Completing the circle

Creating effective UK markets for recovered resources

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By Libby Peake, Caterina Brandmayr and Bente Klein

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Summary

British resource strategy is over reliant on a single policy: recycling targets, which are used to 'push' materials into the collection system. The result is that councils and waste management companies collect resources for which, as yet, there is no market. To date, private companies have not built sufficient domestic infrastructure to reprocess it economically. This is bad for the environment and it is also bad for the economy. Businesses want to use recycled content but the UK is exporting valuable materials that could instead be supporting clean jobs, building resilience and enhancing competitiveness.

It doesn't have to be this way. Policies like taxes on the use of virgin material, green public procurement and minimum standards for including recycled content could all help to 'pull' recovered materials back into use for manufacturing new products and packaging, reducing UK raw material imports and cutting environmental impact.

In this report, we analyse how adding these 'pull' measures to existing policy would address market failures and encourage better product design and materials management for three materials that are fundamental to the economy: plastic, steel and critical raw materials.

Plastic: Currently, just a third of plastic is collected for recycling and only nine per cent of all plastics are recycled domestically. A secondary plastic market, supported by new pull measures, could recycle an additional two million tonnes in the UK and fulfil 71 per cent of UK manufacturing's raw material demand.

Steel: The UK steel industry has suffered from decades of under investment in the technology needed to remain competitive. But building an industry that uses available recycling technology to create high value

products from more than seven million tonnes of low value steel scrap the country exports each year could change this. Our analysis shows that creating domestic markets would generate more value added economic activity in the UK, reduce iron ore imports by 40 per cent and cut carbon emissions from steel production by around 30 per cent.

Critical raw materials: The UK wants to lead the new electric vehicle and renewables markets, but the country is 100 per cent reliant on imports of critical raw materials like rare earth elements and cobalt which are essential to these industries. By introducing pull measures now, critical raw materials in discarded products, which would otherwise be wasted, could supply over a third of domestic rare earth element demand and nearly half of domestic cobalt demand by 2035.

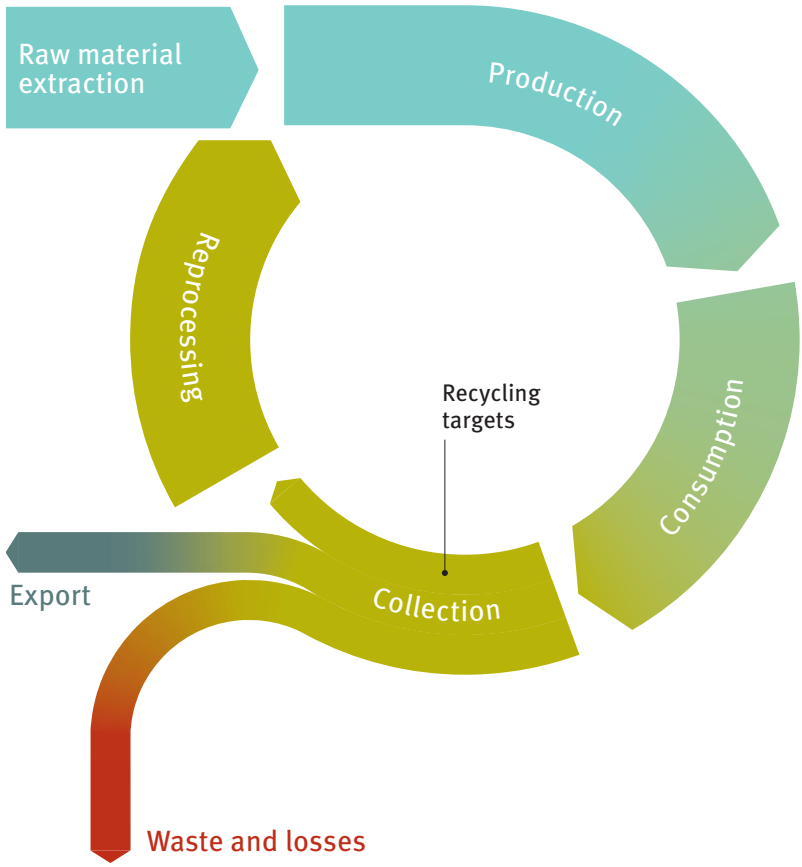
The government is uniquely placed to address the market failures that have led to unnecessary reliance on virgin materials, to the detriment of the environment, industry and the economy. We recommend pull measures are implemented using a clear roadmap. For the highest rewards, long term strategy should be built on three principles: providing certainty for supply chain investors, facilitating collaborative problem solving and encouraging rising ambition over time.

