



WAREHOUSING IN THE UK: OPERATIONS, PLANNING AND DECARBONISATION

Briefing Report - Summary Slide Set

Technical Report ENG-TR.033

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Warehousing is key to earliest written language

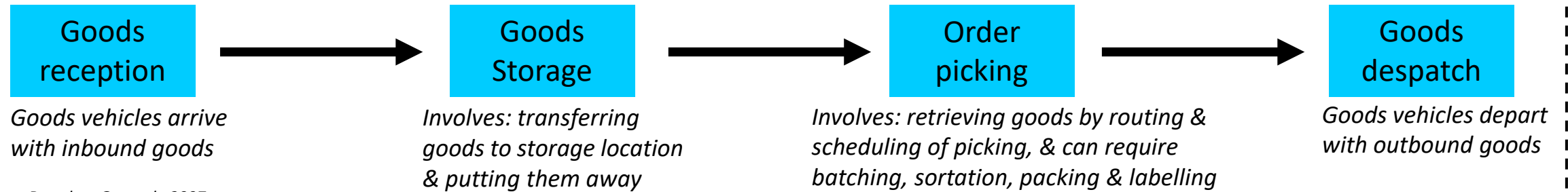
- Clay tablets with cuneiform script were discovered in Uruk in modern day Iraq in 1920s
- These dated back 5,000 years to when Uruk was Mesopotamian settlement on the banks of the Euphrates - among earliest urban civilisations in world
- Scholars struggled to decode the meaning of these earliest surviving examples of writing
- Speculation included they contained stories of gods & goddesses, hagiographies of kings & queens, tales of wonder & awe or epic poetry
- However, when eventually decoded in 1970s, transpired that written language had first emerged to keep count of loaves, jars, crops and animals that were entering & leaving temple storehouses either for trading, planning or taxation purposes
- So, logistics, warehousing & inventory management were inspiration for start of written language
- Even prior to written language, counting marks sometimes accompanied by symbol of a type of product such as grain of wheat, sheep, or loaf of bread, had begun to be inscribed onto clay tokens to keep accounts of goods which were traded from approximately 11,000 years ago in Mesopotamia



Source: Marie-Lan Nguyen
https://commons.wikimedia.org/wiki/File:Sales_contract_Shuruppak_Louvre_AO3766.jpg

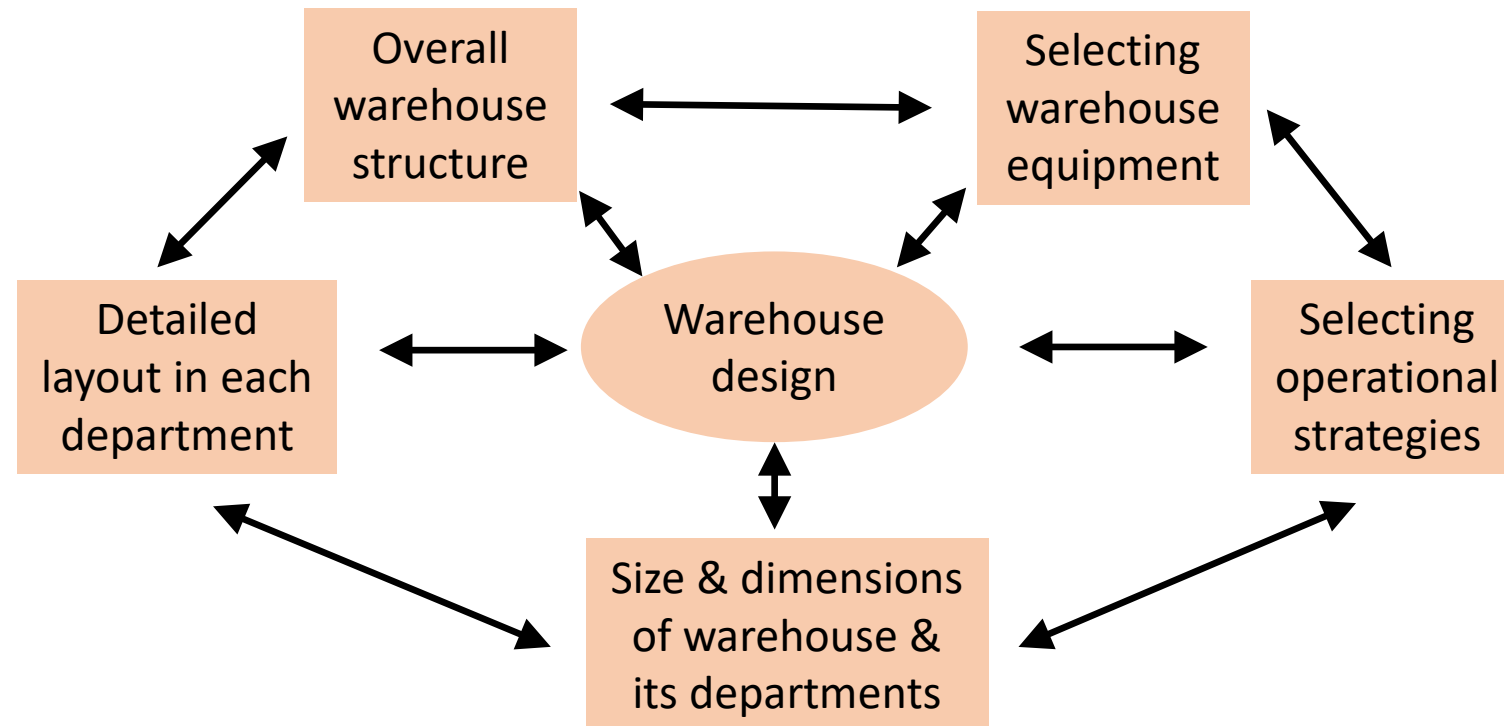
Warehousing: basic activities and design issues

Four basic activities at a warehouse



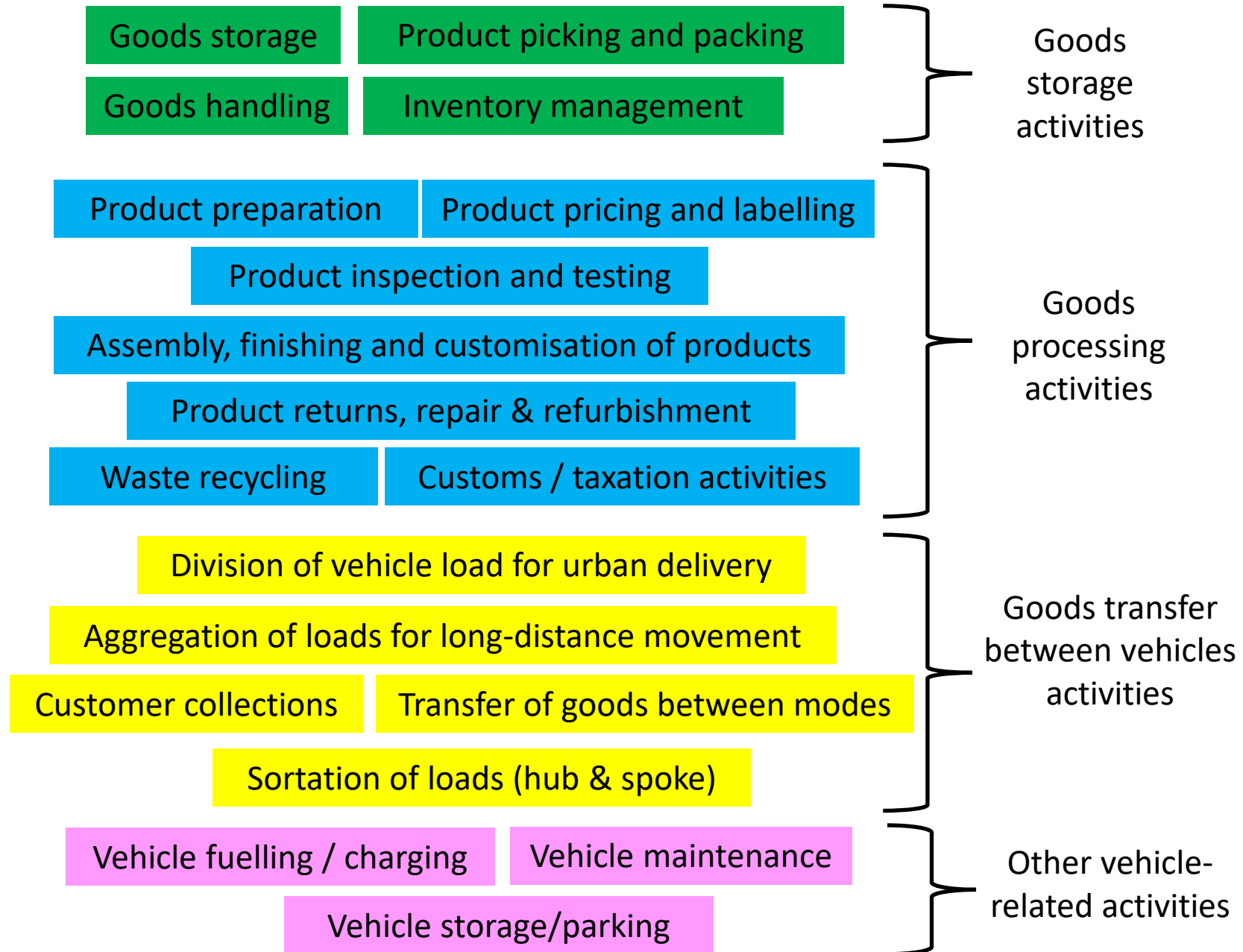
Source: Based on Gu et al., 2007

Five major warehouse design issues



Source: Based on Gu et al., 2010

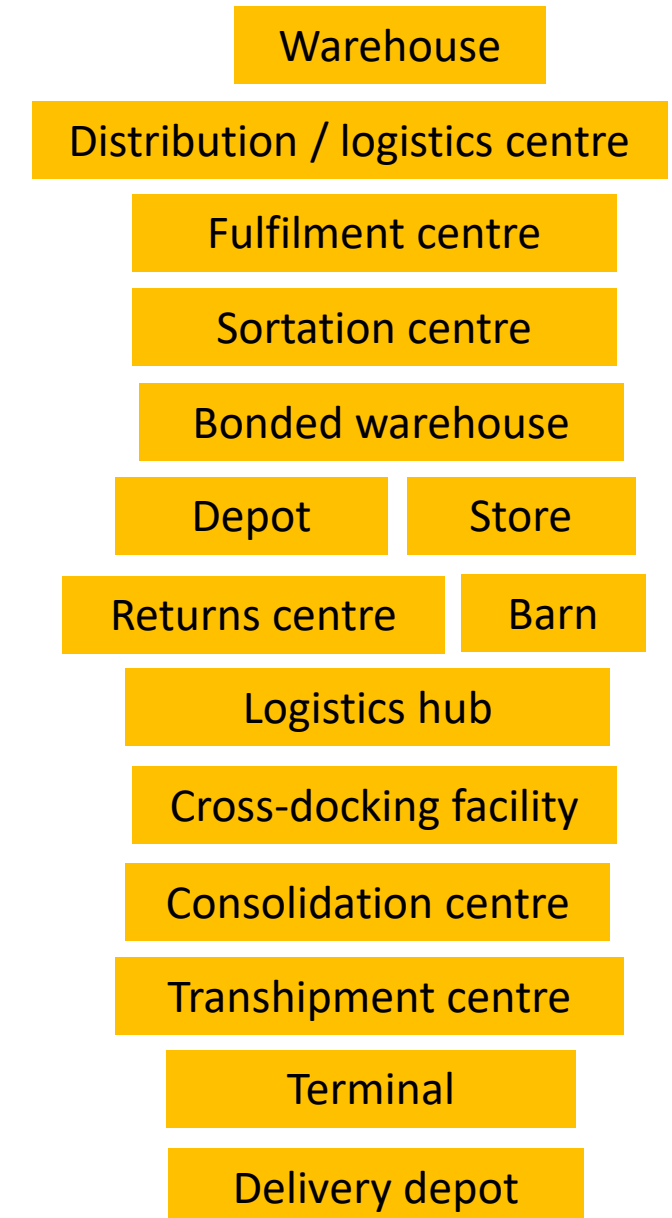
Wider list of activities that can take place at warehouses



