Global flows

Around one quarter of greenhouse gas emissions are embodied in goods and services which "flow" between the country of production and the country of consumption via international trade. A key focus for business action, and the opportunity to further reduce GHG emissions over the next decade, will be to reduce the carbon intensity of traded goods.

Key facts

- **Embodied carbon flows are large and growing**
  Approximately 25% of all CO_2 emissions from human activities 'flow' (i.e. are imported or exported) from one country to another.

- **Embodied carbon flows in both commodities and final products**
  The flow of carbon is comprised of roughly 50% emissions associated with trade in commodities such as steel, cement, and chemicals, and 50% in semi-finished/finished products such as motor vehicles, clothing or industrial machinery and equipment.

- **Embodied carbon imports are significant for many developed economies**
  Major developed economies are typically net importers of embodied carbon emissions. UK consumption emissions are 34% higher than production emissions: Germany (29%), Japan (19%) and the USA (13%) are also significant net importers of embodied emissions. For some economies with very carbon efficient production processes, the relative importance of imported carbon is even greater. The high levels of net imports in France (43%) and Sweden (61%) reflect in part the low carbon intensity of their energy systems.

- **Many developing countries export embodied emissions in international trade**
  Developing countries are generally net exporters of CO_2 emissions. For example, in 2004 China exported ~23% of all its domestically produced CO_2.

Implications for business

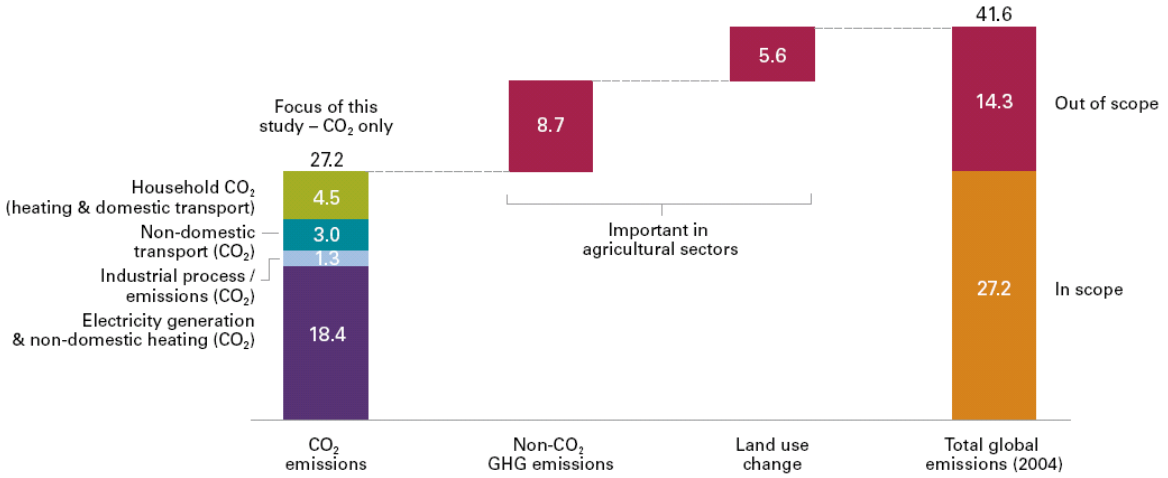
Businesses are primarily responsible for importing and exporting traded goods on behalf of their customers (consumers). The carbon embodied in supply chains is both an opportunity and a risk:

- **Business opportunities from international carbon flows**
  The opportunity is to measure and reduce emissions across the supply chain and communicate this to consumers, in order to be rewarded for action through increased sales and reduced costs.

- **Business risks from international carbon flows**
  The risk in failing to take action is that consumers choose lower carbon alternatives and that ultimately new emissions abatement approaches force businesses to take action at a later date in any event.

Annual global GHG emissions in 2004 were 42GtCO$_2$e

Global greenhouse gas emissions by category in 2005 (GtCO$_2$e)



Source: CICERO / SEI / CMU GTAP7 EEBT / MIRO Model; Climate Analysis Indicators Tool – CAIT (Non-CO_2 GHG estimate); Houghton (land use change); CT analysis.

Greenhouse gas (GHG) emissions, measured in tonnes of carbon dioxide and its equivalent (CO_2e) are a combination of emissions of different gases that arise from different sectors.

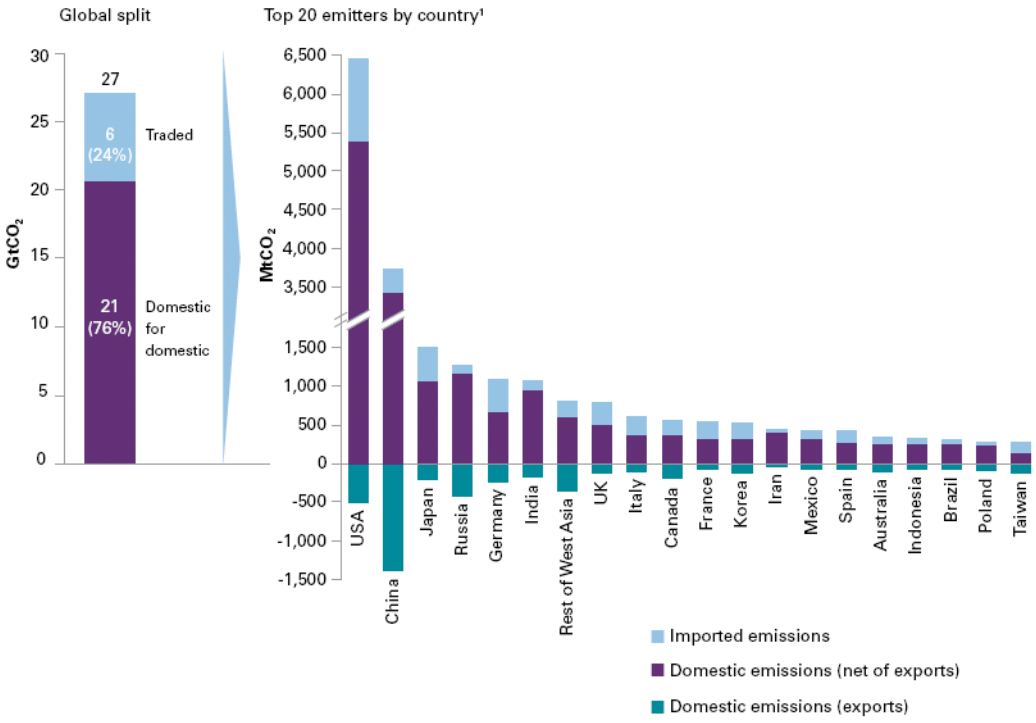
Global annual emissions have been rising over the last century, leading to global climate change. In 2004, human activities contributed around 42GtCO_2e to the atmosphere, of which around 33Gt was from CO_2 emissions, with a further 9Gt of non-CO_2 greenhouse gas emissions (such as methane and other gasses).

This analysis focuses on CO_2 emissions from direct human activities including industrial energy (e.g. burning of fossil fuels in power stations), industrial process emissions (e.g. emissions arising from the manufacture of cement), transport emissions (from fossil fuels) and household emissions (e.g. burning gas to heat homes). Together these sources of emissions account for around 27Gt CO_2e (2004).

Two additional significant sources of emissions, land use change and non-CO_2 GHGs, add a further 14.3GT CO_2e each year. This analysis only considers non-CO_2 emissions in relation to the cotton sector, where they are a significant contributor to the overall footprint of the sector.

Around one quarter of global CO_2 emissions cross an international border between production and consumption

Production of CO_2 emissions by country, and the import and export of CO_2 emissions embodied in trade

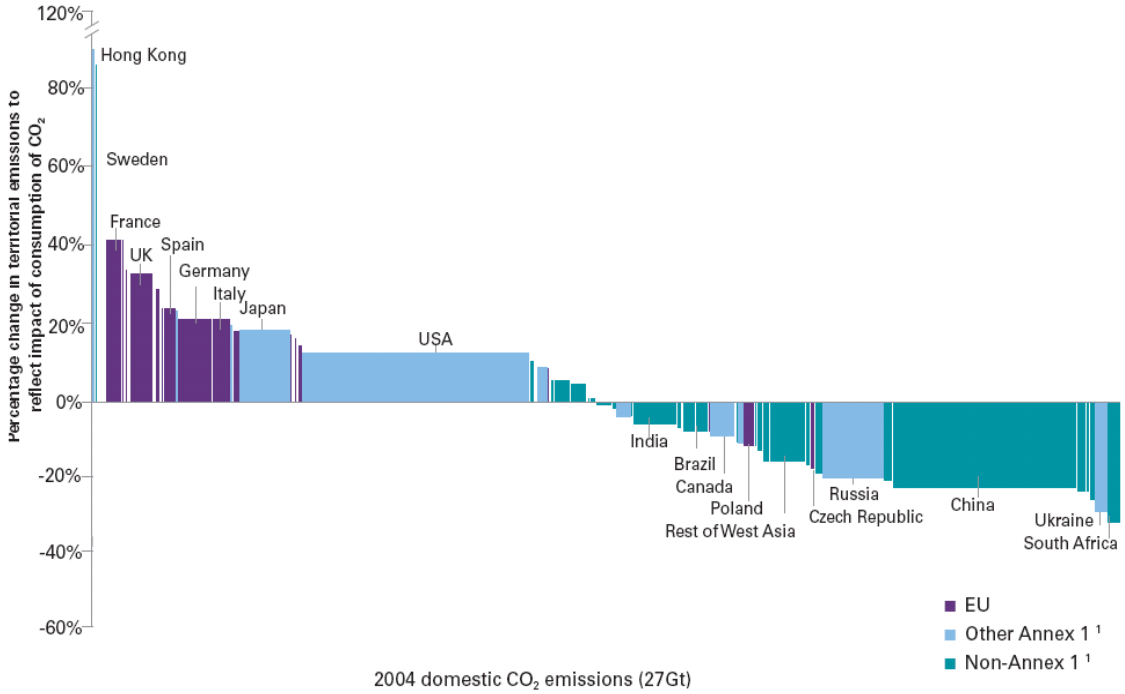


¹Top 20 emitters represent 80% of global emissions (2004, CO_2 only).
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 EEBT Model (2004).