Recycling targets alone are inefficient

The UK's current approach to resource management is not encouraging the recovery of valuable materials or supporting clean jobs because it focuses almost exclusively on recycling targets. These only apply to one stage of the material cycle, working to push recyclables into the country's waste collection system.

Collecting materials for recycling does not guarantee they will be used again. And a policy only focused on collecting recyclables does not encourage products to be designed or collected in ways that make recycling cheap and easy.

Push measures only target one stage of the material cycle



A singular focus on collection targets is a problem for several reasons:

Recycling targets alone are inefficient: Because targets only stipulate that material has to be collected, not used, there is little incentive to make sure it is collected in a condition where it can be used. Many collection systems in the UK gather material too contaminated to be reprocessed domestically. As a result, two thirds of plastics collected for recycling are exported, with little guarantee they will be recycled. This issue is currently in the spotlight because of China's National Sword programme. The country is closing its doors to "foreign garbage" because it no longer wants to be sent low value materials.[1]

Contamination is detrimental to domestic infrastructure: Reprocessors often have trouble obtaining high quality material from the recycling system in the UK, especially if they cannot be certain of an end market for their products. When UK businesses are saddled with contaminated materials, it affects their bottom line, which has been implicated in the failure of several UK reprocessors.[2]

Limited materials are available: Sending material abroad means that those UK companies that want to use recycled content can struggle to source it, especially from the domestic market. This is especially problematic for scarce resources. If the UK continues to lose materials like rare earth elements (which are 100 per cent imported), businesses will remain exposed to supply chain risks, including in the low carbon technology sector which the government champions.

Missed economic opportunities: Previous Green Alliance research, in conjunction with WRAP, has shown that shifting towards a more circular economy could help to reduce unemployment across the country, creating more than 54,000 net jobs in sectors like closed loop recycling and remanufacturing.[3] £1.7 billion worth of just three materials – plastics, food and electronics – are lost to the UK economy each year because our collection systems do not enable domestic reuse or recycling.[4] In the future, UK businesses will have to compete in a world that is low carbon and resource efficient. Establishing a circular economy now will help to build their global competitiveness.

Secondary material markets offer substantial rewards

In this report we show that effective secondary material markets would provide substantial rewards for the UK:

Plastic: The government has promised leadership in tackling plastic pollution, but this is impossible while we continue to generate low value plastics that cannot be used again. The message from China's National Sword programme is that we cannot rely on other countries to continue to take our low quality waste material. A secondary plastic market could keep an additional 2.3 million tonnes of recyclable plastic in the UK and ensure it is used productively rather than ending up as pollution.

Steel: A lack of innovation and fierce competition from abroad has seen the UK steel industry founder in recent decades. But a competitive industry could be rebuilt offering high value material by making better use of the ten million tonnes, and rising, of scrap steel the UK produces each year. Currently, 7.3 million tonnes of this is exported at the same time as the UK is importing 12.3 million tonnes of iron ore a year to make new products.

Critical raw materials: The UK wants to build an automotive industry based on electric vehicles and to continue leading the deployment of low carbon energy globally. But these industries require supplies of vital materials like rare earth elements and cobalt. Implementing the right measures now could create a secure supply by reusing and recycling the materials in existing low carbon technologies, like EVs and wind turbines. By 2035, these sources could supply over a third of domestic rare earth element demand and nearly half of domestic cobalt demand.

Resource policy needs to change

To fix these problems and create resilient domestic reprocessing infrastructure, the government's expected resources and waste strategy must seek to create markets for reused and recycled materials. Policies should seek to pull materials back into productive use, and not just push materials into the recycling collection system.