Various roles performed by warehouses

- raw materials storage – often close to manufacturing site
- finished goods storage - storing products ready for sale, providing buffer stock for manufacturers, wholesalers & retailers
- intermediate, postponement, customisation or sub-assembly facilities –storing products in supply chain plus assembling/customising products prior to final delivery to customer
- transit warehouses & consolidation points - receiving products from various sources & amalgamating them for onward delivery in supply chain
- transshipment and break-bulk centres - receiving products in large quantities and breaking them down into manageable quantities for onward delivery to many locations
- sortation centres – used in parcel distribution to collect products from wide catchment area, sort by destination address, consolidate & deliver overnight to local depots for final delivery
- cross-dock centres – receiving goods from multiple sources, consolidating & moving them on within hours to their destination (without longer-term storage)
- fulfilment centres – specially equipped and designed warehouses for online retailers to quickly pick, pack and despatch many small orders of fast-moving consumer goods
- reverse logistics centres - dealing with returned items, in online shopping and other sectors where specialist reuse and recycling management is required
- public sector warehousing – supporting national & central government, health service, armed forces, for everyday use & one-off humanitarian needs

Names of freight facilities where goods are held, stored & moved between vehicles



Warehousing industry in the UK

- Warehouses built & provided by commercial property market
- But construction requires planning consent from local planning authorities
- Property developers construct & rent warehouses to occupiers (retailers, manufacturers, wholesalers etc.)
- Most warehouses rented rather than owned by occupier
- Developer either retains ownership or sells to / builds for investors
- Warehouses accounted for 12% of all non-domestic buildings and 34% of all non-domestic floorspace in England and Wales in 2022 (BEIS, 2022)
- UK government data indicates that in 2020 approximately 350,000 people were employed by warehousing and storage businesses (SIC code 5210 – ONS, 2022)
- A total of 630,000 employees described their occupation as relating to warehouse and stock control in 2021 (which includes those working for retailers, manufacturers wholesalers and freight transport and logistics operators) (ONS, 2022)

Warehousing and storage businesses in UK (and comparison with all businesses)

	Number of businesses	Turnover (£ billion)
2010	1,950	11.1
2021	2,965	22.9
% change 2010-2021		
Warehousing & storage businesses	+52%	+106%
All businesses	+19%	+38%

Note: Businesses with employees

Source: ONS, 2021

Number of warehouses and floorspace in England by size of warehouse, 2018

Unit Size (Sq ft)	Properties	Floorspace (million sq ft)
< 50,000	81.6%	42.2%
50,000 - 100,000	10.8%	17.9%
100,000 - 250,000	5.8%	20.8%
250,000 - 500,000	1.3%	10.2%
500,000 - 750,000	0.3%	4.5%
> 750,000	0.2%	4.4%
All properties	100%	100%
All properties (number)	40,080	1,657

Source: CoStar data in Turley, 2019.

- Analysis estimates approx. 40,000 warehouses in England in 2018 with a total 1.7 billion sq ft floorspace
- Warehouses over 100,000 sq ft accounted for 8% of warehouses but 40% of warehouse floorspace
- To give sense of scale, 100,000 sq ft of floorspace equivalent to approximately 1.5 full-size football pitches
- Of warehouses below 50,000 sq ft, estimated that approx. 25% below 1,000 sq ft, 25% between 1,000-2,500 sq ft, 20% between 2,500-5,000 sq ft, 15% between 5,000-10,000 sq ft and 15% between 10,000-50,000 sq ft (calculated from VOA data in BEIS, 2022)

Variation in warehouses and their operations

- Type of goods handled and stored (with some having specific requirements requirements):
 - ambient goods
 - goods requiring temperature controlled storage (such as chilled and frozen)
 - bonded goods for import or export
 - hazardous goods with legal requirements
 - licensed goods (such as pharmaceuticals, and certain liquids, powders and gases)
 - goods stored in open facilities (such as agricultural crops)
- Goods handled and stored may be loose items, or contained in secondary or tertiary packaging to assist handling and storage space used (such as boxes, crates, pallets, containers or other type of unit load)
- Rate at which goods move through warehouse, the quantities handled and the storage period vary by product types, supply chain and purpose of warehouse
- Warehouses also vary in terms of their:
 - size
 - location
 - age of the building
 - facilities, handling equipment used and degree of automation

Relationships between owners and occupiers of warehouses

- Warehouses usually rented rather than owned by occupier in UK
- Ownership of warehouse & land either retained by property developer or other investor (such as pension & investment funds, private equity & sovereign wealth funds) who receive rental income
- UK warehousing lease durations fell following 2008 recession, then gradually rose again from 2011 due to strength in sector but experienced further falls since 2018 onwards due to Brexit & Covid-19
- In 2019, average duration of industrial (warehousing & manufacturing) lease in UK was 6.7 years compared to high of 7.3 years (2002) & low of 4.6 years (2011) (MSCI & BNP Paribas Real Estate, 2019)
- Warehouse leases typically longer for larger business occupiers given adaptations to warehousing space they may make (such as fitting of expensive internal layouts, docks and automated equipment) given costs of such adaptations - longest warehouse leases usually not more than 25 years
- Warehousing lease arrangements often favour owner (i.e. landlord) rather than occupier (i.e. tenant)
- Costly legal disputes over warehousing leasing contracts can arise between owners and occupiers
- Requirements for occupiers to obtain permission from owner to make changes to warehouse and its fixtures and fittings & lack of occupier's ownership of assets installed are major sources of inflexibility in use of warehouse space & key deterrent to investment in technology & automation that can improve warehouse efficiency & decarbonisation

Examples of large modern warehouses

Amazon, in Graben in Germany



Source: Gberstel, 2012

https://commons.wikimedia.org/wiki/File:Amazon.de_1204_-_panoramio.jpg

Morrisons in Bridgwater, West of England



Source: Robin Stott, 2012

https://commons.wikimedia.org/wiki/File:Stobart_truck_at_Morrisons_distribution_centre,_Bridgwater,_Somerset,_16_July_2012.jpg

Focus in Tamworth, West Midlands



Source: Geoff Pick, 2009

https://commons.wikimedia.org/wiki/File:Focus_National_Distribution_Centre,_Tamworth_-_geograph.org.uk_-_1370931.jpg

Tesco in Cheshire, North West England



Source: J.Thomas, 2012

https://commons.wikimedia.org/wiki/File:Amazon.de_1204_-_panoramio.jpg

Examples of other types of warehouses

Modern multi-storey warehouse in Tokyo, Japan



Source: Comyu
[https://commons.wikimedia.org/wiki/File:DPL_Koto_Fukagawa_\(Warehouse_Etchujima_Street_Side\).jpg](https://commons.wikimedia.org/wiki/File:DPL_Koto_Fukagawa_(Warehouse_Etchujima_Street_Side).jpg)

Small post-war warehouse in Maidstone



Source: N.Chadwick
https://commons.wikimedia.org/wiki/File:Wrights_Warehouse,_Waterloo_St_-_geograph.org.uk_-_2253435.jpg

Post-war warehouse in dock area in Hull



Source: Ian S
https://commons.wikimedia.org/wiki/File:Warehouse_J_on_Albert_Dock,_Hull_-_geograph.org.uk_-_3708222.jpg

Smaller modern warehouse in Newton Abbott



Source: Derek Harper
https://commons.wikimedia.org/wiki/File:Warehouse,_Brunel_Industrial_Estate_-_geograph.org.uk_-_4020466.jpg

Examples of older warehouses

Canal warehouse in Gloucester



Source: Christine Johnstone, 2011
https://commons.wikimedia.org/wiki/File:The_National_Waterways_Museum,_Llantony_Warehouse,_Gloucester_Docks_-_geograph.org.uk_-_2522736.jpg

Bonded warehouse on canal in Stourbridge



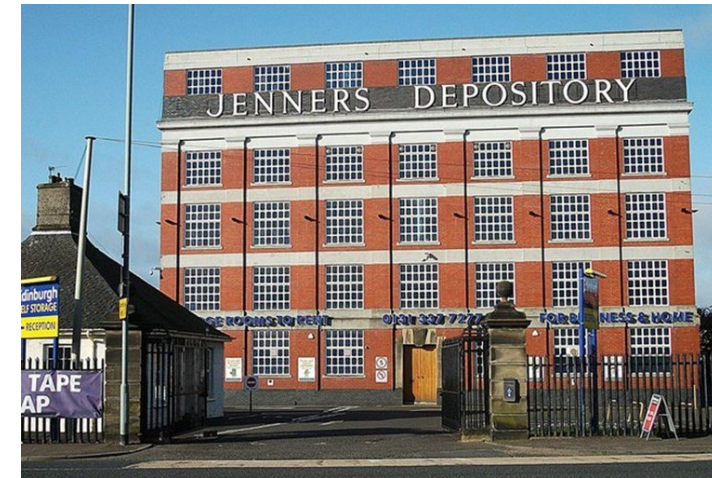
Source: Richard Rogerson, 2010
https://commons.wikimedia.org/wiki/File:Bonded_Warehouse,_Stourbridge_-_geograph.org.uk_-_1960494.jpg

Piano warehouse in Brighton



Source: Paul Gillett, 2012
https://commons.wikimedia.org/wiki/File:Brighton_Piano_warehouse_-_geograph.org.uk_-_2761914.jpg

Jenners Depository in Edinburgh



Source: Michael Ely, 2011
https://commons.wikimedia.org/wiki/File:Jenners_Depository,_Saughtonhall_-_geograph.org.uk_-_2356710.jpg

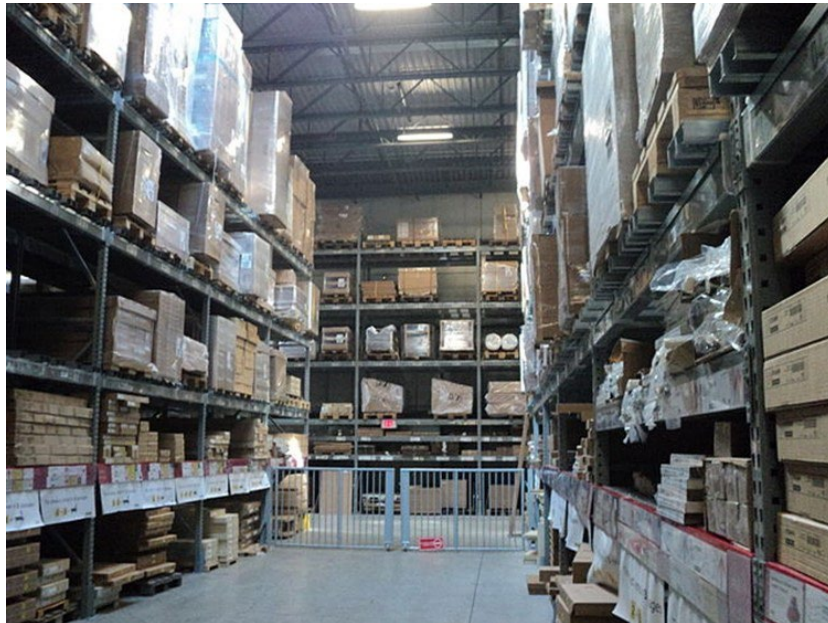
Examples of modern warehouse interiors



Source: axisadman https://commons.wikimedia.org/wiki/File:Modern_warehouse_with_pallet_rack_storage_system.jpg



Source: https://commons.wikimedia.org/wiki/File:Warehouse_md17.jpg



Source: https://commons.wikimedia.org/wiki/File:Ikea_warehouse_interior.JPG

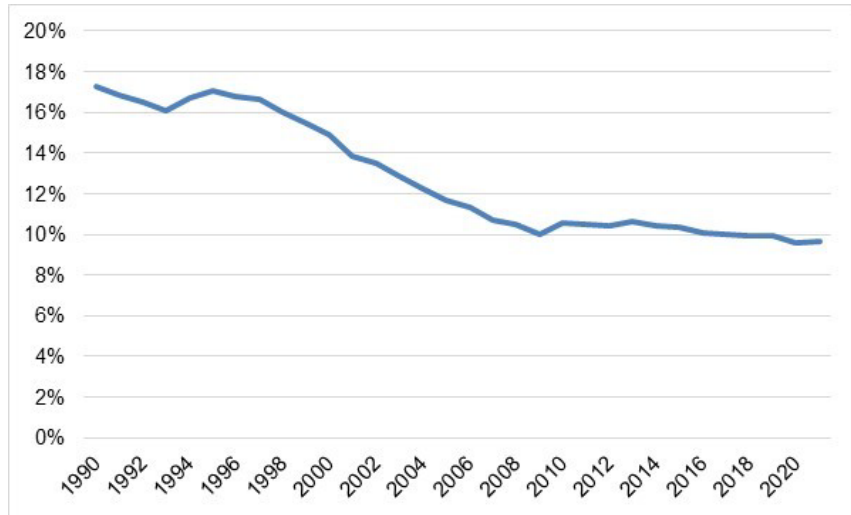


Source: <https://commons.wikimedia.org/wiki/File:Magazyn-logiq.jpg>

Issues affecting warehouse quantity, size and location in the UK since mid-1960s

- Growth in relative and absolute importance of retailing
- Growing reliance of imports of manufactured goods
- Changes in inventory management:
 - Retail market concentration
 - Centralisation and rationalisation of stockholding into fewer, larger warehouses
 - Led to lower total costs of holding stock and deploying automation in fewer warehouses (economies of scale – square-root law) but higher freight transport costs (but freight transport relatively cheap)
 - Move of warehousing away from urban areas due to manufacturing loss, land values, traffic congestion, catchment areas served
 - Reduction in stockholding levels in shops and offices requiring more frequent replenishment
- Large warehouses developed outside of urban areas – good accessibility to motorway network and cheaper land values
- Ever greater dependence on and levels of road freight transport activity
- Shift towards more road freight activity serving fewer but larger warehouses facilitated by vehicle technology and regulatory change in vehicle carrying capacities (weight & volume) and vehicle speeds

