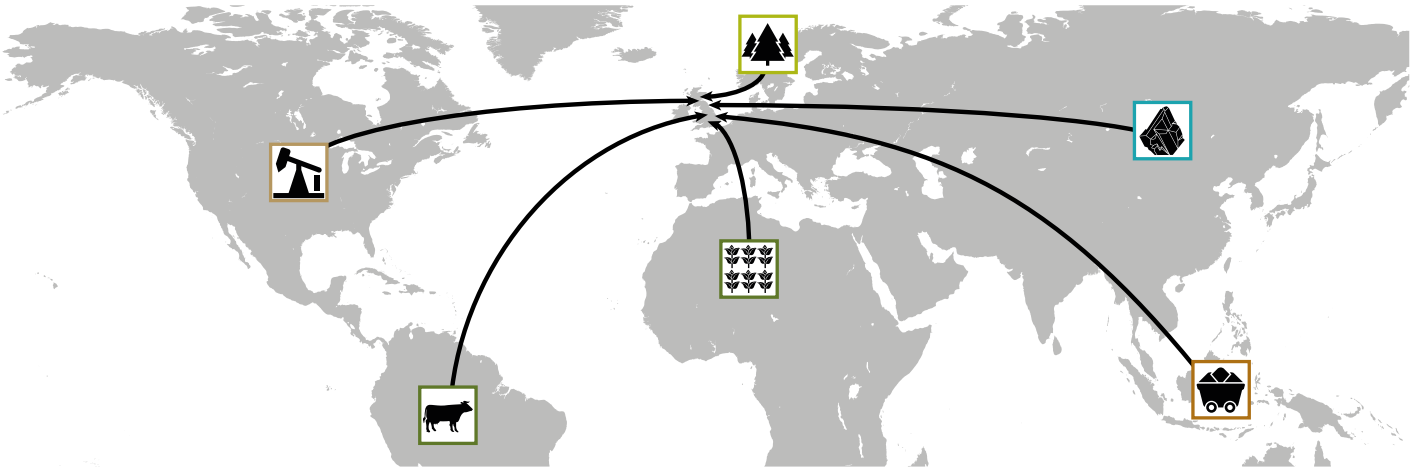
CIE-MAP

Centre for Industrial Energy, Materials and Products

Developing a carbon based metric of resource efficiency

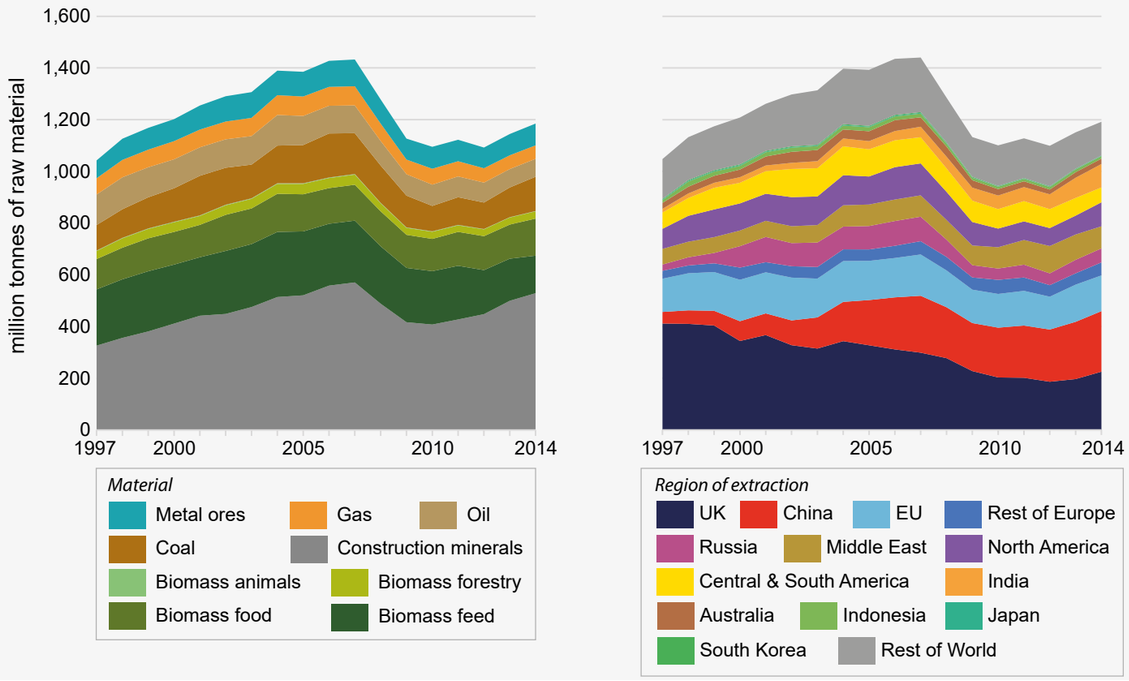
The UK Government is targeting a doubling of resource productivity over the next 25 years[1], whilst making deep reductions in greenhouse gas emissions[2]. Each year the supply chains that currently service UK final demand require over a billion tonnes of raw materials[3] and are responsible for greenhouse gas emissions exceeding 800MtCO_2e[4]. Significant improvements in the carbon intensity and resource efficiency of industrial supply chains will be required to deliver our national climate targets. Developing effective strategies requires a deeper understanding of the link between resource use and carbon emissions and an improved set of metrics to monitor changes over time. In a report to the Department for Environment, Food and Rural Affairs[3] CIE-MAP explored this link by calculating the UK's material and carbon footprints and developing a new carbon-based metric of resource efficiency. The metric was used to explore the extent of decoupling of raw material consumption from economic activity and decomposed to enable comparisons across sectors of the economy. This briefing note summarises the report's key findings and recommendations.