Around 25% of global man-made CO_2 emissions cross international borders embodied in goods and services. In these cases, there is a separation between the country of origin of those emissions, and the final consumption of the products (and their embodied emissions). The two largest countries for both production and import/export of emissions are the USA and China, due to the size of their economies. However, many other countries also contribute to the import and export of emissions embodied in products.

Most developed countries tend to be net importers of embodied emissions, while most developing countries are net exporters

The impact of a consumption-based view on emissions by country



1 Annex 1 to UNFCC.
Note 1: Includes CO_2 emissions from production, process, transport and household sources only (27Gt in 2004); excludes non–CO_2 emissions due to land-use-change.
Note 2: Based on an MRIO (multi-region input/output) model allocating emissions to regions of consumption.
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

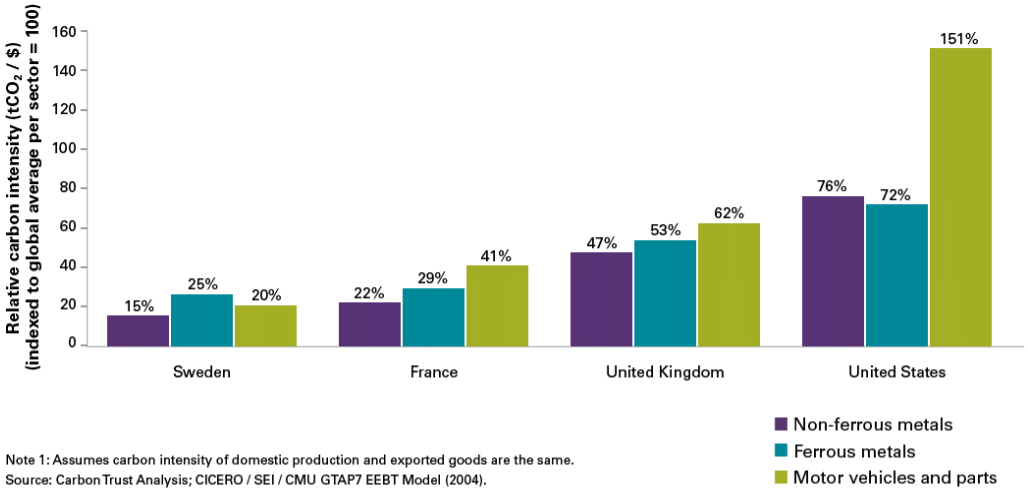
By taking into account the production, import and export of CO_2 emissions throughout the full upstream supply chain that supports consumption in any country, emissions can be allocated to individual countries on the basis of their consumption of goods and services (rather than their production of emissions).

By comparing the production emissions arising in a country with the consumption emissions that a country is responsible for, the net impact of embodied emissions in trade can be determined for each country or region in the world. The x-axis shows the proportion of emissions produced in each region or country in the world, while the y-axis shows the percentage change in this assessment of emissions once the effect of imports and exports of embodied emissions are taken into account.

While imports and exports of embodied emissions must be equal when considered at the global level (the country areas above and below the “neutral” line must be equal), the net impact of these exchanges on individual countries is very different. This consumption view of emissions reveals that many developed (especially European) countries are net importers of emissions, while many developing countries are net exporters of emissions embodied in trade.

Domestic carbon intensity of production varies strongly between different developed countries

The carbon intensity of production in selected sectors in Sweden, France, the UK and USA



Note 1: Assumes carbon intensity of domestic production and exported goods are the same.
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 EEBT Model (2004).

The consumption of goods and services in European countries such as the UK, France and Sweden results in significant net embodied emissions imports into these countries compared to their production emissions. There are two key factors behind these results:

1. The level of net imports. For countries that have a large trade imbalance of goods, this will drive a net flow of emissions either into (net trade importer) or out of (net trade exporter) the country assuming that the carbon intensity of exports and imports is broadly comparable.

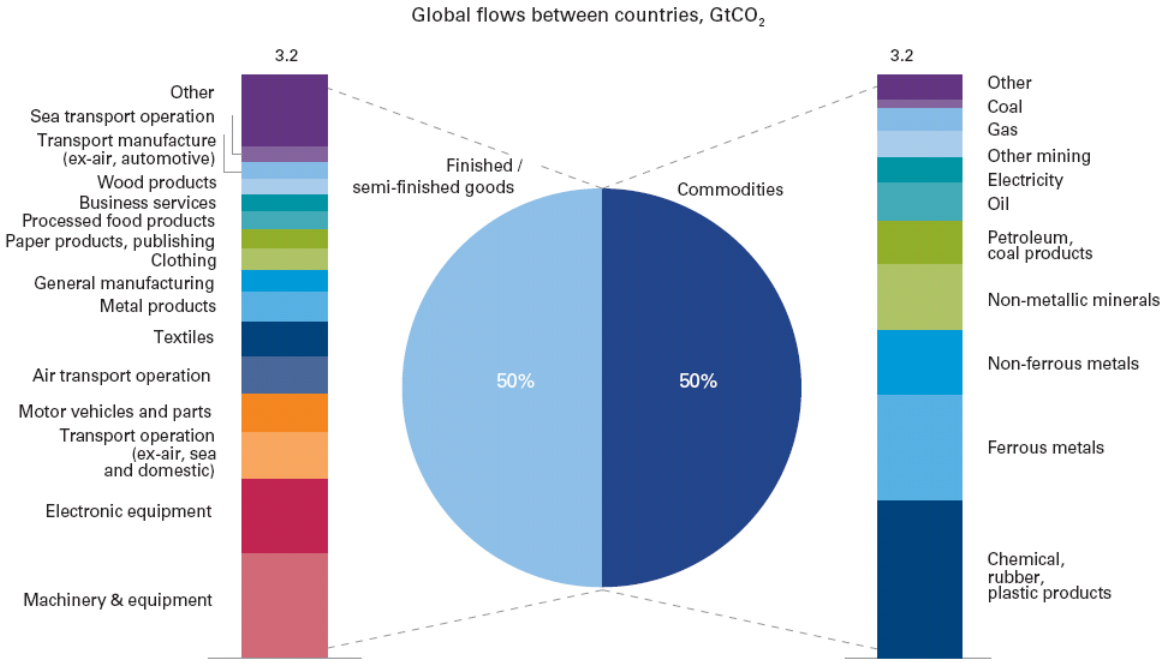
2. The carbon intensity of production in the importing country. Where there is a large difference in the carbon intensity of imports and exports, countries may appear to be relatively significant importers of embodied emissions in part because the carbon intensity of domestic production is low compared to imports.

For example, Sweden is a net exporter by value, while France is a small net importer (relative to GDP), suggesting that trade imbalances are not the key driver of their apparent high dependence on imported embodied emissions. At the same time, Sweden and France both have a significantly lower carbon intensity of domestic production than the global average (due to low carbon domestic energy sources such as hydro and nuclear). This is in strong contrast to the UK and USA, where both countries are large net importers by value, and both have a significantly higher carbon intensity of production than either Sweden or France.

This analysis suggests that the difference between production and consumption emissions assessment for the UK and the USA is driven primarily by large net imports of embodied emissions, while the higher results for France and Sweden are significantly influenced by the much lower carbon intensity of production in these counties compared to the carbon intensity of their imports. As developed economies decarbonise over time, imported carbon will become relatively more important from a consumption perspective.