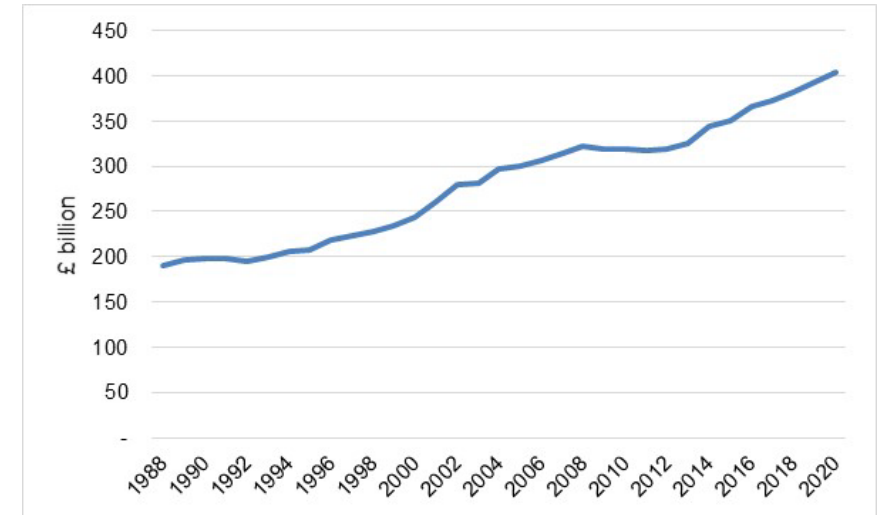
Manufacturing industry share of the UK's total economic output, 1990-2021



Source: ONS, 2022

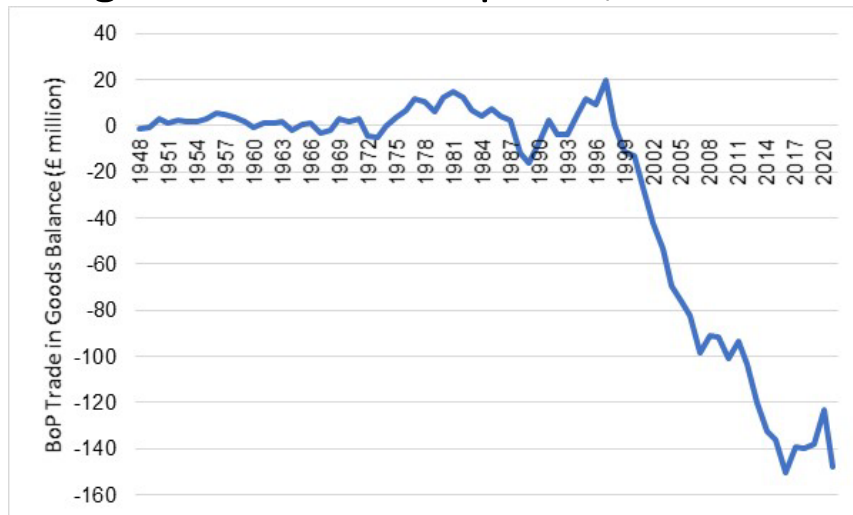
Changes in UK manufacturing, retailing and international trade in goods

Retail spending in the UK at constant prices, 1988-2020



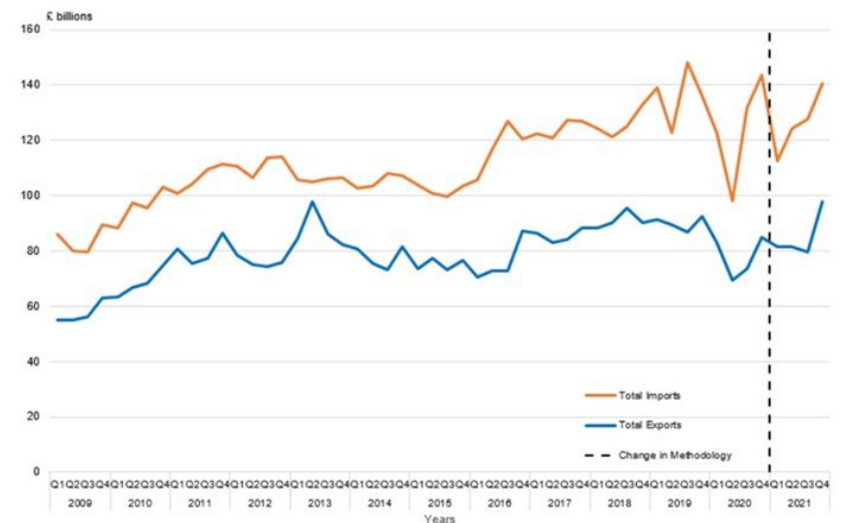
Source: calculated from data in ONS, 2022

UK Balance of Payments international trade in goods at constant prices, 1948-2021



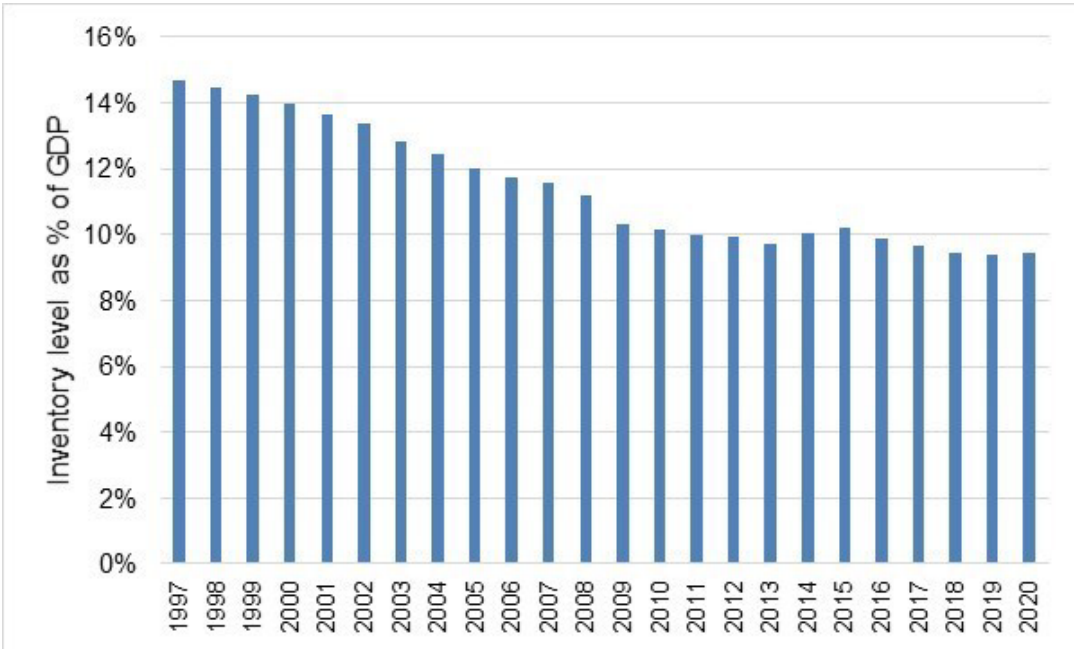
Source: ONS, 2022

Quarterly UK Trade in Goods, 2009 – 2021



Source: HM Revenue & Customs, 2022

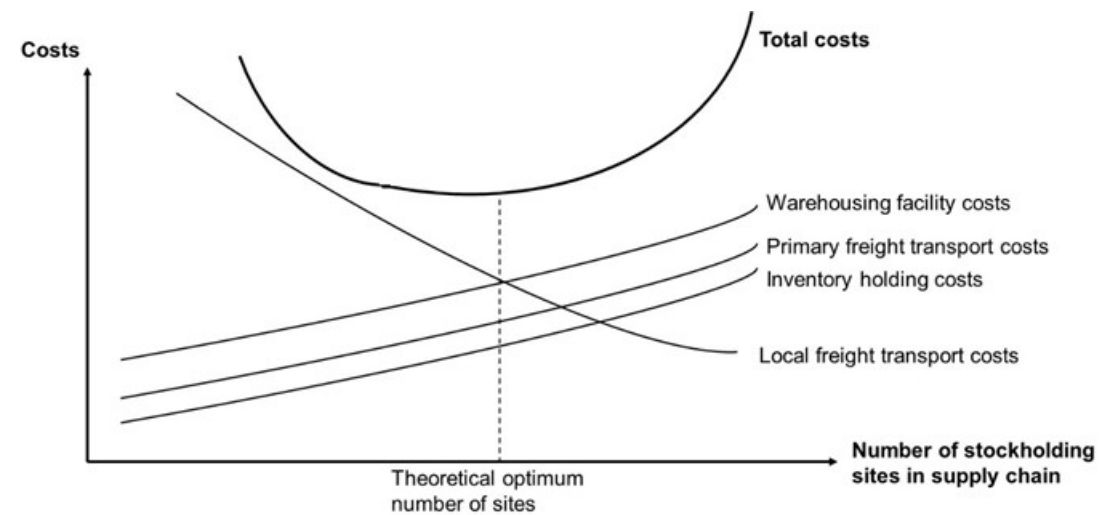
Value of stock in UK economy as proportion of GDP, 1997-2020



Note: includes stocks of raw materials, work-in-progress materials, and finished goods and based on current prices.

Source: calculated using data in ONS, 2021, 2022.

Trade off-between warehousing and freight transport costs

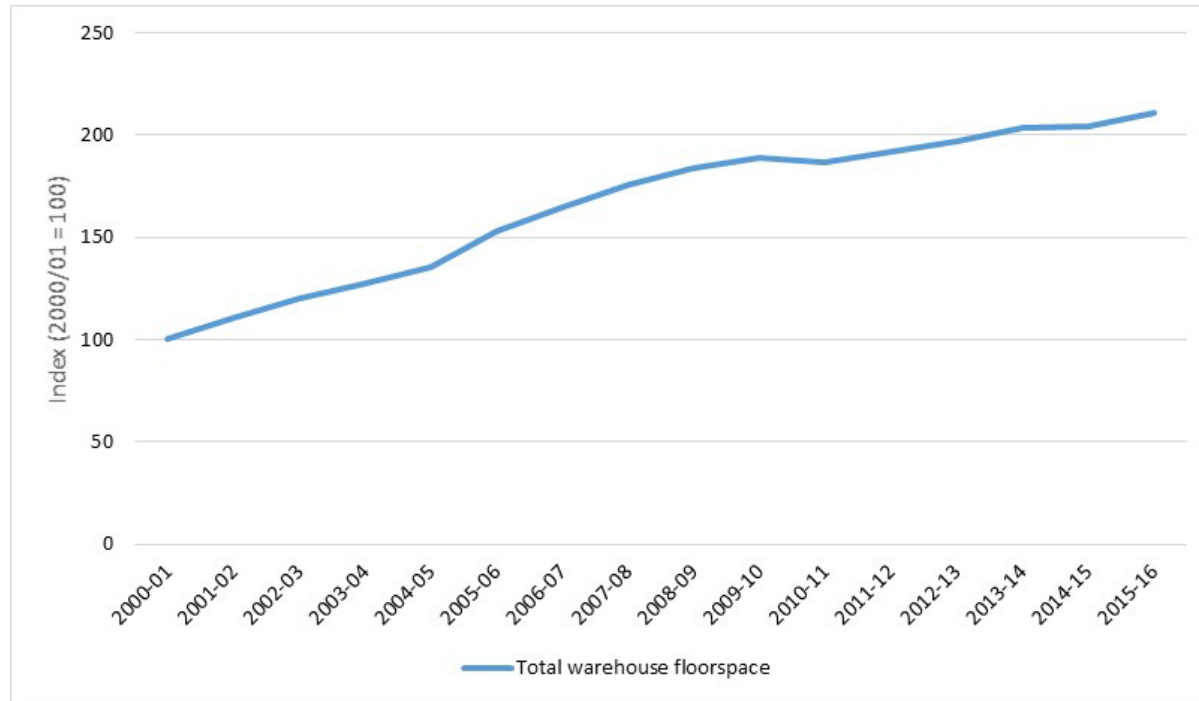


Source: Adapted from Braithwaite and Christopher, 2016.