Key findings and recommendations

1. The UK's *material footprint* increased steadily between 1997 and 2007. The footprint sharply declined during the recession but has returned to growth in recent years. Over this period an increasing proportion of materials were extracted abroad (81% of total in 2014). In 2014 the UK's raw material footprint was 1,092 million tonnes.
2. The *material intensity* and *carbon intensity* of UK domestic production and imports reduced between 1997 and 2014. This change reflects changes in efficiency, the structure of the economy and trade. The *carbon intensity of materials* that were imported reduced between 1997-2014. However, the *carbon intensity of materials* produced in the UK increased between 1997-2012. Outside of the recession, the primary driver of increased carbon emissions was increased demand for goods and services. This increase was offset by the declining *carbon intensity of materials*, particularly amongst imports.
3. There is a strong link between resource use and carbon emissions, with a small number of economic sectors accounting for the majority of both the UK's carbon and material footprints. 30 out of 106 sectors accounted for 80% of the UK's *carbon* and *material footprints* in 2014. Efforts to reduce both footprints should be concentrated on the products of these sectors.
4. Additional resource productivity metrics are needed to guide Government policy and support the Clean Growth Strategy[2], Industrial Strategy[5] and the upcoming Resources and Waste Strategy. CIE-MAP recommends the annual production of a UK material footprint account with refinements to that which is currently available. Key metrics, such as the *carbon intensity of materials*, should be tracked using this account. Further research should develop supplementary metrics which track improvements across key sectors and products.

Figure 1: The UK's material footprint by material and region of extraction



The UK's material footprint

In 2014 the UK's *material footprint* was 1,092 million tonnes of raw material. This total can be broken down by material type, region of extraction (both Fig1) and product group. The UK's material footprint increased from 1,047 million tonnes in 1997 to 1,440 million tonnes in 2007. In the wake of the global financial crisis, the footprint reduced to 1,100 million tonnes in 2010. The footprint has increased over the two most recent years for which data is available.

Over the analysis period an increasing share of materials were imported from countries such as China and India. In 2014 81% of the UK's total material footprint occurred outside the UK. The largest contributor to recent reductions in the total material footprint has been manufacturing, which accounted for 45% of the reduction in the UK's total material footprint between 2007 and 2014.

See the back page of this brief for a description of the methods, analyses and definitions of key terms.

Changing material & carbon intensity

Measured as extracted tonnes of material used by the economy per £'000 of GVA, the *material intensity* of UK production and imports reduced over the analysis period (Fig2). The same is true of *carbon intensity* (Fig3). This change in intensity reflects changes in efficiency, the structure of the economy and trade.