Half of all globally traded emissions are embodied in final products, half in commodities

Division of embodied emissions flows, by final product, commodity and sector



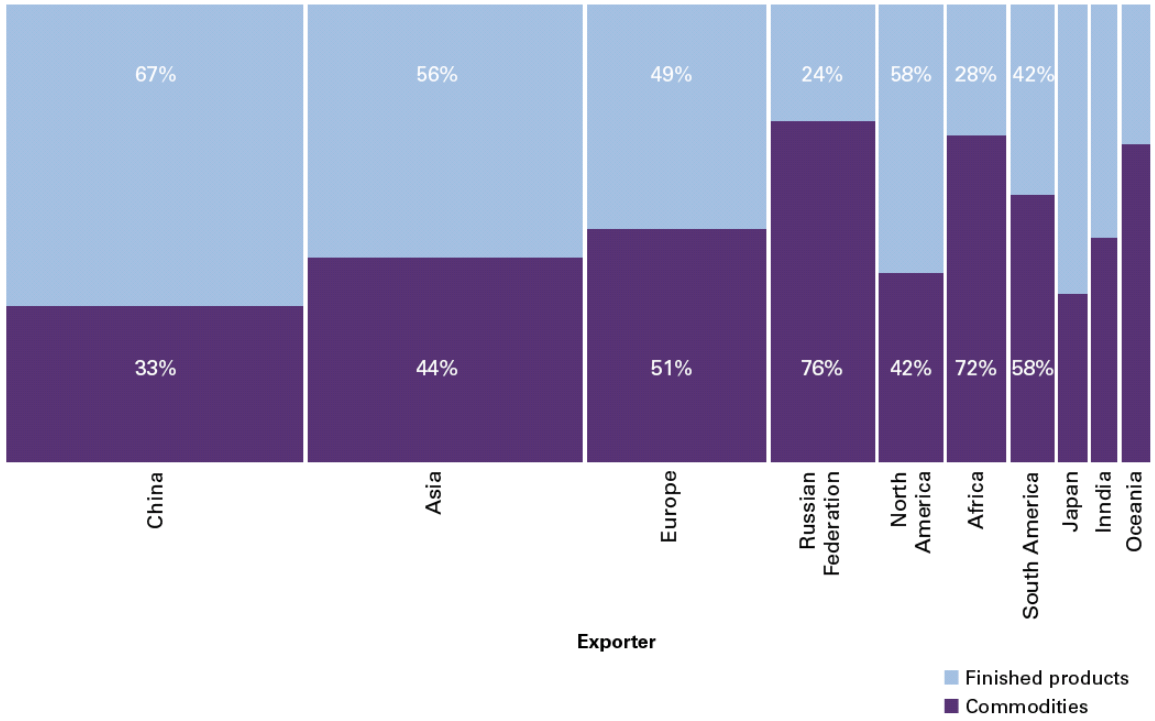
Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 EEBT Model (2004)..

Carbon emissions are embodied in the trade of both commodities (broadly defined as materials with a spot price) and finished or semi-finished products, in approximately equal amount. Over half of all embodied carbon flowing internationally in the trade of commodities occurs in the chemicals, ferrous and non-ferrous metals sectors.

For final products (including goods and services) there are a diverse set of contributing sectors. Machinery, electronics, air and other transport operations, and motor vehicles and parts account for around half of the embodied emissions flowing across borders, with the remainder made up of a wide range of other goods and services.

The relative importance of commodities or final products in embodied emissions exports varies strongly between regions

Nature of exported emissions by region (x-axis scaled to total embodied emissions exports)



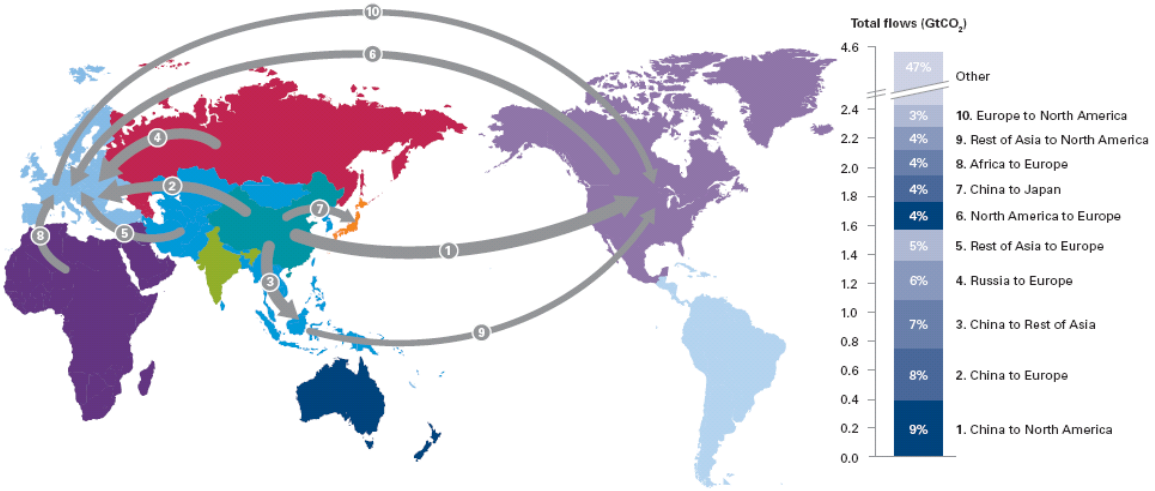
Note 1: Includes Scope 1 (direct) and Scope 2 emissions (indirect, allocated electricity).
Source: Carbon Trust Analysis; CICERO, SEI and CMU – GTAP7 EEBT & MRIO model.

There are significant differences in the export profiles of different regions, with the embodied emissions exported from China being overwhelmingly found in finished products, rather than commodity exports.

By contrast, embodied emissions in exports from the Russian Federation and Africa are overwhelmingly biased towards commodities, with finished products being responsible for only a minority of embodied emissions exports.

China, North America and Europe are major players in the global exchange of embodied emissions in trade

Top 10 largest inter-regional flows of embodied CO_2 emissions

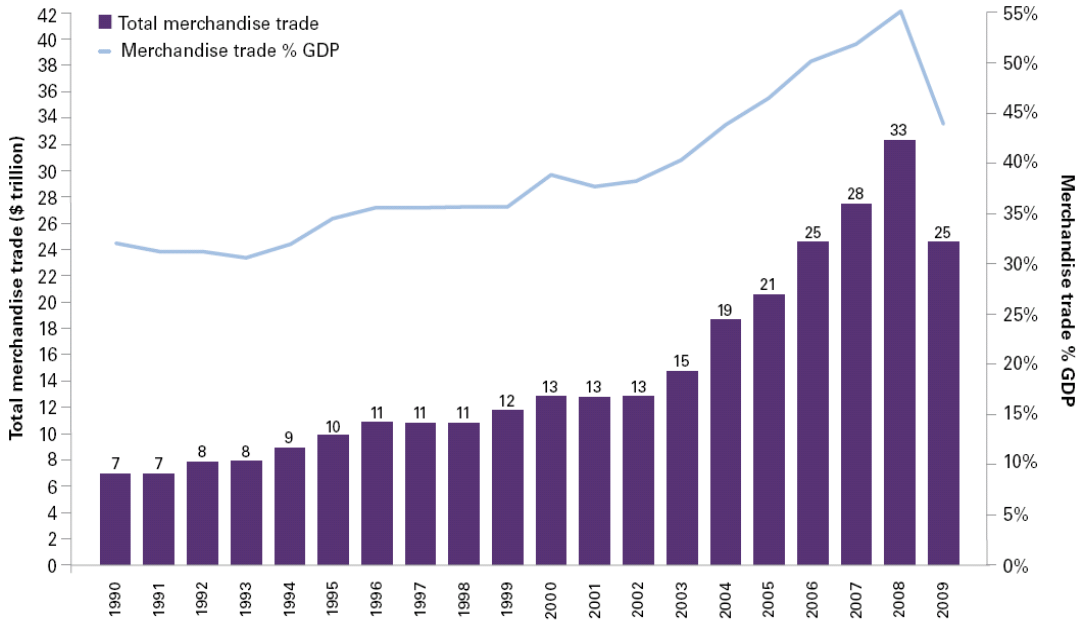


Note: Rest of Asia excludes China, Japan and India.
Data includesflow of Scope 1–3 (direct, indirect and upstream) emissions arising in region of export that are embodied in trade flows to the rgion of import.
Refer to Annex [B] for region definitions.
Source: Carbon Trust Analysis: CICERO/SEI/CMU GTAP7 EEBT (2004) Model.

Four of the top 10 embodied emissions flow routes originate in China, representing a net transfer of emissions embodied in trade to North America (rank 1), Europe (rank 2), rest of Asia (rank 3) and Japan (rank 7). In this analysis, the international embodied emissions flows have been simplified by grouping countries into 10 regions. In this view, it is the net embodied emissions imbalance between China (exporter) and the USA (importer) that is the most significant inter-regional flow of embodied emissions. The USA and the EU are destinations for the majority of the top 10 inter-regional trade flows. Other inter-regional flows, such as those between Oceania, South America, Africa or India and all other regions, collectively account for less than 30% of inter-regional embodied emissions flows.

There is a strong relationship between the increasing value of global trade (and therefore emissions embodied in trade) and increasing trade relative to GDP

Value of world merchandise trade



Note 1: Current US$.

