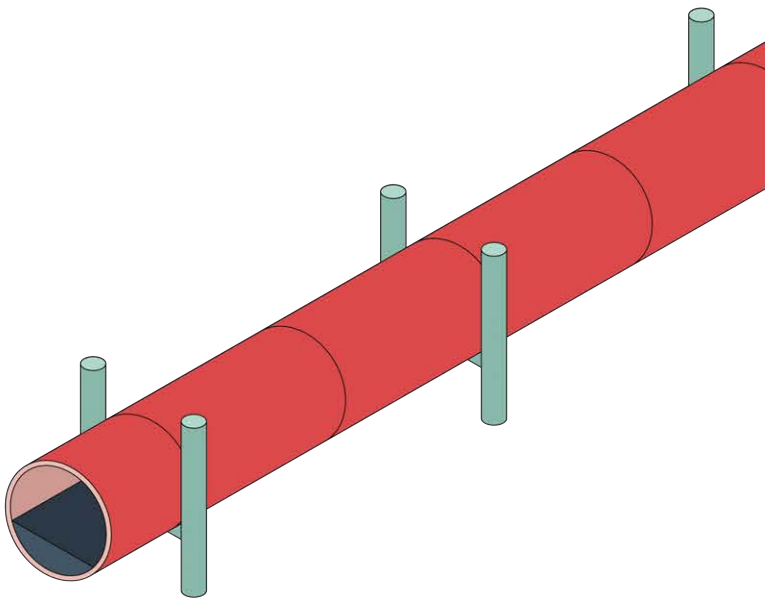
Pipelines offer a safe and efficient way to transport certain liquids and gases without the use of vehicles, but they lack the flexibility of other modes which can carry liquids, gases and other forms of freight. As pipelines are almost solely used in the fossil fuels industry, their role will need to evolve significantly if they are to remain in common use in a net zero scenario. The future of pipelines is therefore highly dependent on the future of hydrogen. Pipelines can be used to transport hydrogen and other clean fuels where volumes are significant. This will remove the need for large numbers of vehicles to transport these fuels, freeing up capacity within those more flexible transport modes for other uses.

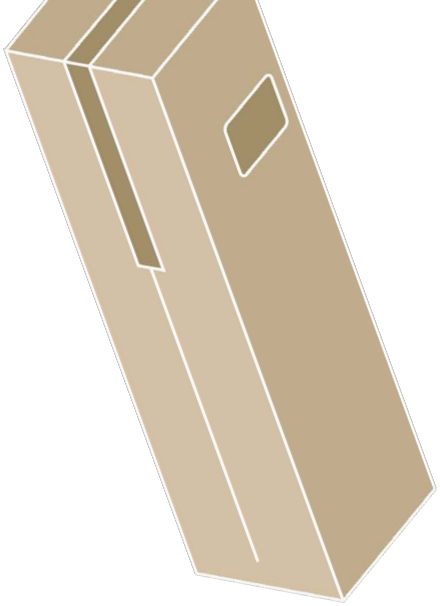
Key considerations, risks and opportunities for future pipelines based on our study are as follows:

1
Coherent planning for repurposing existing pipelines.

2
Guard against overreliance on key conduits.

3
Assess environmental cost of pipelines in comparison to other freight modes for new projects.





3
Key Implications

An overarching change which needs to be implemented in freight related planning under all scenarios for the future is the need to take an integrated systems-level approach to set targets and plan for the desired role of individual transport modes across key corridors (regional and global). As described in this document, the freight industry is a highly interconnected system made up of different components, needs, and actors. Mode-specific targets should only be designated after taking a holistic view of the full freight ecosystem, rather than by mode-specific interests which overlook the wider freight system needs and options. A 'systems-view' – enabled through cross collaboration between industry and government and tracking and sharing of strategic information – to drive decisions and investments for specific technologies, policy mechanisms, and transport modes will be essential. It would allow the industry to successfully overcome some of the challenges seen globally in recent years (and which are predicted to grow) due to unexpected disruptions to goods movement.

In the context of emerging trends and the driving imperative to move towards a more sustainable model for using the world's resources, this report explains the ways in which the movement of goods must change to fulfil its ongoing vital role within the world economy. This includes:

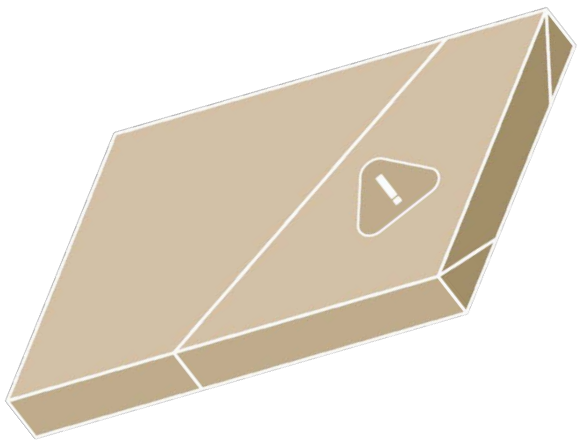
1
Adaptation to serve more sustainable and circular patterns of consumption

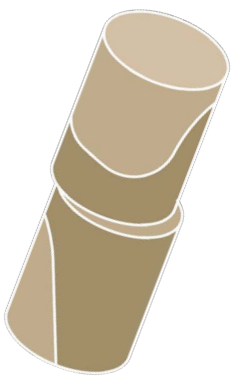
2
Increased resilience of supply chains for critical goods

3
Decarbonisation of all modes of goods movement and adoption of other new technologies to increase efficiency

4
Holistic planning of major flows to incorporate environmental impacts

5
Careful planning of future infrastructure, including (re)use of existing assets





Key Implications *continued*

Overlooking some of the major shifts which could shape the future demands on freight, and continuing the business-as-usual patterns for delivering freight services would likely risk giving way to a period characterised by increased impacts of climate change, disruption to supply chains, misdirected spending on critical infrastructure which lacks resilience to external shocks, and diminishing security of the supply of critical goods for consumers. This will impede the world's ability to implement other vital measures by creating diversion in other efforts and investments which deal with crises, and make it more difficult to deliver other major infrastructure change such as that required for the energy transition.

The currently complex and fragmented nature of the global freight industry means that it is not set up to respond to these unprecedented types of change in a coordinated manner. Some changes can be made by market forces, but the findings of this report are that in many critical areas, a cross-modal and cross-border approach to develop national and regional strategies which inform freight planning and investment would significantly strengthen the future goods movement network. Greater coordination is required between and across industries and governments to provide the freight industry with a framework in which it can effectively manage and react to change.

Key areas where this coordination is most needed are regulation, and in particular, the development of incentives to encourage adoption of lower and zero-carbon technologies, planning, funding and financing of necessary infrastructure changes, and the rollout of industrial polices which fully consider the benefits of simpler supply chains.

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About Arup

Dedicated to sustainable development, Arup is a collective of designers, consultants, and experts working globally. Founded to be humane and excellent, we collaborate with our clients and partners using imagination, technology, and rigour to shape a better world.

About Arup Foresight

Arup Foresight helps organisations understand trends, explore new ideas, and radically rethink the future of their businesses. We examine the many forces shaping the future of a diverse range of topics and industries.

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