- Value of stock as % of GDP falling despite absolute growth in warehousing floorspace and increases in retailing and net imports of goods over period
- Indicates improvements in logistics management (time goods spend stored in warehouses)
- Role of warehouses becoming increasingly dynamic as goods move quickly through them with increasing reliance on freight transport activity

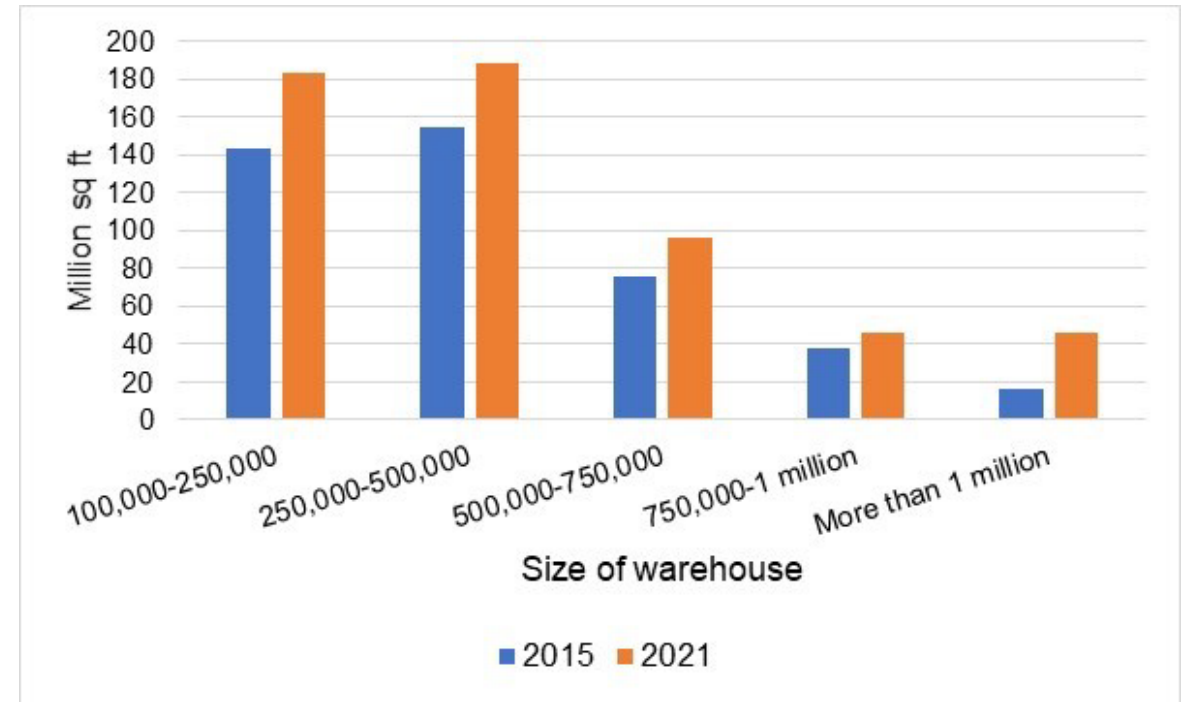
Growth in warehouse floorspace (for those over 100,000 sq ft)

Change in total floorspace of large warehouses in England and Wales, 2000/01-2015/16



Source: calculated from data in VOA, 2018

Change in warehousing in Britain by floorspace, 2015-2021



Source: Savills research in UKWA and Savills, 2021

- Average warehousing size increasing over recent decades with growing proportion of floorspace in warehouses over 100,000 sq ft
- Floorspace of large warehouses increased by approx. 100% between 2000-2015 & further 35% from 2015-2021
- Average eaves height of warehouses has also increased greatly over time (from typical 5 metres fifty years ago to 14 metres for large warehouses in 2021 - Allen et al., 1996; UKWA and Savills, 2021)

Floorspace in large warehouses (over 100,000 sq ft) in 2021 by region

Region	Floorspace (% of total)	Sq ft per head of population
East Midlands	22%	23.7
West Midlands	16%	13.9
South East	15%	9.0
North West	15%	10.9
Yorkshire and Humber	12%	11.4
Inner M25	7%	4.3
South West	6%	5.7
East of England	4%	3.7
North East	3%	6.3
Total	100%	9.6

Source: calculated from data in UKWA and Savills, 2021; ONS, 2022



620,000 sq ft



450,000 sq ft



150,000 sq ft

- Can be on distribution parks with multiple warehouses
- Only about 6% of this floorspace is rail-connected (GL Hearn et al., 2022)
- Difficulty gaining planning approval for strategic rail freight interchanges (SRFIs)

Uses of warehousing space in Britain in large warehouses

Warehouse type	% of total warehousing space in 2021
Freight transport/logistics	19%
Retail (high street)	16%
Retail (food)	12%
Retail (online)	11%
Manufacturing	8%
Food service	6%
Automotive	3%
Wholesale	3%
Parcel/mail	3%
Other	20%
Total	100%

Notes:

'Other' includes waste management sites, data centres and film studios.

Only includes warehouses over 100,000 sq ft

Source: UKWA and Savills, 2021.

Largest gainers in warehouse floorspace 2015-2021 (in order of importance):

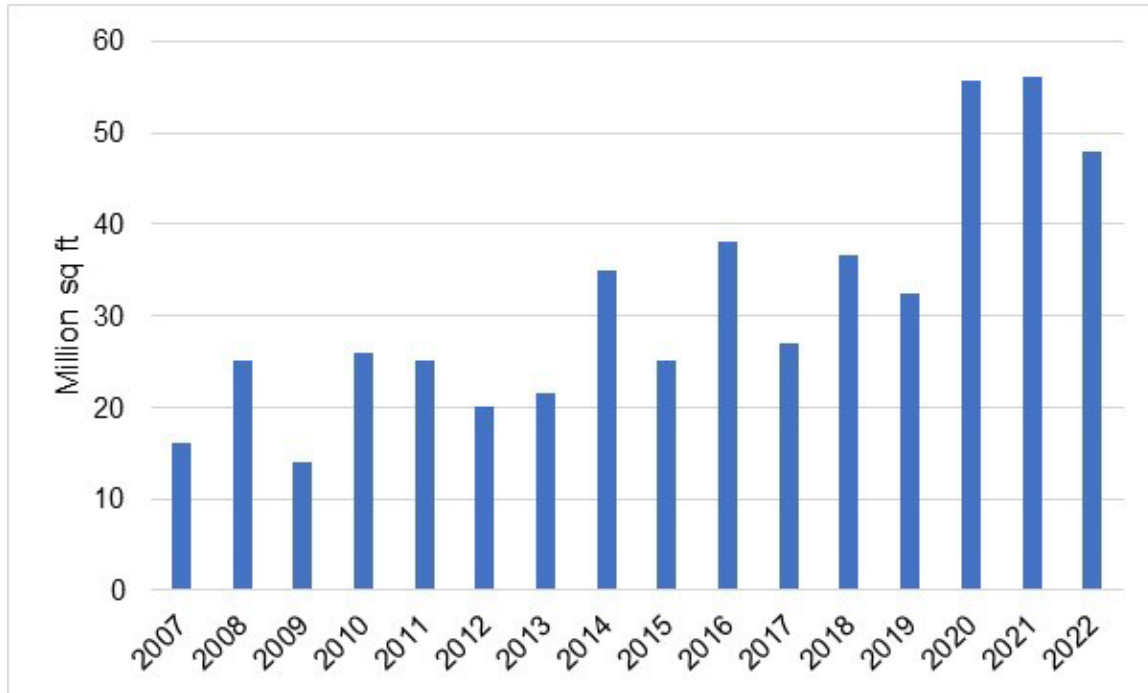
- Online retail
- Freight transport / logistics operators
- Other (filming and data centres)

Largest fallers in warehouse floorspace 2015-2021 (in order of importance):

- High street retailing
- Manufacturing
- Grocery retailing

Online retail accounted for 35-40% of take-up of UK warehousing space in warehouses over 100,000 sq ft in 2021

New leases signed for warehouses in Britain, 2007-2022

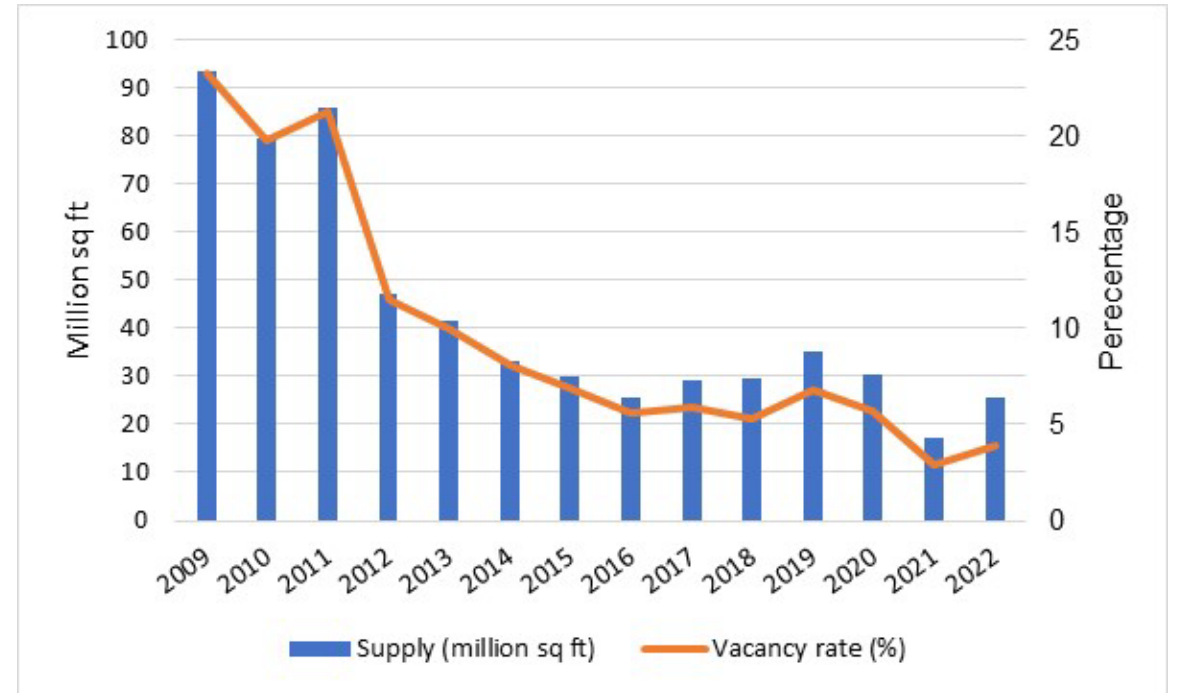


Note: only includes warehouses over 100,000 square feet

Source: based on data in Savills, 2022

- 55 million sq ft taken up in 2021 (highest ever recorded) & 48 million in 2022
- Factors increasing demand for warehousing:
 - Brexit and Covid-19 causing disruption in international goods shipment
 - Rise in online shopping
 - Improving customer service levels / delivery lead times

Warehouse floorspace annual supply and vacancy rate in Britain, 2009-2022



Note: only includes warehouses over 100,000 square feet

Source: based on data in Savills, 2022

- Vacancy rate of 2.9% in 2021 - lowest ever recorded
- Supply not keeping up with demand
- Warehouse rental prices increasing
- Insufficient land being made available by planning authorities in locations required
- National & local government keener on housing development
- Likely to lead to warehouse shortage as supply cannot keep up with demand

Changes in warehousing rental prices

- Warehousing demand has been outstripping supply & this is having upward pressure on warehouse rental rates, which rose by 61% nationally from 2011-2021, more than double rate of inflation (CoStar quoted in BPF and Savills, 2022)
- Increases in rental prices especially strong in recent years, rising 18% on average nationally from 2020-2021 & further 13% from 2021-2022 (JLL, 2023)
- Between 2019-2021 average rental prices rose in all regions, with increases exceeding 15% in all regions except the North West, & the South West & Wales (calculated from data in Savills, 2022, 2023)
- Between 2021-2022 average rental prices again rose in all regions, with increases exceeding 10% in all regions except the South West and Wales (calculated from data in Savills, 2022, 2023)