The carbon intensity of materials

Between 1997 and 2012 the *carbon intensity of materials* (carbon emissions per tonne of extracted materials) produced in the UK was increasing (Fig7 back). This is because the carbon intensity of production (tonnes CO_2e per £'000 of GVA from UK production) fell but at a slower rate than the material intensity. Post 2012 the carbon intensity of materials produced in the UK reduced. The carbon intensity of materials imported has reduced slightly over the time period 1997-2014. This is because, for imported materials, the carbon intensity of production fell (improved) at a faster rate than the material intensity of production.

Figure 2: Changing material intensity

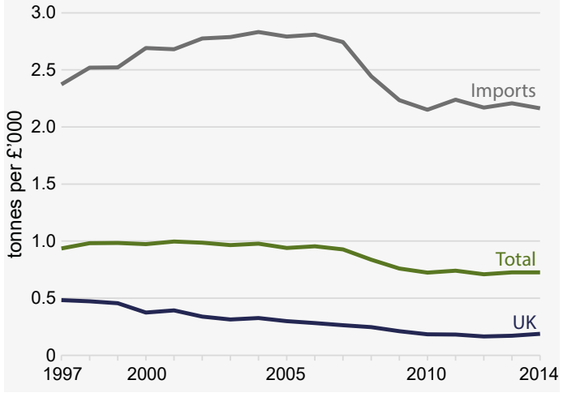


Figure 3: Changing carbon intensity

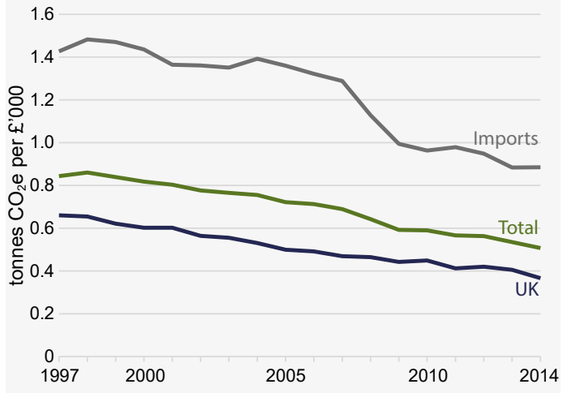
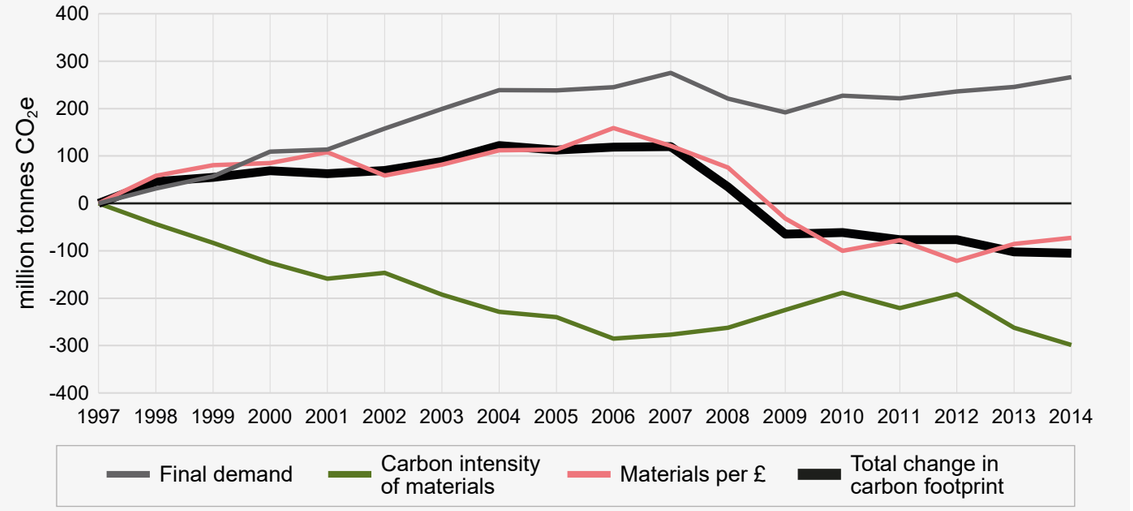