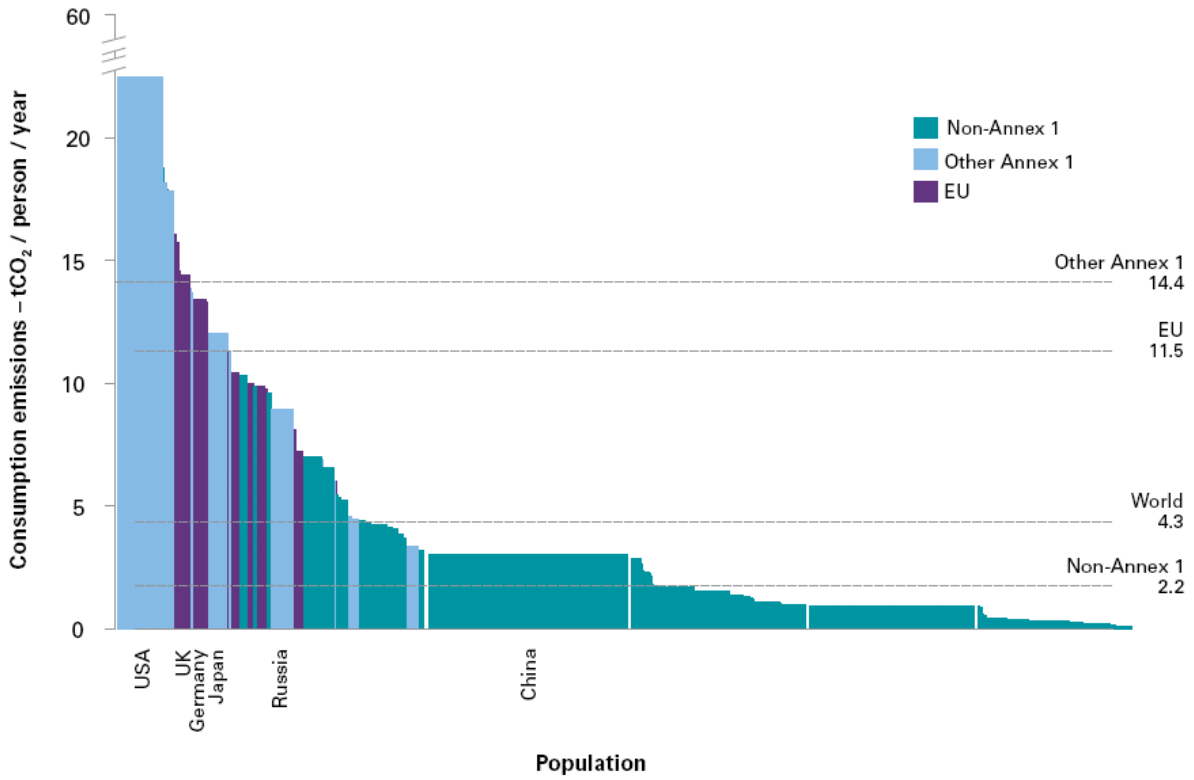
Source: World Trade Organisation (total merchandise trade); GDP (World Bank).

International carbon flows have been increasing over time, in both relative and absolute terms. This increase mirrors the increasing importance of international trade in the global economy, which has featured the increasing separation of traditional demand centres in developed economies from rapidly expanding production capacity in developing countries. Projections for the increase in imported or exported emissions for the UK and China are given in following pages.

There are a wide variety of drivers behind this dislocation of production and consumption, most of which are unrelated to greenhouse gas emissions. Differences in labour, energy and other input costs, access and proximity to raw materials, different regulatory regimes and reporting requirements, financial incentives and a closing of the technology and industrial leadership of developed countries will have all played a part in this evolution over time.

There is a large difference in per-person consumption emissions across different countries

Per-person consumption emissions v population



Source: Carbon Trust Analysis; CICERO / SEI / CMU GTP7 MRIO Model (2004).

In 2004, global CO_2 consumption emissions averaged around 4.3tCO_2 per person, but with significant differences by country average. EU countries had average emissions of 11.5tCO_2 per person, nearly three times higher than the global average. Other Annex 1 countries (including the USA, Canada and Australia) had average emissions of 14.4tCO_2 per person, over three times the global average. At the other extreme, Indian emissions were around 1tCO_2 per person per year (less than one-quarter of the global average). Around one-third of the worlds' population has per person emissions at or below 1tCO_2 per person. The consumption view gives different results compared to the production view. For example, the UK's per person consumption emissions were 14.5tCO_2, but on a production basis, they were only ~11tCO_2, the difference reflecting the net imports of emissions.

To achieve a 50% chance of limiting global temperatures to 2^0C likely requires that average per person emissions would need to fall to around 2tCO_2 per person in 2050, less than half the 2004 average. With projections of further economic growth, and expectations of higher consumption lifestyles in both developed but especially developing countries, achieving the 2050 target will require a fundamental shift in the way the world produces and consumes goods and services.

The United Kingdom

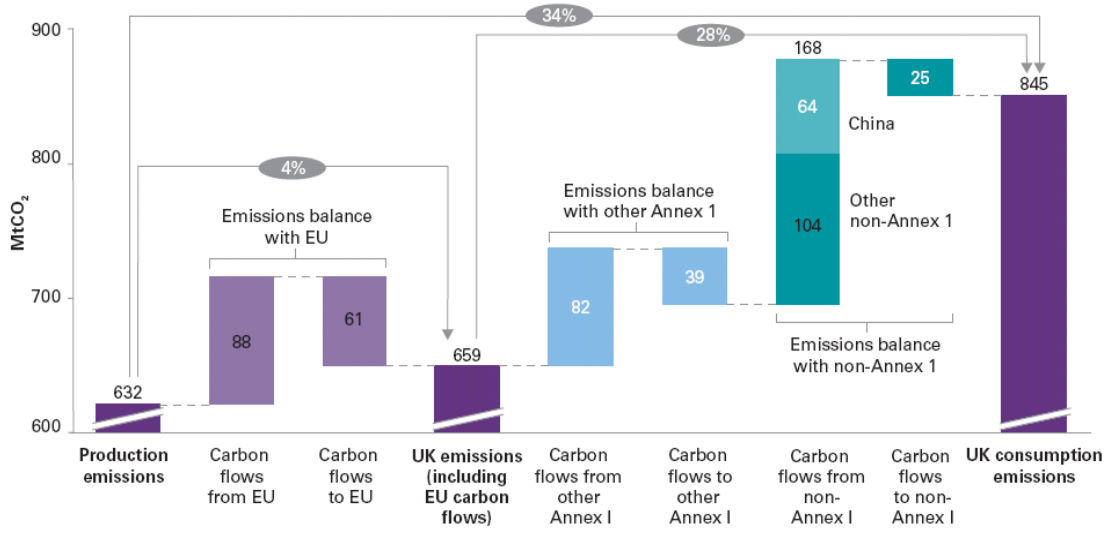
The UK is a significant net importer of emissions embodied in trade, and this drives a large difference between production and consumption views of UK emissions "responsibility". This section explores the dynamics of UK emissions flows in greater detail, identifying the major flows and international sources of emissions arising from consumption in the UK, and projecting the future importance of imported emissions in the overall UK GHG footprint.

Key United Kingdom analysis

- *The UK is a major net importer of emissions from both developed and developing countries*
- *Forty per cent of emissions arising from UK domestic consumption occur outside of the UK*
- *Over half of the emissions embodied in consumption (excluding private energy consumption) arise overseas*
- *The UK produces, exports and imports embodied emissions across a wide range of sectors*
- *Different UK production sectors show different levels of embodied emissions imports and exports*
- *Growth in trade has traditionally been in step with GDP growth in the UK*
- *The significance of imported embodied emissions in UK consumption emissions is likely to increase over time*

The UK is a major net importer of emissions from both developed and developing countries

UK embodied emissions balance (import and export) with major regions, 2004

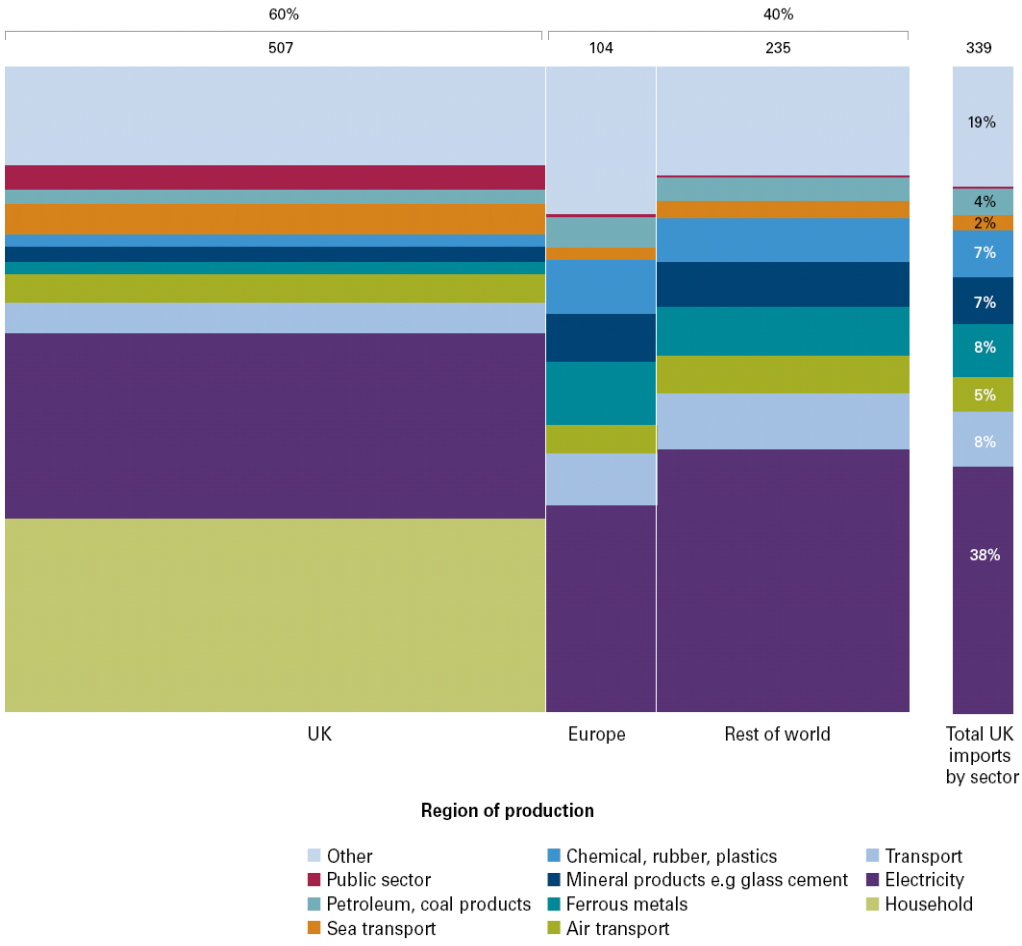


Source: Carbon Trust Analysis; CICERO/SEI/CMU GTAP7 MRIO Model (2004).