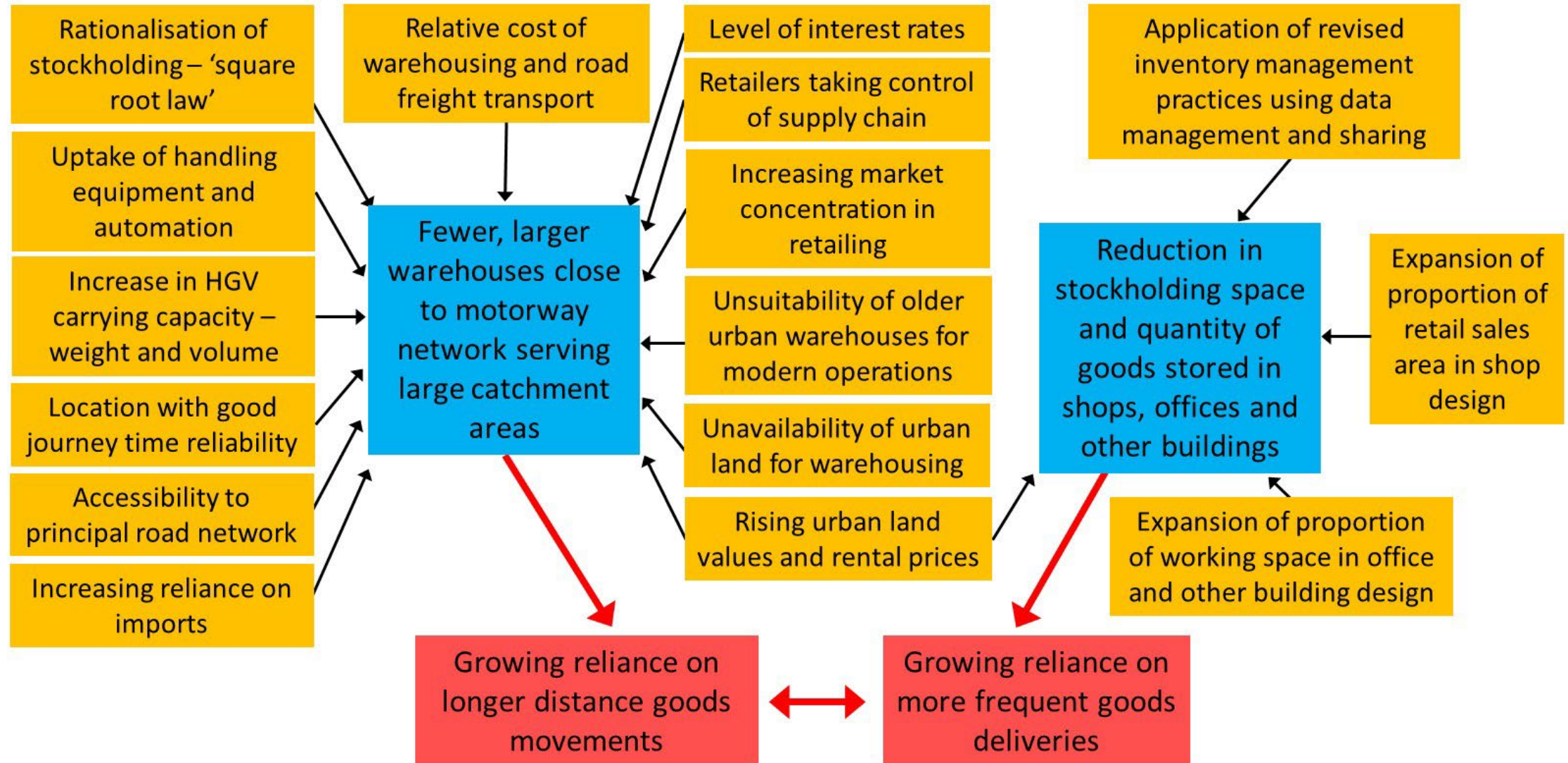
Average rental prices for warehouses over 100,000 sq ft by region, 2017, 2019, 2021 and 2022 (£ per sq ft)

Region	Rental price (£ per sq ft)				% change**			
	2017	2019	2021	2022	2017-19	2019-21	2021-22	2017-22
East Midlands	£6.50	£6.75	£8.25	£9.75	4%	22%	18%	50%
West Midlands	£7.00	£6.95	£8.75	£9.75	-1%	26%	11%	39%
London & South East	£7.00-14.50	£7.75-20.00	£8.50-25.00	£9.00-35.00	11-38%	10-25%	6-40%	29-141%
North West	£6.50	£7.25	£7.75	£8.75	12%	7%	13%	35%
Yorks & North East	£5.75	£5.75	£7.50	£8.25	0%	30%	10%	43%
East of England	£5.50	£6.00	£7.00	£7.75	9%	17%	25%	59%
South West & Wales*	£7.25	£7.25	£7.50	£8.75	0%	3%	3%	7%
Scotland	£5.25	£5.75	£7.00	£8.00	10%	22%	14%	52%

Notes: Rental prices for grade A warehouses. * South West only not including Wales in 2017 data. ** shows range in percentage change for lower and higher rental values where applicable.

Source: calculated from data in Savills, 2018, 2020, 2022, 2023.

Summary of issues driving change in warehousing and stockholding strategies and their impact on road freight activity in recent decades in UK



Freight lifted to/from UK and domestically within the UK, 1980-2020 (million tonnes)



Source: calculated from data in DfT, 2021

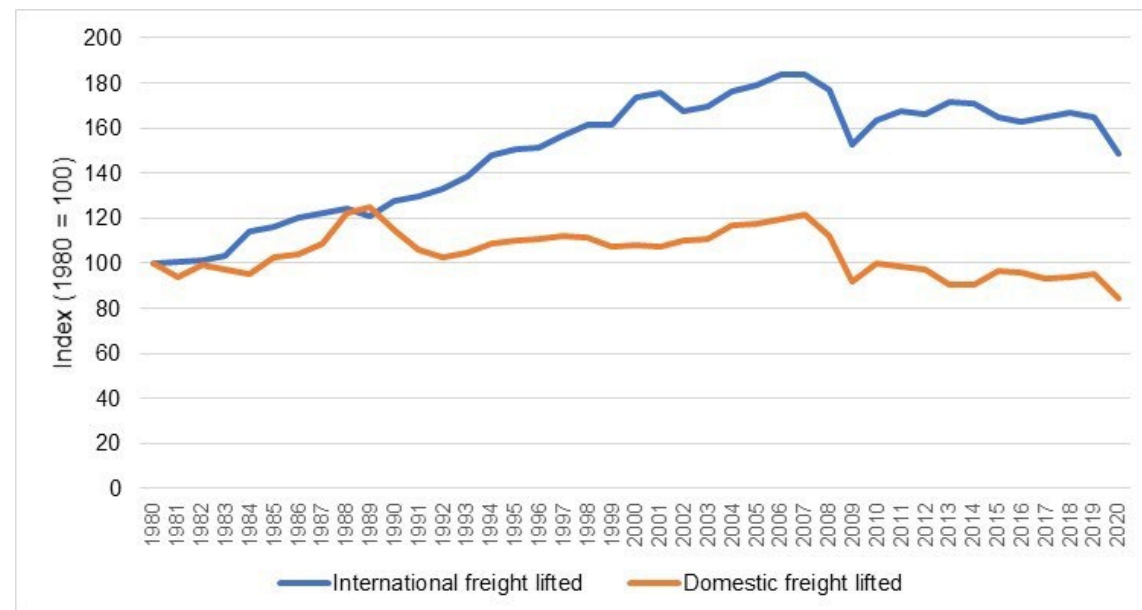
International freight transport to/from UK, 2020

Mode	Million tonnes	% of tonnes lifted
Maritime	348.7	93.4%
Rail	22.9	6.1%
Air	1.9	0.5%
Total	373.5	100%

Note: rail includes through trains and HGVs on Le Shuttle

Source: calculated from data in DfT, 2021

Freight lifted to/from UK and domestically within the UK, 1980-2020 (based on tonnes lifted: index 1980=100)



Source: calculated from data in DfT, 2021

Domestic freight transport within UK, 2020

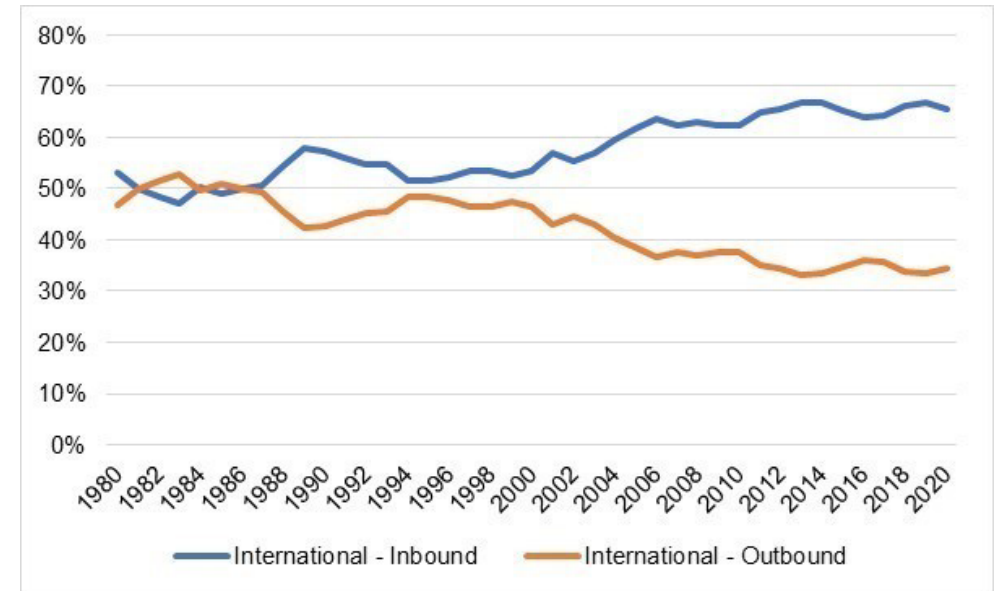
Mode	Million tonnes	% of tonnes lifted
Road	1271.8	89.1%
Water (coastal & inland)	86.8	6.1%
Rail	69.0	4.8%
Air	0.1	0.01%
Total	1427.6	100%

Source: calculated from data in DfT, 2021

Growing goods imports to UK travelling via warehouses over recent decades

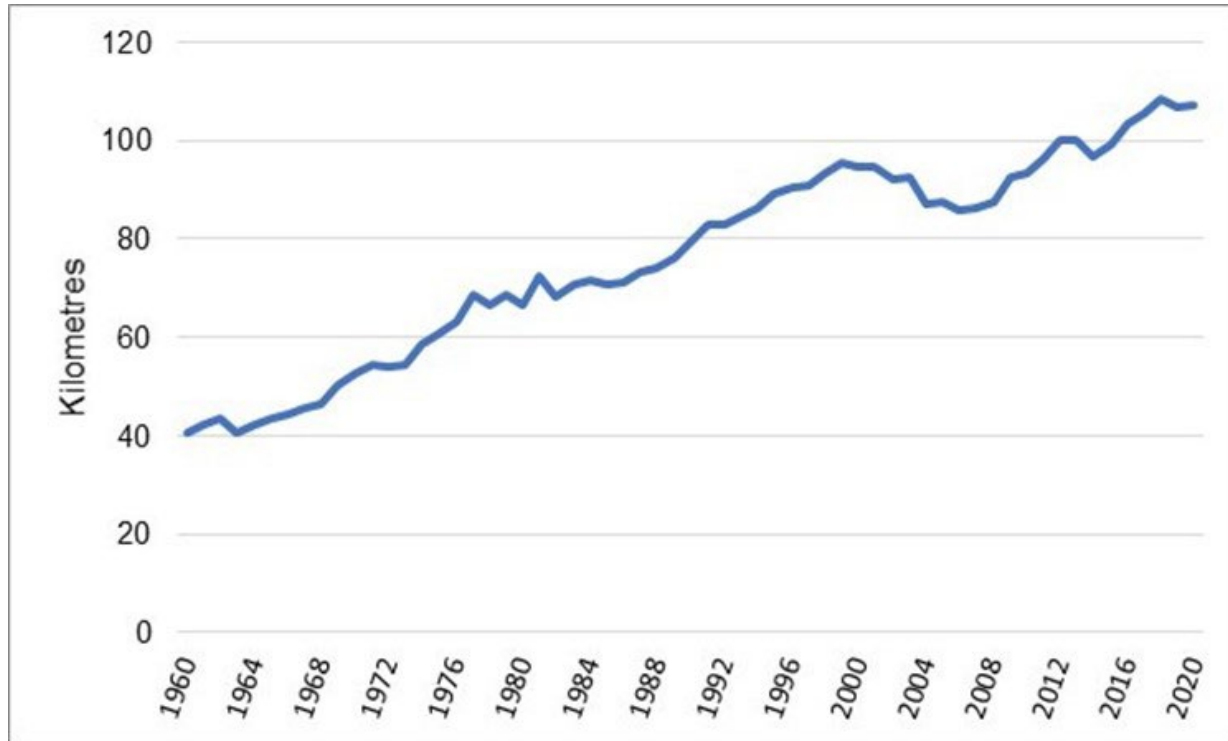
- The growing importation of consumer and capital goods into UK has led to increasing international freight transport
- Extent to which goods imports exceed exports at major UK seaports has grown over last 40 years
- Since 2000 outbound cargo has fallen in absolute terms while inbound cargo has continued to increase when economy has grown
- Tonnes of international freight to/from UK accounted for 26% of domestic freight lifted in UK in 2020 (up from 15% in 1980)
- In 2020, imports at UK major seaports accounted for 65% of all international cargo handled
- Vast majority transported to/from UK by sea (93%) (via short-sea and long-sea routes) by rail (6%) (through Channel Tunnel) & air (<1%)
- 3.0 million RoRo goods vehicle/trailer crossings to/from UK (compared with 0.7 million in 1983)
- Imported consumer & capital goods transferred to warehouses mostly moved in containers (RoRo and LoLo) with onward movement from port to warehouse mostly by road (only 6% of floorspace at large warehouses has rail connection)