Figure 4: Change in the UK's carbon footprint decomposed by 3 factors

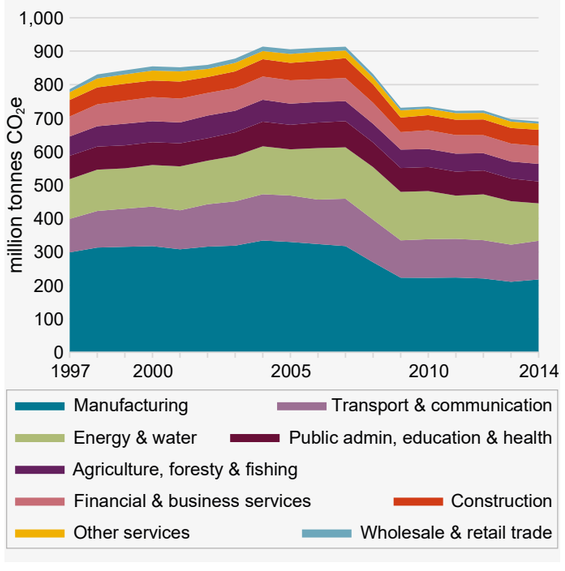


Changes in the UK's carbon footprint

Results from a decomposition analysis reveal final demand to be a positive driver of the emissions increase in non-recession years (Fig4). The *carbon intensity of materials* acts as a negative driver of emissions as the proportion of imports increases (because the carbon intensity of imports has fallen). *Material intensity* was a positive driver of emissions between 1997 and 2008 but has been a negative driver of emissions since.

Results from a product group analysis (Fig5) show that decreasing *material intensity* has contributed to emissions reductions for agriculture, forestry & fishing products and financial & business services but is a positive driver for energy & water products (where material intensity has increased). The effects of final demand and the carbon intensity of materials on carbon emissions across the product groups are similar to the total UK results, with increasing demand and reducing intensity.

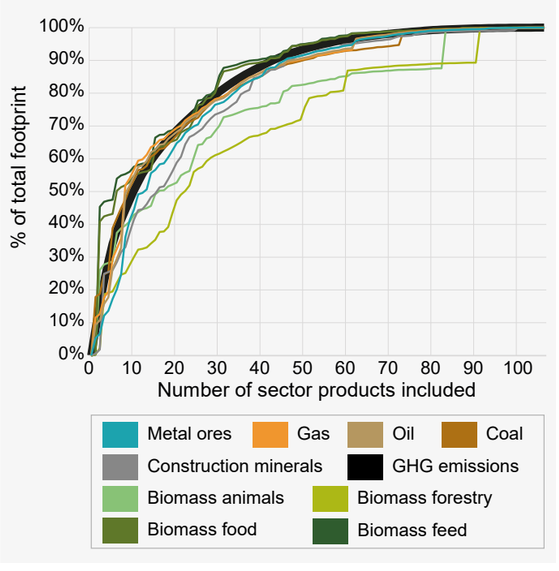
Figure 5: The UK's carbon footprint by product group



Link between resources & emissions

The analysis revealed a strong link between resource use and greenhouse gas emissions, with a small number of economic sectors accounting for the majority of both the carbon and material footprints (Fig6). For instance, the 30 economic sectors that accounted for 80% of the UK's total carbon footprint in 2014 also accounted for 62-85% of the footprint of each material type and 80% of the total material footprint. This suggests that a set of supplementary metrics which tracks key sectors and products, could be an effective indicator of national progress in improving resource efficiency and reducing carbon emissions. These metrics could take a number of forms. For instance, the full report[3] outlines proposals to develop an Index of Product Resource Efficiency which tracks improvements in emissions across the lifetime of a basket of representative products.