The UK's balance of emissions with other countries in the EU shows a small net import of emissions equivalent to around 4% of UK production emissions: a similar magnitude of impact on UK emissions results from the small net import of embodied emissions with other developed countries. By far the largest impact on the UK's consumption of emissions is the large net imbalance of embodied emissions occurring with developing countries, and in particular China. Embodied emissions imports from developing countries are the single largest source of embodied emissions imports to the UK, with one-third of this net imbalance coming from China alone. Of the net import of 213MtCO_2 of embodied emissions into the UK in 2004, 33% are from Annex 1 countries with a defined emissions cap under the Kyoto Protocol, but only 13% of these emissions have arisen in EU ETS zone countries.

Forty per cent of emissions arising from UK domestic consumption occur outside of the UK

Global source of emissions by sector and region to satisfy UK consumption ($MtCO_2/y$)



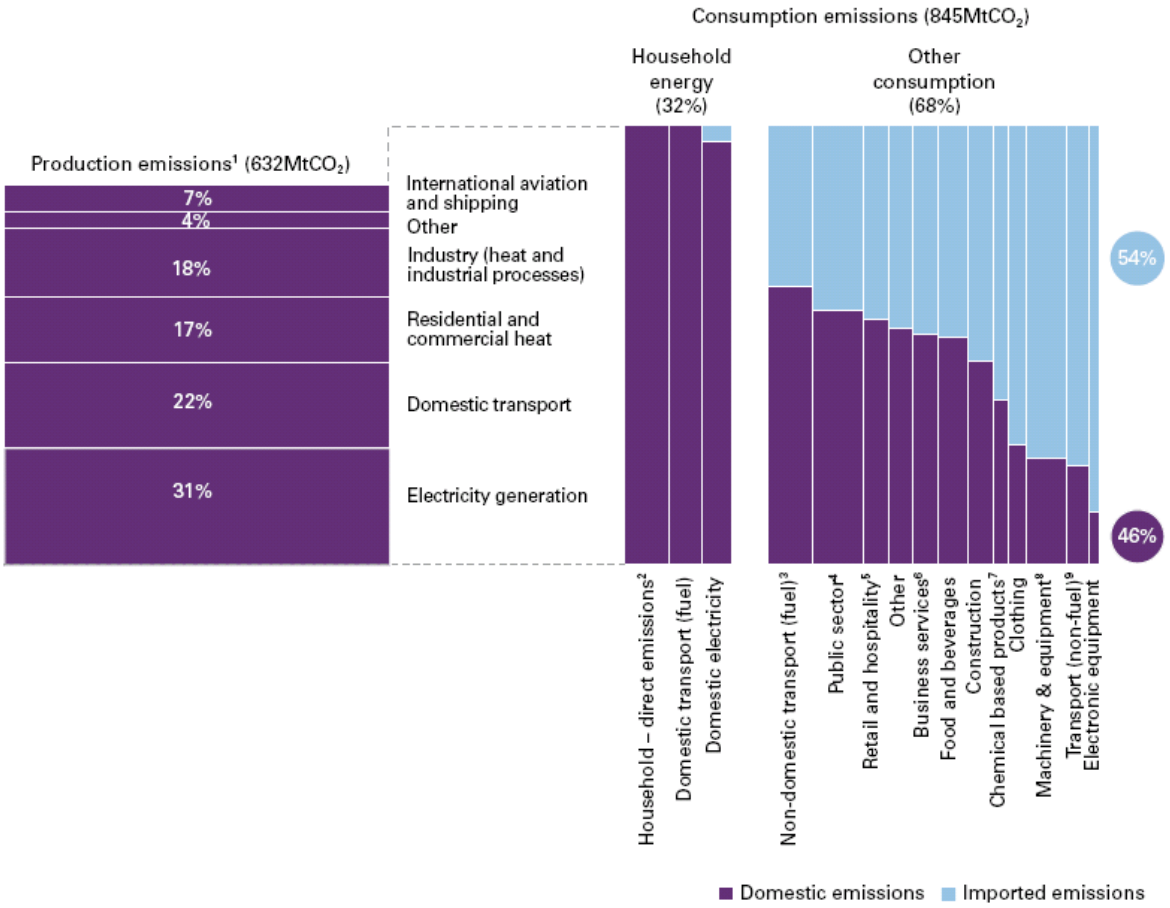
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model (2004).

Sixty per cent of emissions arising from consumption in the UK occur in the UK, with a further 12% arising in European (EU ETS) countries. Around 38% of embodied emissions occurring outside the UK as a result of consumption in the UK arise in the electricity sector; the global electricity sector is the single largest source of emissions from all regions with the exception of South America.

This reinforces the importance of global decarbonisation action in the electricity sector. While the UK is not a large importer of electricity as electricity per se, emissions from electricity generation in other countries are embodied in many of the goods and services consumed in the UK.

Over half of the emissions embodied in UK consumption (excluding private energy consumption) arise overseas

UK CO_2 emissions from a consumption perspective

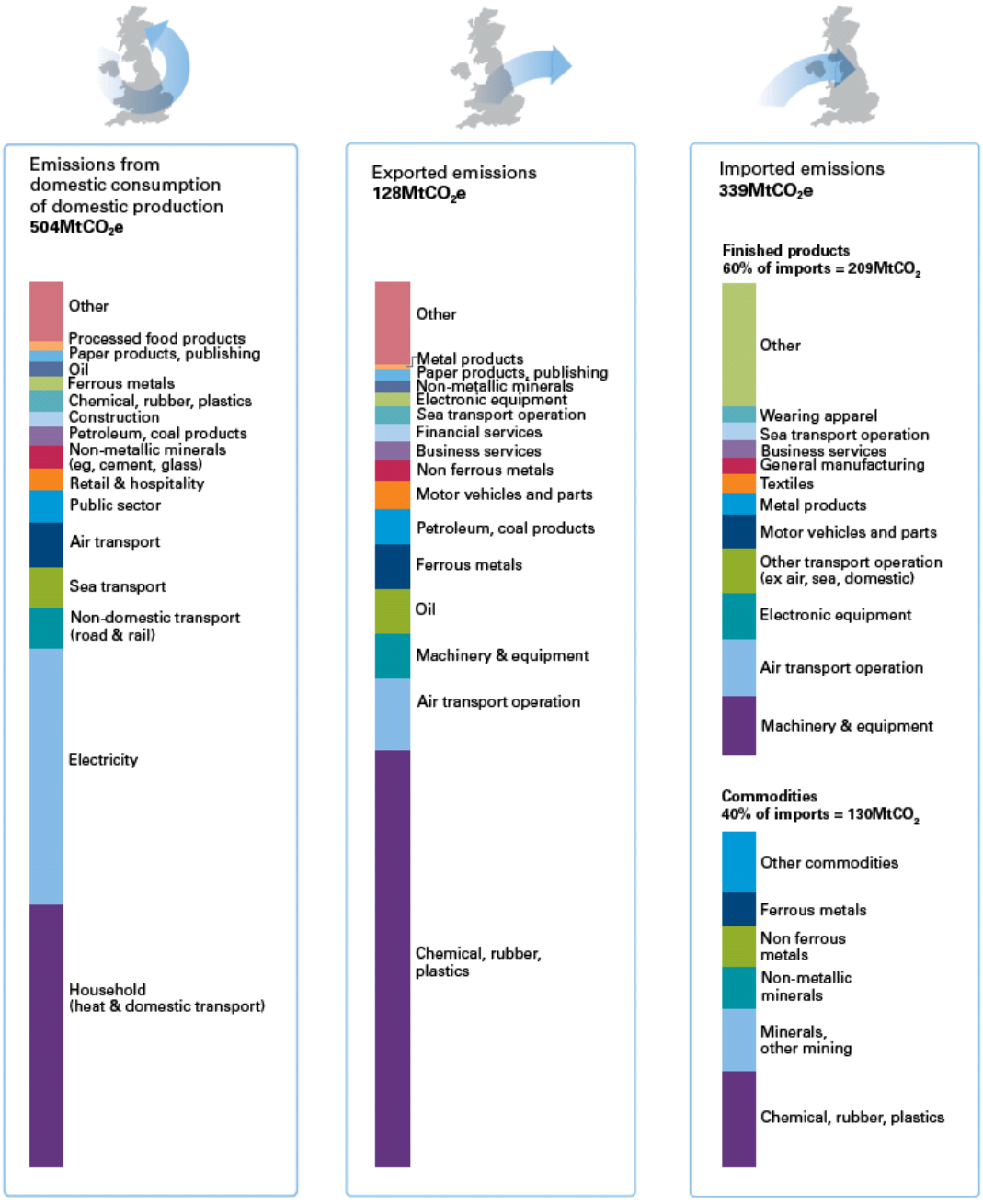


Note 1: CO_2 only – excluding non CO_2 emissions and land use change.
1. Based on split of emissions from Committee on Climate Change (CCC).
2. All direct combustion of fuel in households for heating, cooking, etc.
3. Includes all non-domestic Air, Rail, Sea & Road transport operation.
4. Includes Defence, Health & Public Administration.
5. Includes Retail, Hotels, Restaurants.
6. Includes Financial Services, Communication Services and other business services.
7. Includes household chemicals, cosmetics, pharmaceuticals.
8. Includes domestic appliances and industrial machinery.
9. Includes automotive, aviation, rail, road and marine.
Source: CT Analysis; CICERO / SEI / CMU GTAP7 MRIO Model (2004); CCC

A consumption perspective shows that the UK's consumption emissions are ~34% higher than the production emissions, the difference being made up of carbon emissions originating outside of the UK, but which are allocated to UK consumption. The importance of net imported emissions in driving this difference varies by sector, with around 90% of carbon emissions associated with the manufacture of electronic equipment and around 80% of clothes originating overseas.