Proportion of inbound and outbound international freight to and from UK major seaports, 1980-2020 (based on tonnes handled)



Source: calculated from data in Department for Transport, 2021

Average length of haul by HGVs in Britain, 1960-2020



Source: calculated from data in Department for Transport, 2021

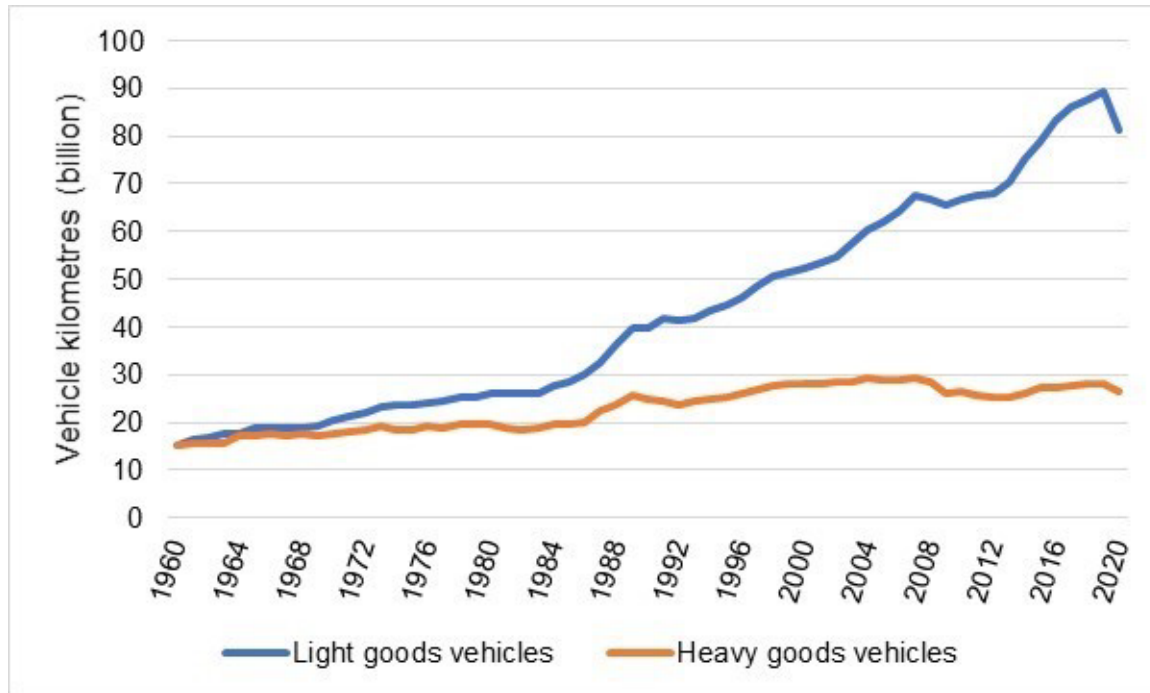
Period	% change in ave. length of haul
1960-1970	30%
1970-1980	26%
1980-1990	19%
1990-2000	19%
2000-2010	-1%
2010-2020	15%
Entire period (1960-2020)	165%

- Average length of haul by HGV increased 165% over the period 1960-2020

Vehicle trip generation at warehouses

- Can be substantial vehicle movements
- Vehicle trip generation methodology used in planning applications can result in underestimates
- This can lead to inadequate warehouse site plot ratios

Vehicle kms travelled by LGVs and HGVs in Britain, 1960-2020



Source: calculated from data in Department for Transport, 2021

- Shift towards:
 - fewer but larger warehouses
 - growth in total warehousing floorspace
 - reduction in stockholding space & stock levels in other commercial buildings
- Consequent increase in journey distances & frequency of deliveries to shops, offices & residential homes
- Should be noted that LGVs used to provide services as well as to distribute goods

- Articulated HGVs: typically transport goods from sea ports, air ports & manufacturing plants to national & regional warehouses
- Importance of articulated HGVs in Britain increasing over time (from for 42% of all tonnes lifted and 69% of all tonne-kilometres performed by HGVs in Britain in 1990, to 66% of all tonnes lifted and 82% of all tonne-kilometres performed in 2020)
- Smaller HGVs and LGVs: used for delivering goods from warehouses & depots to shops, offices & private residences
- Articulated HGVs used to make deliveries to largest retail & commercial outlets
- Reflected in 2020 traffic data by road type:
 - Articulated HGVs 60% of total mileage on motorways and 24% on trunk A-motorways and trunk A-roads
 - LGVs travelled only 20% and 13% of total mileage on motorways and trunk A-roads, respectively with much of their travel taking place on urban roads

(Calculated from data in Department for Transport, 2021)

Freight transport operations at warehouses (1)

- Goods both enter and leave warehouses as they move their supply chains facilitated by inbound & outbound goods movements, vast majority of which take place using road goods vehicles
- Inbound goods can be delivered by vehicles operated directly by warehouse operator or third party operator
- Planning of inbound goods flows & vehicle movements easier to coordinate if operated by warehouse operator
- Over recent decades, growing concentration of retail markets has meant major retailers have taken greater control over both upstream & downstream goods movements, whether or not these freight movements are operated by logistics providers working directly for them
- Arrangements have to be made & planned for inbound goods flows & vehicle arrivals at warehouse
- These include managing delivery schedules, preparing warehouse resources required for these vehicle arrivals, having systems in place for reception of arriving vehicles, & operating holding area for vehicles that have to wait until the loading bay becomes available
- Once vehicles are at the warehouse unloading point it is necessary to validate goods being delivered & any documentation associated with them & provide confirmation of delivery
- Goods unloaded from vehicle to warehouse typically using either handling equipment or automated systems & taken to holding point in warehouse where they are sorted & allocated to planned storage location
- Issues that can arise dealing with inbound vehicles include late or early arrival of vehicles & vehicle queuing

Freight transport operations at warehouses (2)

- Suitable holding area is required for arriving goods vehicles to prevent queueing affecting traffic flow on road from which access to warehouse is obtained
- Warehouses require suitable plot ratios to be able to accommodate vehicles waiting to unload in such holding areas
- If suitable off-street holding space does not exist at warehouse then drivers can be contacted prior to arrival to redirect them to alternative waiting location in locality
- Outbound goods flows require that goods are prepared for despatch which involves goods picking from storage locations, followed by product & load preparation
- As for inbound goods flows this requires use of planned systems for dealing with this in careful, consistent & accurate manner
- In addition, outbound goods flow planning requires that transport resources are available & in place when required to facilitate deliveries made from the warehouse
- Many warehouses handling fast-moving goods or operating cross-docking operations make use of additional vehicle trailers to facilitate preparation of loads prior to actual planned departure times – helps make best use of resources and maximises goods throughput
- Although this requires additional investment in vehicle trailers this is more than offset by economic, efficiency & punctuality benefits it offers, especially in terms of drivers & tractor units spending less time waiting for loads to transport

Time utilisation surveys of goods vehicles operating to/from warehouses in UK, 2002-2007 (1)

- Overall, results indicated considerable amount of time HGVs involved spent at warehouses either carrying out loading/unloading or inactive
- Non-food retail sector - 2002 survey (Department for Transport, 2002):
 - Goods vehicles and trailers were found to be unproductive for 54% of time (either empty and stationary - 21%, pre-loaded, awaiting departure - 21%, or delayed/loaded and inactive 12%)
 - Vehicles spent 23% of their time running on the road, 15% loading/unloading (either at warehouses or other locations), 7% receiving maintenance/repairs and 1% stationary while drivers took rest breaks
- Food sector (production and retail operations) - 2002 survey (Department for Transport, 2002, 2003):
 - Rigid vehicles & articulated trailers unproductive for 47% of their time (either empty and stationary - 28%, pre-loaded, awaiting departure - 15%, or delayed/loaded and inactive 4%)
 - Vehicles spent 28% of their time running on the road, 16% of their time loading/unloading (either at warehouses or other locations), 7% of their time receiving maintenance/repairs and 2% of their time stationary while drivers took rest breaks
 - Vehicles were, on average, pre-loaded three and a half hours before their departure from warehouse
 - Temperature-controlled vehicle operations consumed far more energy and emitted more CO₂ than goods stored in the warehouse, given the energy requirements to store such products in a vehicle compared to a cold store

Time utilisation surveys of goods vehicles operating to/from warehouses in UK, 2002-2007 (2)

- Follow up survey in food sector in 2007 (Department for Transport, 2007) produced comparable results:
 - Rigid vehicles & articulated trailers unproductive for 50% of their time, running on the road for 30%, loading/unloading for 14%, and receiving maintenance/repairs for 6%
- Pallet sector – 2005 survey (Department for Transport, 2005):
 - Articulated HGVs used for trunking operations between warehouses were found to be unproductive for 42% of the time (either empty and stationary - 32%, pre-loaded, awaiting departure - 4%, or delayed/loaded and inactive 6%)
 - Vehicles spent 38% of their time running on road, 16% loading/unloading (either at warehouses or other locations), 1% receiving maintenance/repairs and 3% stationary while drivers took rest breaks
- Parcels sector - 2006 survey (Department for Transport, 2006):
 - Vehicles used for trunking operations between national/regional sortation centres and local depots were found to be unproductive for 50% of the time (either empty and stationary - 48%, or pre-loaded, awaiting departure - 2%)
 - Vehicles spent 21% of their time running on the road, 26% loading/unloading (at hubs and depots), and 3% stationary while drivers took rest breaks

Facilities required for freight operations and drivers at warehouses

- Plot ratio
 - Ratio of the gross floor area of warehouse to total area of site
 - In addition to the warehouse, there can be a need for land for other activities on site: goods vehicle manoeuvring and turning space, external storage (such as pallet storage areas), vehicle maintenance workshops, fuel storage facilities, parking space
 - Plot ratios tend to be lower at warehouses outside urban areas due to lower cost of land
 - Typical plot ratio of 35-40% at many larger warehouse developments
- Parking space for HGVs at warehouses
 - Often underestimated at planning stage due to method used
 - Can result in inadequate parking space to prevent queueing & for visiting HGVs requiring rest breaks
 - CILT has recommended revised methodology to help planning officers ensure enough parking space built in (Drury, 2017)
- Driver welfare facilities
 - Warehouses should provide toilet & handwashing facilities & rest areas to visiting HGV drivers – despite former being a legal requirement, some do not make these available

Logistics land occupiers' views of real estate factors they felt were greatest concern for ability of their business to grow, 2020

Real estate factor	Percentage of respondents mentioning this factor
Cost/financial terms of logistics facility	27.2%
Environmental permits	19.5%
Lease term/length – inflexible current lease conditions	14.4%
Lack of suitable logistics facilities	12.3%
Long lead time for development of new units	11.8%
Obsolescence of existing logistics facilities	10.3%
Reconversion of logistics space to other land uses	4.6%
Total	100%