Figure 6: Percentage of total footprint accounted for by material – based on sector products ranked by carbon footprint in 2014



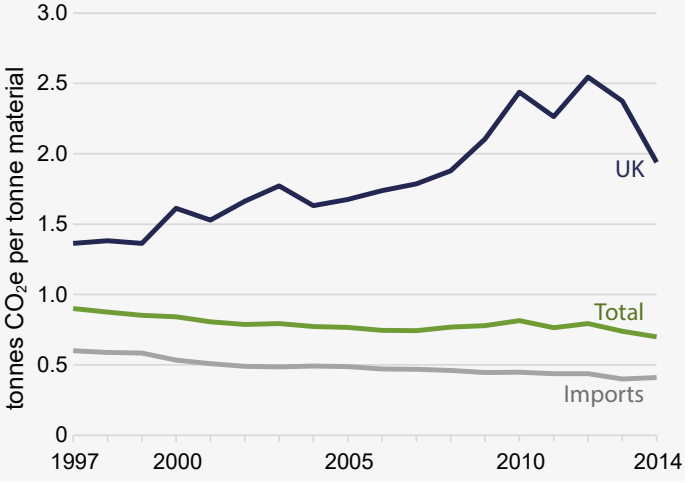
Implications of findings

If substantial reductions in the UK's material and carbon footprints are to be delivered, then increased attention must be paid to improving resource productivity across the sectors and products that constitute the bulk of impacts. This will require improved measurement and monitoring. CIE-MAP recommends the annual production of a UK material footprint account with refinements to that which is currently available. Key metrics, such as the carbon intensity of materials, should be tracked using this account. Further research should develop supplementary metrics which track improvements across key sectors and products. These sectors should then be supported in improving resource productivity by active Government policy. The Clean Growth Strategy[2], Industrial Strategy[5] sector deals and the upcoming Resources and Waste Strategy present ideal opportunities to set out such measures. For further analyses, including breakdowns by material, country and product group, see the full report '*Resource efficiency metrics - initial findings*'[3].

Methods and analyses

This analysis used a 14 region UK Multi-Region Input-Output (UK MRIO) model constructed at the University of Leeds using supply and use tables from the ONS, supplemented by trade data from the EXIOBASE MRIO database. The full report[3] compares results from this model with others including Eora, the Global Resource Accounting Model and the ONS material flow accounts. This model was used to calculate the raw material footprint and the carbon footprint associated with UK consumption from 1997-2014. The material footprint includes all raw material extraction associated with the supply chains servicing UK final demand. The results were calculated across a range of materials for 106 economic sectors and a set of 9 aggregated product groups. A decomposition analysis was used to understand the role of changes in final demand, material intensity and the carbon intensity of materials on each product group and the UK's total carbon footprint.

Figure 7: Changing carbon intensity of materials



Definitions

Carbon footprint the full amount of greenhouse gas emissions required to meet a nation's final demand for all goods and services. The carbon footprint for the UK is an official statistic[4]. This analysis uses a model with a greater disaggregation of trade regions and therefore the values reported are slightly different.

Carbon intensity tonnes of greenhouse gas emissions per £'000 of gross value added. The carbon footprint divided by gross value added.

Carbon intensity of materials tonnes of greenhouse gas emissions per tonne of material extraction. The carbon footprint divided by the material footprint.

Final demand is the total amount of money spent in the UK on goods and services to satisfy our needs.

Material footprint the full amount of raw materials required to meet a nation's final demand for goods and services.

Material intensity tonnes of materials per £'000 of gross value added. The material footprint divided by gross value added.

References

[1] HM Government 2018. A Green Future: Our 25 Year Plan to Improve the Environment

[2] DBEIS 2017. The Clean Growth Strategy

[3] Owen, A., Giesekam, J. & Barrett, J. 2018 Resource efficiency metrics - initial findings. Report to DEFRA.

[4] DEFRA 2017. The UK's Carbon Footprint

[5] HM Government 2017. Industrial Strategy. Building a Britain fit for the future

Icons courtesy of Matthew Davis, Chris Pyper, Milinda Courey, Arafat Uddin, Creative Stall and Catherine Please from the Noun Project.

CIE-MAP

Working closely with government and industry, CIE-MAP conducts research to identify all the opportunities along the product supply chain that ultimately deliver a reduction in industrial energy use.

CIE-MAP brings together the four leading UK universities of Bath, Cardiff, Leeds and Nottingham Trent with a range of expertise in engineering, economics, psychology, design, political science and governance. This work was supported by the Research Councils UK (RCUK) Energy Programme's funding for the Centre for Industrial Energy, Materials and Products (CIE-MAP), grant reference EP/N022645/1.

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