The UK produces, exports and imports embodied emissions across a wide range of sectors

UK import, export and domestic consumption of emissions



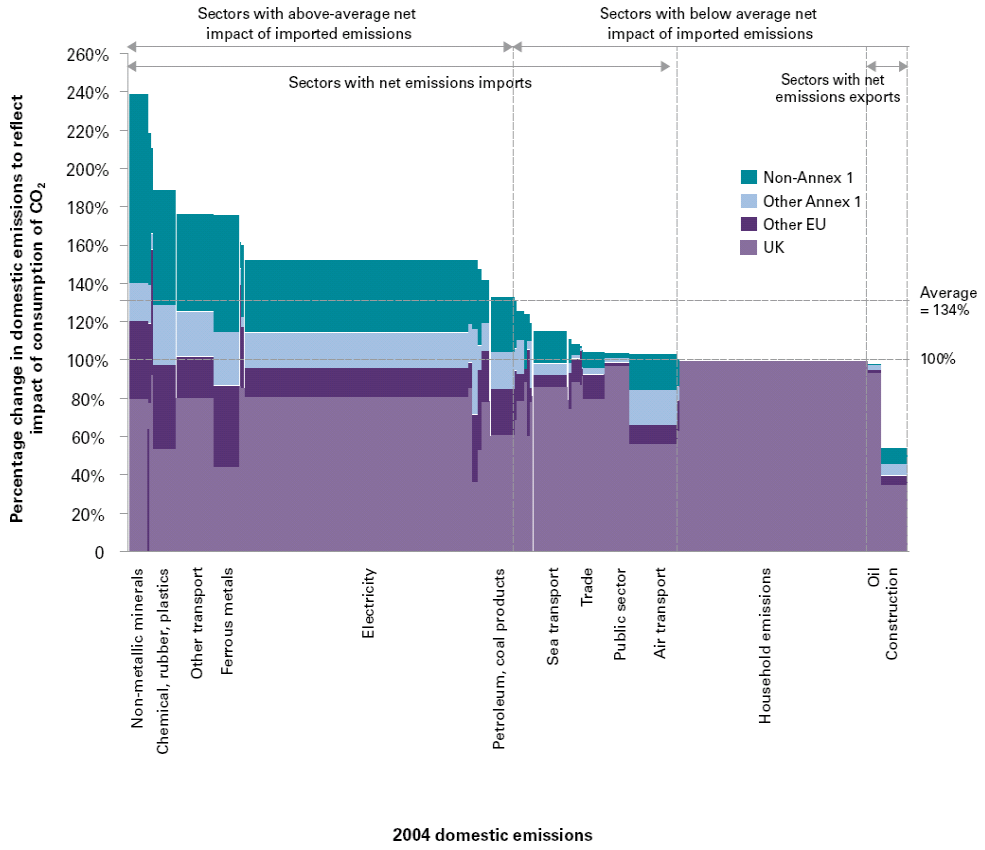
Note 1: Bars are not to scale.
Note 2: This is EEBT perspective on carbon flows, and not consistent with a full MRIO allocation.
Source: CT analysis; CICERO / SEI / CMU GTAP7 EEBT Model.

This perspective of UK emissions is based on bilateral exchange of emissions with direct trade partners.
This presentation should not be directly compared to an MRIO view of UK consumption emissions.

Embodied emissions flow into the UK in imports across a wide range of commodities and goods, with chemicals and rubber, machinery, air transport operations and minerals accounting for around one-third of all embodied emissions flowing into the UK. Overall, around 60% of emissions flowing into the UK arrive embodied in finished products, reflecting the UK's net position as a consumer rather than manufacturer of final goods.

Different UK production sectors show different levels of embodied emissions imports and exports

Emissions (by sector of production) arising from total consumption in the UK



Note 1: Electricity comnsumption associated with other sectors is aggregated as a single category, rather than allocated as scope 2 emissions to individual production sectors.
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTP7 MRIO Model (2004).

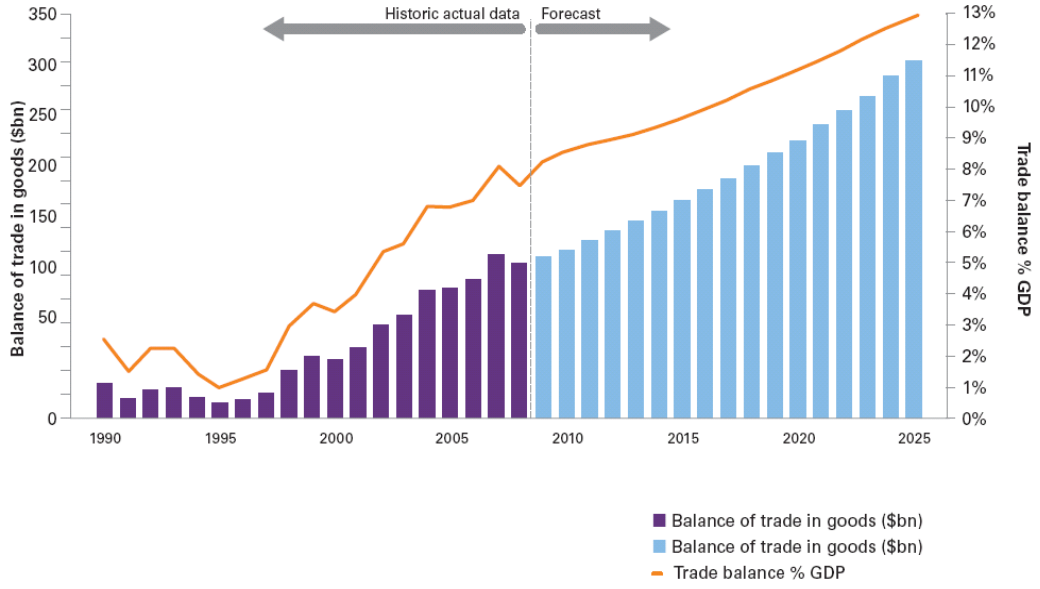
The relative importance of embodied emissions flows vary by sector. The “100%” line represents the emissions produced in the UK for each sector, with the difference between UK production of emissions in any sector and the 100% line represents emissions embodied in net imports to (or exports from) the UK. In all sectors except construction and oil, the emissions embodied in imports exceed those embodied in exports. (There are no exports or imports of household emissions, as these emissions always take place within the UK).

The “134%” line represents the average impact of net imports of emissions across all UK sectors. For some sectors, such as non-metallic minerals, chemicals and ferrous metals, net imports of emissions in these sectors is significantly greater than the average net import occurring due to the UK’s consumption of goods and services.

The UK is also a net importer of emissions embodied in electricity; however, while a small proportion of these emissions are associated with physical electricity flows, the vast majority of these electricity emissions are embodied in the goods imported into the UK (e.g. the emissions arising from the generation of electricity that was used in the overseas assembly of a car sold in the UK).

Growth in trade has traditionally been in step with GDP growth in the UK

Estimated increase in trade for the UK over time (1990-2025)

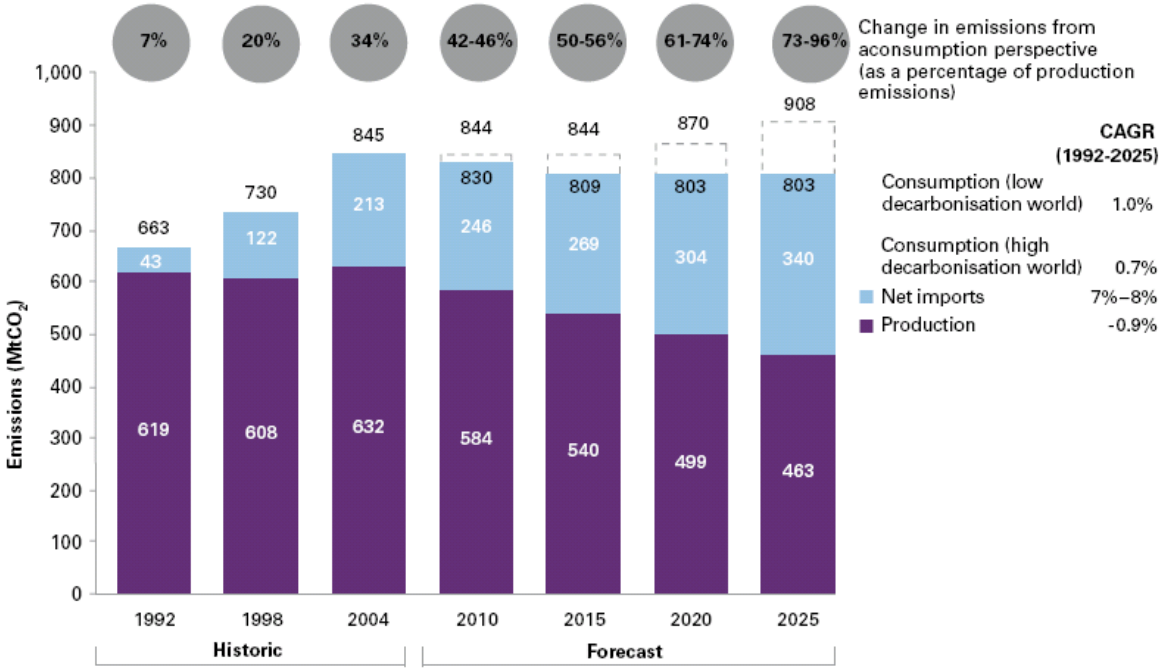


1. Constant prices, constant exchange rates using OECD base year 2000.
Source: Carbon Trust Analysis; OECD; IMP; UK Treasury.