Source: BEIS, 2022

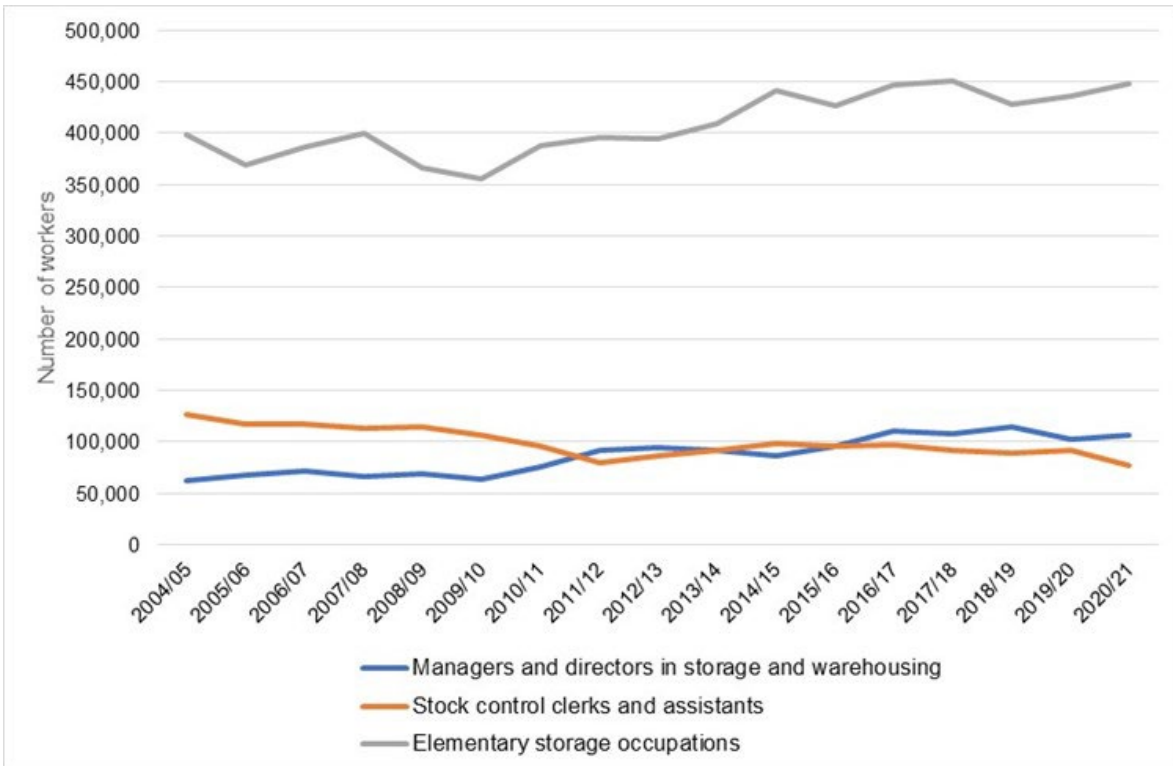
European real estate stakeholders' views of the single greatest challenge facing the logistics sector, 2021

Real estate factor	Percentage of respondents mentioning this factor
Lack of supply of new buildings	36%
The zoning/permitting system for logistics facilities	17%
Employment within logistics facilities	12%
Managing changes in international trade (inc. Brexit)	11%
Rising rents of logistics facilities	8%
Implementing sustainability measures	7%
Power supply to logistics facilities	6%
Other	4%
Total	100%

Source: Savills and Tritax Eurobox, 2021

- 2021 survey of 174 European logistics experts asked which supply chain trends that affect warehouse decision-making they agreed would occur in next 3-5 years (JLL, 2021)
- Most commonly cited trends were 'investment in automation & robotics' (90% of respondents), 'digitization of supply chains' (87% of respondents), 'focus on environmental solutions' (76% of respondents) 'on-demand warehousing' (74% of respondents), 'transparency of supply chains' (74% of respondents), 'increased reshoring' (74% of respondents), 'hold more inventory' (63% of respondents), and 'locate more inter-modal' (56% of respondents)

Employees in warehousing and storage-related work in UK, 2004/5-2020/21



Source: ONS, 2022

Workers by type of occupation in large Prologis warehouses in UK, 2006 & 2018

Type of worker	2006	2018
Warehouse staff	68%	48%
Vehicle drivers	13%	9%
Office staff	11%	25%
Managerial staff	7%	12%
Other	1%	6%
Total	100%	100%

Source: Prologis, 2019

- Growth in manual warehouse workers lower than growth in warehousing floorspace (due to automation)
- Current shortage of warehouse workers since Brexit & Covid pandemic
- Concerns about pay and conditions of manual workers (esp. agency work / zero hour contracts)
- 2022 survey of warehouse workers found net satisfaction scores were lowest for 'my pay', and 'the amount of work' (Frontier Economics, 2022)
- Representations of warehouses in news, film and TV drama tend to be negative

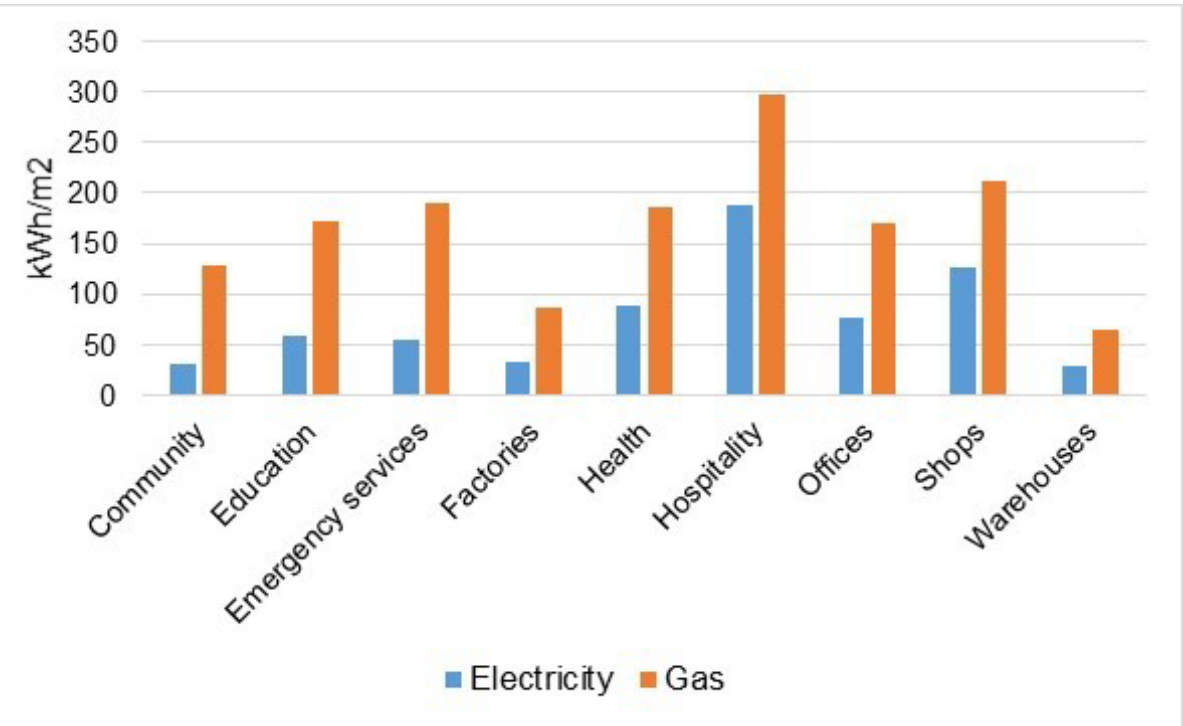
Traditional dislike among UK planning authorities for warehouses due to levels of job / wealth creation

- Policymaker concerns:
 - Warehouses create relatively few jobs per sq ft of building
 - Many warehouse jobs are manual and low paid
 - High casual workforce
 - Transport impacts
 - Planning complaints from local residents
- But:
 - Automation is changing warehouse job profile and pay rates (if not employment per unit area)
 - Reduction in demand for retail and office space

Employment Densities Matrix, 2015

Category of land use	Sub-sector	Employment density (sq m per FTE)
Storage and distribution	'Final mile' Distribution Centre	70
	Regional Distribution Centre	77
	National Distribution Centre	95
General office		10-13
Call centre		8
Industrial and manufacturing		36
Small business workplace	Co-worker, studio, maker spaces	10-40
Retail	High street / food store	15-20
	Retail warehouse	90
Financial & professional services		16
Restaurant / cafe		15-20
Data centres	Co-location, wholesale, wholesale dark site	180-1440

Median electricity & gas consumption of non-domestic buildings in England & Wales by building use, 2020 (kWh/m²)



Source: BEIS, 2022

Total electricity & gas consumption of non-domestic buildings in England & Wales by building use, 2020

Building type	Electricity	Gas
Community	2%	3%
Education	4%	9%
Emergency services	1%	1%
Factories	33%	38%
Health	2%	7%
Hospitality	5%	6%
Offices	15%	8%
Shops	12%	6%
Warehouses	12%	6%
Other	15%	16%
Total	100%	100%

Source: BEIS, 2022

- Warehouses use relatively low quantities of gas & electricity per unit area of building
- But due to total floorspace, warehousing responsible for 12% of all electricity and 6% of all gas used in non-domestic buildings in 2020
- Lighting, heating/cooling, and equipment use/computing are main sources of energy consumption
- UK Government target set in 2008 for new non-domestic buildings to be zero carbon by 2019 was scrapped by incoming Government in 2015

Change in total electricity & gas consumption of non-domestic buildings in England & Wales, 2012-2020

Building type	Electricity	Gas	Total
Community	-34%	-27%	-30%
Education	-18%	-3%	-7%
Emergency services	-13%	-10%	-11%
Factories	-13%	10%	-1%
Health	-12%	11%	5%
Hospitality	-33%	-28%	-30%
Offices	-24%	-7%	-19%
Shops	-27%	-4%	-19%
Warehouses	-2%	-7%	-3%
Other	17%	20%	18%
Total	-14%	2%	-7%

Source: calculated from data in BEIS, 2022

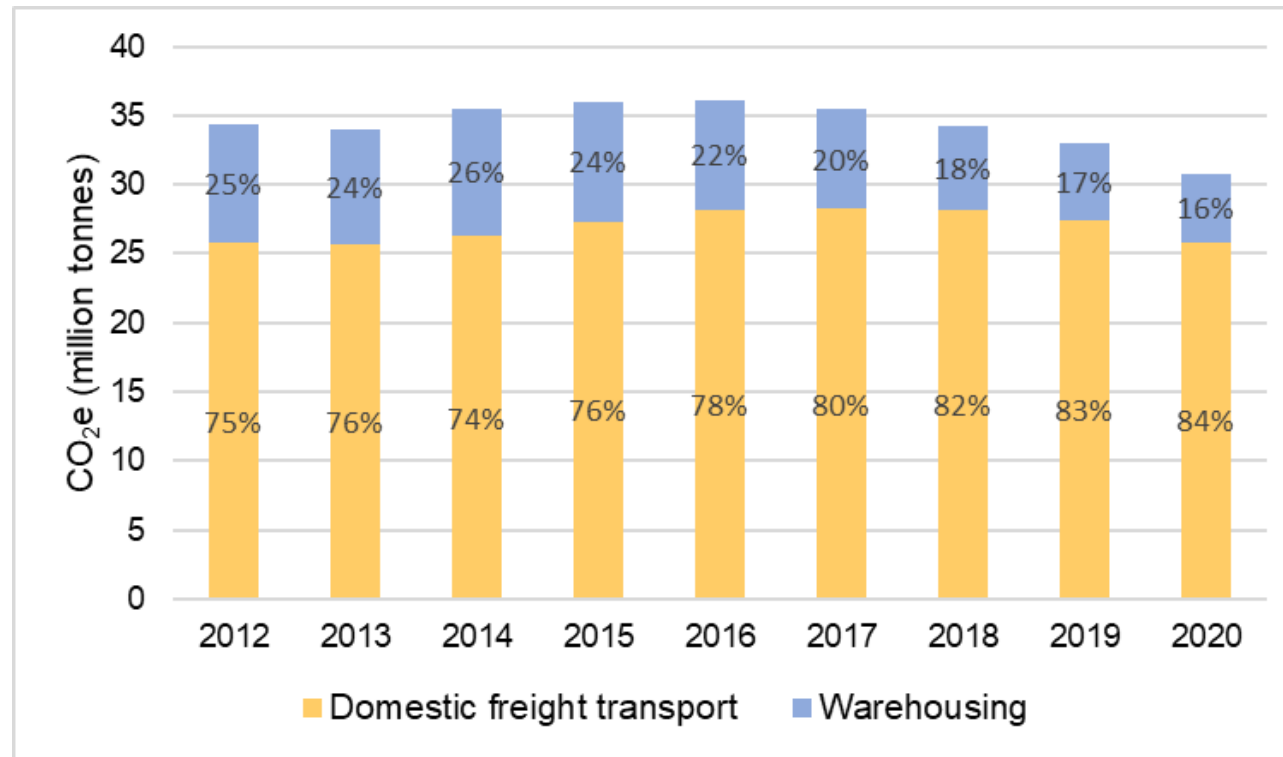
- **Warehousing achieving less improvement in energy efficiency than other non-domestic building types**
- Total quantity of electricity & gas used in warehouses fell far less between 2012-2020 than for many other types of non-domestic building
- Due to:
 - Growth in total warehousing floorspace
 - Increasing use of automation
- Less target setting for decarbonising warehouses than for transport vehicles by policymakers to date
- 2008 UK Government target for new non-domestic buildings to be zero carbon by 2019 was scrapped in 2015

Increase in fossil fuel use by goods vehicles

- The total quantity of petroleum used by goods vehicles in Britain increased by approximately 8% between 2012-2019, while total warehousing energy increased by 1%
- Indicates ever-greater reliance on road freight transport in UK supply chains

(calculated from data in DfT, 2021; BEIS, 2022)

Estimated contribution of warehousing operations to UK supply chain GHG emissions, 2012-2020



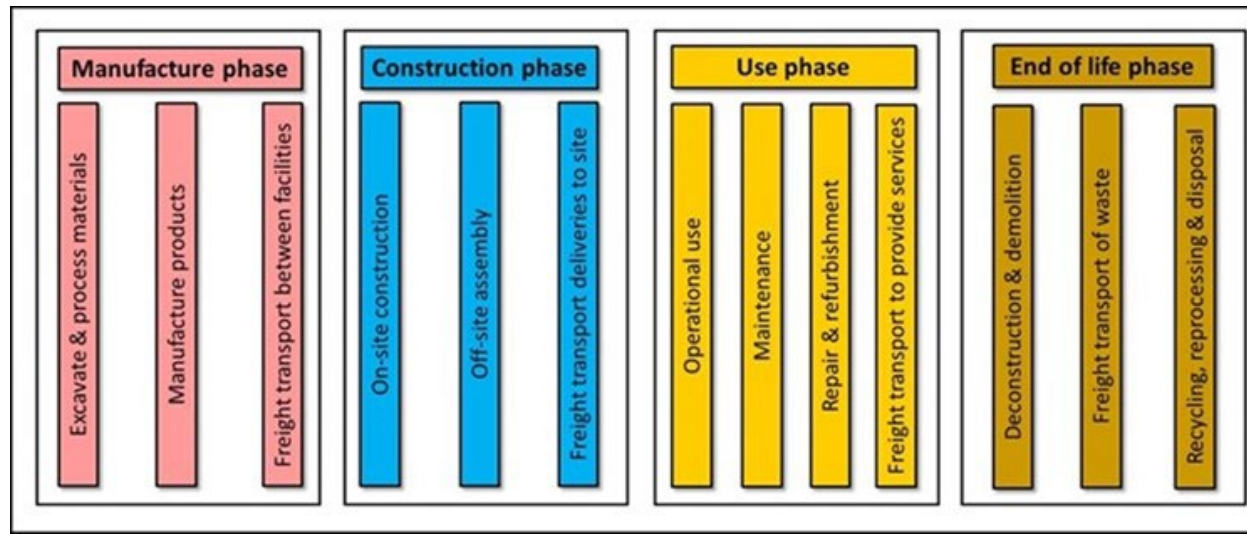
Note: The estimated supply chain GHG emissions are based on total domestic UK freight transport operations but warehousing only in England and Wales due to coverage in BEIS data collection.

Source: calculated from data in BEIS, 2022.

- Warehousing estimated to account for 16% of GHG emissions in domestic UK supply chain in 2020 (& 11% if international freight transport to/from UK also taken into account) with freight transport accounting for majority
- Fall in warehousing's share due to increasing renewable content of UK electricity & increase in road freight transport
- Combined warehousing and domestic freight transport GHG emissions estimated to be 4% lower in 2019 than 2012 (& 10% lower in 2020 than in 2012)

Whole of life warehouse energy use and GHG emissions

- Energy use in manufacturing and constructing the warehouse (embodied energy):
 - Materials used (much steel often used in modern construction)
 - Construction site equipment
 - Freight transport to supply materials
 - Worker transport to and from site
- Operational life (use phase):
 - Warehouse energy use: lighting, heating, cooling and equipment
 - Lighting is major source of energy use
 - Equipment consuming greater energy as automation progresses
 - Freight transport to and from site (collections and deliveries)
 - Worker transport to and from site
- Disposal/demolition of warehouse at end of life



Sustainable design features for warehouses

Feature	Comment
Significant proportion of building materials sourced locally/ regionally	Reduce transport emissions during construction phase
High-efficiency roofing and walls	Optimise interior temperatures, minimise energy wastage
Rooflights (and/or above dock areas)	Reduce need for lighting in day
Internal/external LED lighting	Reduce energy usage and light pollution
Rainwater harvesting	Minimise water consumption
Rooftop solar panels	Generation of green energy
Wind turbines and other green energy generation	Generation of green energy
Electric car charging stations	Reduce emissions from commuters
Battery storage	Allow occupiers to vary their battery requirements
Designed for deconstruction / disassembly	Reduce emissions at end of life demolition

Rooftop solar panels at warehouses

- New warehouse developments can be almost energy independent if at least 40% of the roof space is used for PV installation) (BPF and Savills, 2022)
- Largest 20% of warehouses in UK estimated (Delta Energy & Environment, 2022):
 - to have (75 million sq metres or approximately 750 million sq ft) roof space
 - sufficient roof space to double UK's solar generation capacity from 14 to 28 GW
- Payback periods for capital and installation costs can be as low as 4 to 6 years with an estimated internal rate of return of 10-15% per annum on self-financed projects
- Payback period depends on warehouse location, building size, orientation of the building, on-site energy demand and market electricity prices)

'Sustainable' warehouse developments

- 60,000 sq ft parcel sortation hub at Symmetry Park, Bicester occupied by DPD & owned by Tritax Symmetry was first 'net zero carbon in construction' building in the UK
- Magnitude 314 at Magna Park in Milton Keynes (300,000 sq ft warehouse with 15,000 sq ft of office space developed by GLP) was first building verified as net zero carbon in construction in line with UK Green Building Council definition
- PLP completed its first net zero speculative logistics development in 2020 (343,000 sq ft warehouse in Sheffield)
- Some developers also focusing on warehouse design features & amenities to improve worker wellbeing, primarily to improve workforce attraction & retention rates
- Can include greater attention to air flow, light, temperature, sound, water use, space for movement & exercise

Barriers to installing renewable energy generation technology at warehouses

- Relatively low energy consumption at some warehouses
- Most warehouses occupiers lease rather than own the building & may have short remaining lease durations
- Risk of stranded assets if occupier leaves warehouse
- Obtaining permission from landlords who may be reluctant to grant approval
- Design knowledge & expertise required
- Potentially high cost & long timescale of obtaining necessary grid connection upgrades from Distribution Network Operators (DNOs)

Vehicle refuelling at warehouses

- Issue of refuelling / recharging goods vehicles using warehouses overlooked by policymakers & remains to be addressed
- Can be necessary for warehouse to have upgrade to its grid connection to provide necessary vehicle recharging infrastructure
- Depends on various factors including: current grid connection & electricity use, local grid infrastructure, number of vehicles that require charging at same time & speed of charging required
- Cost of grid connection upgrades & waiting times has hindered switch to electric vans at some warehouses
- Changes in Ofgem approach first indicated in 2022 may assist this
- If energy network provider needs to use another party's land to carry out necessary work it must obtain this other party's agreement to do so – can lead to legal costs & delays
- Electric charging points vary considerably in purchase cost & installation lead time depending on power rating & associated work required
- Given occupier is often not warehouse owner requires landlord permission & can result in stranded assets
- Parcel carrier UPS - £600,000 cost of depot upgrade & time period of two years for system capable of recharging sixty five 7.5 tonne vehicles & required permission from three-tiers of depot landlords (Quak et al., 2017)
- The parcel carrier, DPD - installing suitable EV charging equipment at its depots has cost at least £250,000 per depot, compared to the cost of installing a diesel tank which is approximately £50,000 (DPD, 2021)

Conclusions and recommendations (1) – Future trends in warehousing

- After several years of strong demand for warehousing, future demand at national scale uncertain:
 - Some commentators expect continued growth in demand due to re-shoring of production to mitigate future supply chain disruptions
 - Some are suggesting reduction in centralised stockholding with more warehousing sites located closer to sales markets
 - However such strategies takes time to implement, are capital intensive, may increase operating costs & does not necessarily overcome disruption
- Economic factors (cost of living crisis and recession) may damp down demand for goods and hence warehousing space & may adversely affect growth of online retailers
- Greater thought needs to be given by businesses to supply chain resilience to prevent disruption to long distance goods transport
- Warehousing supply and demand & rental values dealt with by the market
 - But UK Government has important role in terms of national planning law & guidance concerning the granting of planning consent for warehouse development & local planning authorities make decisions on individual warehouse applications
- Warehousing automation likely to continue to increase in deployment, resulting in fewer but better paid jobs
 - But humans performing manual roles likely to continue to co-exist alongside technology given substantial costs of making a warehouse fully autonomous & to cope with seasonal peaks
 - Automation ethical questions include: how to ensure humans have good working environment when collaborating with automated machines, & how to remove tasks most associated with human worker injury, discomfort & boredom.
 - Little research has been carried out into environmental impacts of various automated technologies for warehouses

Conclusions and recommendations (2) – Actions for public & private sectors

- Warehousing traditionally viewed by public sector economic development officers & town planners as generating low employment density, low paid, unskilled work but now demand for office & retail space declining
- National Government can reflect warehouse importance in national strategy for warehousing that takes account of its importance in modern, efficient, decarbonised supply chains & provision of space for it & enshrine this in National Policy Planning Framework
- Planning authorities need to reconsider importance of warehousing when setting strategic land-use plans
- National & local government need to speed up decision-making for warehouse planning applications
- Warehouse site intensification as being encouraged by local planning authorities likely to lead to less not more warehousing space
- Local planning authorities should pay more attention to vehicle trip generation estimates submitted as part of planning applications for new warehousing sites to ensure adequate parking space & facilities developed
- Warehousing & logistics industry (developers, investors, occupiers, freight transport & logistics operators & trade associations/professional bodies) needs to better communicate economic & other benefits warehouses offer as well as take joint stance against any unethical practices of those among its ranks
- Government needs to ensure pay & working conditions of elementary warehouse workers are monitored & changes made to existing labour law in respect of zero hours contracts
- Industry needs to make greater efforts to provide washing, toileting & rest facilities to those vehicle drivers visiting warehouses to make collections & deliveries

Conclusions and recommendations (3) – Decarbonising warehouses

- Total quantity of energy consumed operationally in warehouses fell far less between 2012-2020 than for many other types of non-domestic building (likely due to growth in total warehousing floorspace & increasing use of automated machinery)
- Analysis indicates in 2020 operational energy used by warehouses accounted for 16% of total GHG emissions (CO₂e) from domestic UK supply chain (& 11% if international freight to/from UK taken into account)
- Assessments of energy use & GHG emissions related to buildings often only take account of operational life ('use phase') of building - proper consideration must take account of energy use & GHG emissions at all phases & activities in life of warehouse (i.e. manufacturing, construction, use and end of life phases)
- In 2015, UK Government scrapped its predecessor's target that non-domestic buildings (including warehouses) should be net zero by 2019
- Changes can be made to national planning law to require low-carbon new buildings
- Use of planning requirements or financial incentives could assist inclusion & use of rail & water facilities for new large warehouse developments
- Government plans for decarbonising goods vehicles & other freight transport modes do not address their refuelling at warehouses & other distribution centres
- Far closer working & co-ordination between government department (inc. BEIS, DLUHC, & DfT, DIT) necessary to achieve supply chain decarbonisation that takes account of warehousing & freight transport activity that handles goods to & from them (domestically and internationally)
- National government must work far more closely with local & regional government if decarbonisation of warehousing & freight transport is to be achieved in timely, cost-effective & efficient manner