The significance of net imports to the UK has been increasing over time, with a steady rise in the UK's trade imbalance of goods with other nations rising from only ~1-2 % in the late 1990s to ~8% in 2008 and projected to rise to ~13% by 2025.

The significance of imported embodied emissions in UK consumption emissions is expected to increase over time

Time series of UK consumption emissions, split by domestic production or imports



Note 1: Declining UK production emissions based on CO_2 reduction involved in UK achieving 2020 carbon budget for CO_2e reduction of 34% vs 1990 levels (Committee on Climate Change).
Note 2: Growth in imported emissions based on continuation of historic growth in UK trade balance, and varying degrees of decarbonisation in the exporting countries. In the "high world decarbonisation" scenario it is assumed that the emissions intensity of exports from Brazil, Russia, India and China (BRIC nations) declines in line with the targets noted in the Copenhagen Accord (2009), that exports from the EU and other Annex 1 nations decline in line with the EU's target to reduce emissions by 20% from 1990-2020, and that exports from the rest of the world achieve decarbonisation of the order of half that achieve in the BRIC countries. In the "low decarbonisation" scenario it is assumed that the EU hits its targets as stated in the "high decarbonisation scenario", that all other Annex 1 nations and the BRIC nations achieve half the level of decarbonisation as in the "high decarbonisation" scenario, and that the rest of the world does not decarbonise at all.
Source: Carbon Trust Analysis.

In 1992, the UK imported an additional 7% emissions (net) embodied in trade; by 2004, this had grown to 34%. Net UK imports of emissions are projected to continue to grow to 73 – 96% of production emissions by 2025, the range depending on the carbon intensity of production in other countries, and the anticipated reduction in the UK's production emissions from 2004 to 2025. This will result in the UK potentially importing as much carbon as it produces at home by around 2025, making imported carbon a significant issue.

China

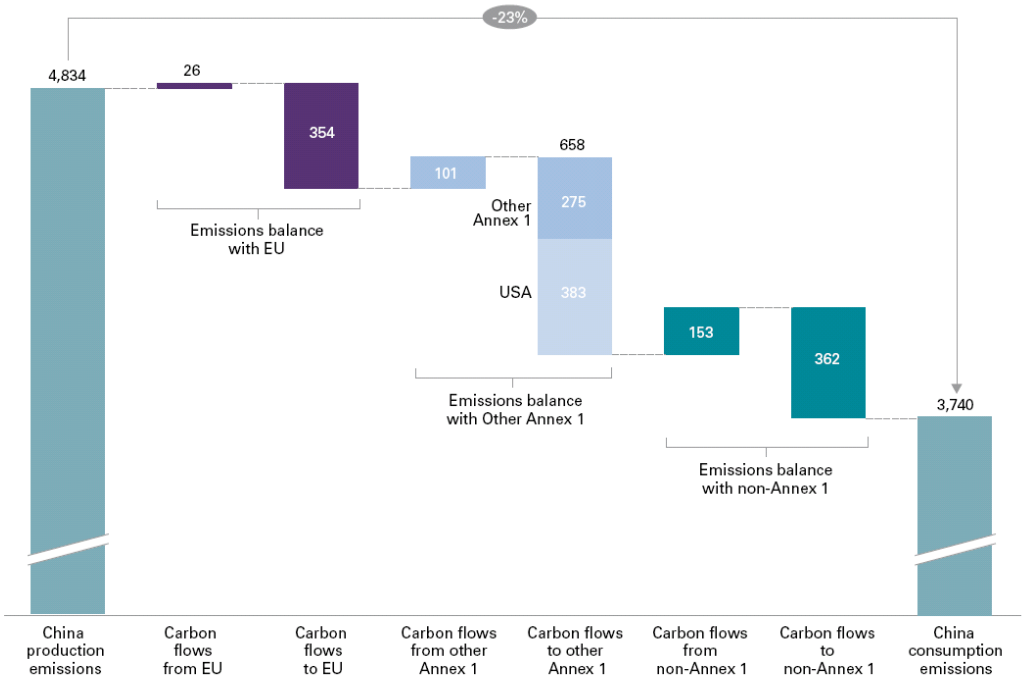
China is a significant net exporter of emissions embodied in trade, and this drives a large difference between production and consumption views of Chinese emissions "responsibility". This section explores the dynamics of Chinese emissions flows in greater detail, identifying the major export flows and international destinations of emissions arising from production in China.

Key China analysis

- *China is a major net exporter of emissions embodied in trade, particularly to developed countries*
- *The vast majority of emissions associated with Chinese consumption arise in China*
- *China produces, exports and imports embodied emissions across a wide range of sectors*
- *Different Chinese production sectors show different levels of embodied emissions imports and exports*
- *Chinese production emissions have been growing faster than consumption emissions*

China is a major net exporter of emissions embodied in trade, particularly to developed countries

Nature of international carbon flows between China and its trade partners

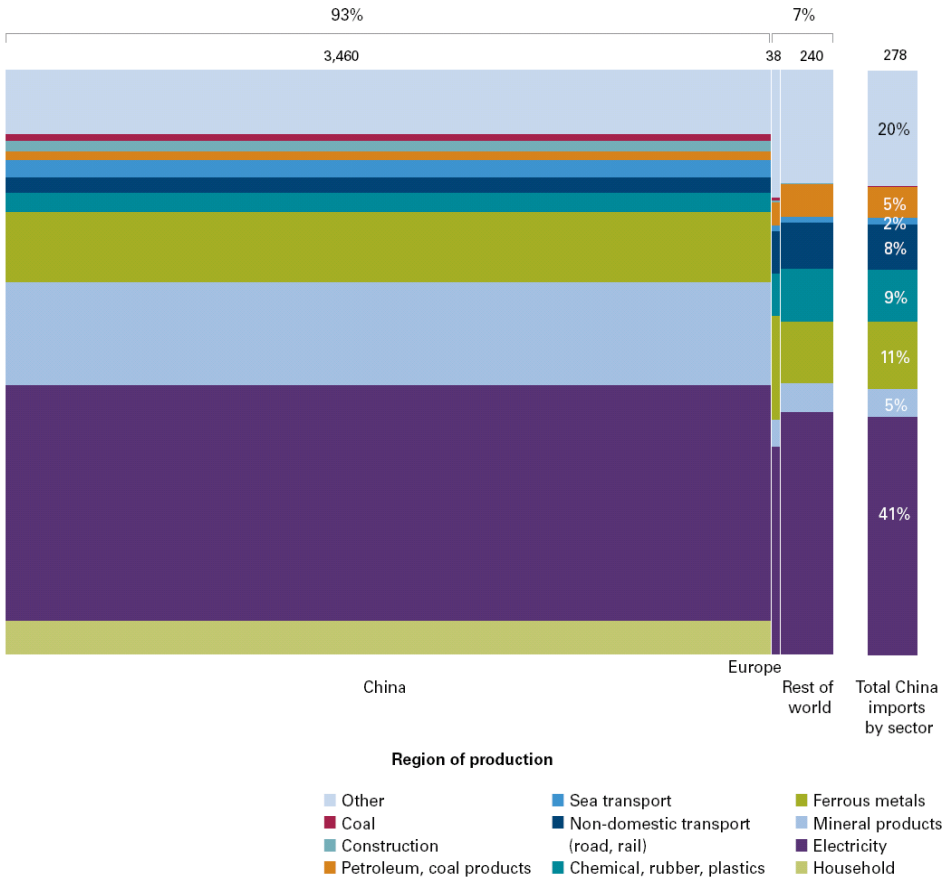


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model (2004).

China is a net embodied emissions exporter in all major trade partner categories, with embodied emissions exports to the EU around 15 times greater than embodied imports from the EU, and more than half of the embodied carbon exports to other developed countries going to the USA. Embodied emissions exports to the USA account for more than one-third of net emissions exports from China, and are greater than China's emissions exports to the EU.

The vast majority of emissions associated with Chinese consumption arise in China

Region of emissions production to satisfy Chinese consumption, by sector

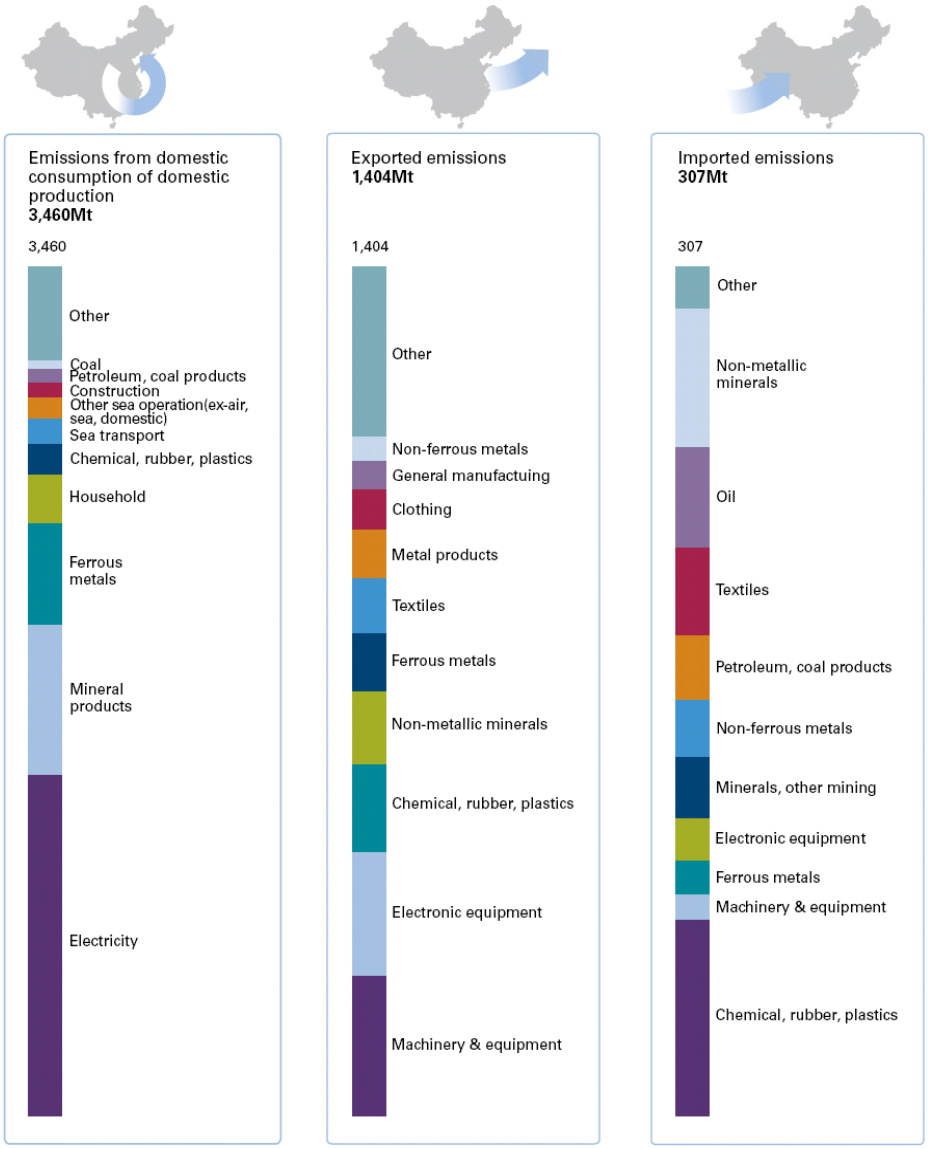


Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model (2004).

While China is a net exporter of embodied emissions, around 7% of emissions arising from consumption in China arise in other countries; the single most important sector of emissions embodied in trade arises from electricity generation. China's most significant source of overall emissions imports is from Asia, its closest trade partner region; imports from Europe account for just 1% of final CO_2 emissions from Chinese consumption.

China produces, exports and imports embodied emissions across a wide range of sectors

Split of import and export emissions from China

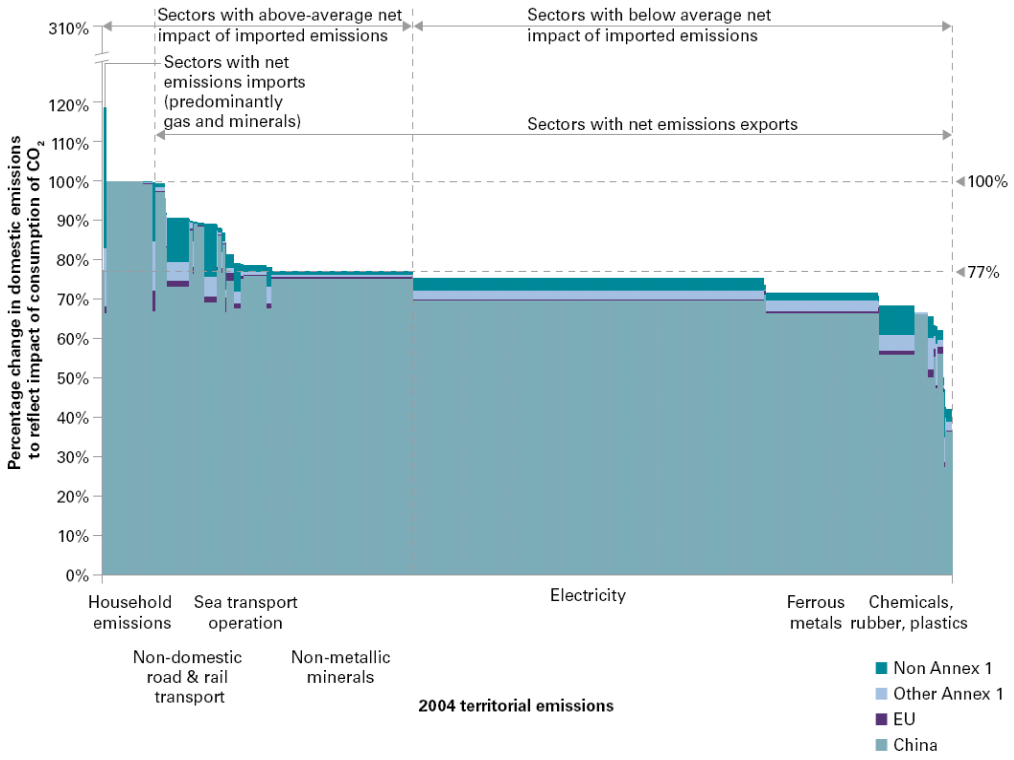


Note 1: Bars are not to scale.
Note 2:This is EEBT perspective on carbon flows, and not consistent with a full MRIO allocation.
Source: CT analysis; CICERO / SEI / CMU GTAP7 EEBT Model.

Overall, only around one-third of emissions flowing from China are embodied in commodities, with the remaining exported emissions from China embodied in intermediate and final products. This is quite different to the global average of an even split between emissions being embodied in commodity and products trade, and reflects China's increasing role as a value-added producer of final products rather than an exporter of basic commodities and raw materials.

Different Chinese production sectors show different levels of embodied emissions imports and exports

Emissions (by sector of production) arising from total consumption in China



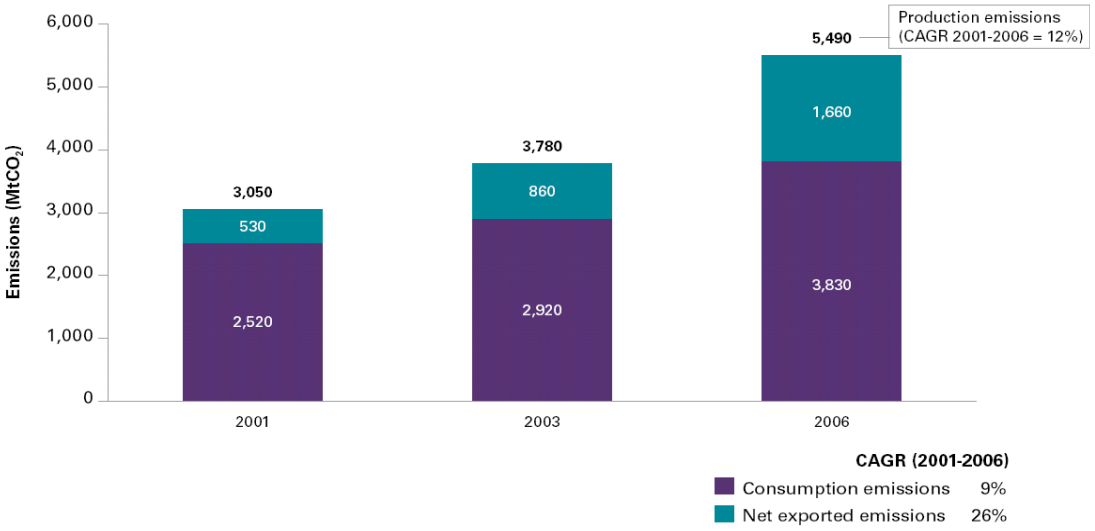
Note 1: Electricity consumption associated with other sectors is aggregated as a single category, rather than allocated as scope 2 emissions to individual production sectors
Source: Carbon Trust Analysis; CICERO / SEI / CMU GTAP7 MRIO Model (2004)

Emissions arising from consumption in China are 23% lower than from a production perspective, arising from net exports of embodied emissions across a wide range of sectors. The difference in Chinese production emissions in any sector and the 100% line represents either the net export (below the line) or import (above the line) of emissions embodied in trade from that sector.

The “77%” line represents the average impact of net exports of emissions across all Chinese sectors. In all sectors except minerals, gas, dairy, sugar and oil seeds and other crops, the emissions consumed in China are below those produced in China.

Chinese production emissions have been growing faster than consumption emissions

Time series of Chinese emissions growth by category of import, export and domestic emissions



Source: Pan et al (2008), "China's balance of emissions embodied in trade: approaches to measurement and allocating international responsibility".

Between 2001 and 2006, the compound annual growth rate (CAGR) in embodied emissions of exports from China was almost 26%, much higher than the 12% growth (CAGR) in overall domestic production of emissions. At the same time, emissions associated with Chinese consumption (of domestic production emissions) grew at a relatively low 9% CAGR.

In absolute terms, production emissions associated with domestic consumption in China grew more than emissions associated with exports; however, in relative terms, growth in Chinese production emissions that support overseas consumption has been more rapid than the growth in emissions produced to support domestic consumption.

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