Pull measures

These can be used to create and shape demand for recycled material by targeting raw material extraction, production, consumption and reprocessing. For example:

Tax the use of virgin material (or reduce VAT for reprocessed material) By encouraging a shift to recycled or reused content this could lower the need for environmentally damaging mining operations that supply raw materials to the production process.

Use purchasing power The government could use its substantial purchasing power to increase demand for recycled or reused content through public procurement.

Introduce a price stabiliser This could help the economics of reprocessing stand up by providing support to counter material price volatility.

Phase in recycled content standards These would increase the use of reprocessed material in production.

Such measures would help to address existing market failures, not only by creating demand, but also by encouraging better design and management of materials for productive use.

In this report we show how a variety of pull measures could be applied to different points in the material cycle. (For more details on different types of pull measures, see annex one on page 24.)

Pull measures would address the rest of the material cycle

Five reasons why the government should intervene

Under the UK's current resource management system, which relies on recycling targets to drive action, the economics of recycling do not always stack up. The government is best placed to change the market framework to one that incorporates both push and pull measures, for the following reasons:

1. **Materials markets can fail:** Rare earth elements are a useful study in how markets are failing. China currently produces most of the world's rare earth elements and has used its monopoly to manipulate markets to its advantage. Starting in the 1990s, it undercut world prices, which forced mines in other countries to shut. In 2009, China then announced restrictions on the export of rare earths, driving up prices, which drove interest in recycling.[5] However, before early stage reprocessing technologies could be commercialised, China began exporting greater quantities, dropping the prices again.[6] As a result, companies like Belgian chemical specialist Solvay stopped most of their rare earth elements recycling initiatives, deeming them "unprofitable".[7]

2. **Voluntary agreements cannot go far enough:** Voluntary initiatives like the UK Plastic Pact, which commits companies to using 30 per cent recycled content by 2025, show that businesses want to use recycled material. However, these initiatives only thrive when supported by a credible prospect of government regulation if industry does not deliver.

An illustration of how voluntary action without government regulation can go wrong is the Dairy Road Map. This committed milk producers to using 30 per cent recycled content in HDPE milk containers by 2015. Recycling companies invested in UK factories to meet this demand, but the rapid fall in the price of oil in late 2014, and Defra's earlier decision to 'step back' from recycling policy, led milk companies to renege on the agreement. This contributed to the collapse of Closed Loop Recycling, the UK's largest recycler of plastic milk bottles.[8]

3. **Secure material supplies are in the national interest:** Certain materials are critical to the country's economy. If the UK is to continue to produce low carbon technologies like EVs and renewables, for example, it will need a secure supply of rare earth elements. But the UK imports 100 per cent of its supply of these materials. The British Geological Survey has consistently given rare earth elements a relative supply chain risk of 9.5 out of ten, indicating they are more at risk of supply chain disruption than any other material.[9]

4. **Environmental impact is not factored into market prices:** According to the government's chief scientific adviser: "Because externalities are not priced into primary resources, their prices do not reflect their true economic costs. Many of these economic costs will have to be paid when the externalities 'come home to roost', in the form of climatic and other forms of environmental damage… The effect today, though, is to make it very hard for alternative energy, mineral or metal sources to compete in the market place, especially in the context of widely fluctuating primary commodity prices."[10] The government is the only actor that can address this market failure.

5. **Improving domestic reprocessing will support the industrial strategy:** The industrial strategy's goals would be supported by more resilient secondary material markets.[11] In particular, our analysis shows that increasing the UK's reprocessing infrastructure could provide 54,000 net jobs in places and at skill levels which are suffering from job losses due to globalisation and mechanisation.[12] Our work has also shown that raising the resource productivity of the manufacturing industry would improve overall economic productivity outside the south east.[13] The UK's strong innovation ecosystem can be used to drive developments to support a resilient reprocessing industry and strengthen its manufacturing base.

The prime minister has said that the UK will take a new and active role to help UK industry succeed. Supporting the development of secondary material markets is the perfect place to start. There is limited domestic recycling of the three materials we discuss in this report, which is unlikely to change without strategic government action.

Below, we show how supply chains for three materials – plastic, steel and critical raw materials – could be improved by the introduction of new pull measures. Doing so would support greater economic resilience, higher competitiveness and lower environmental impact.

Plastics

The case for action

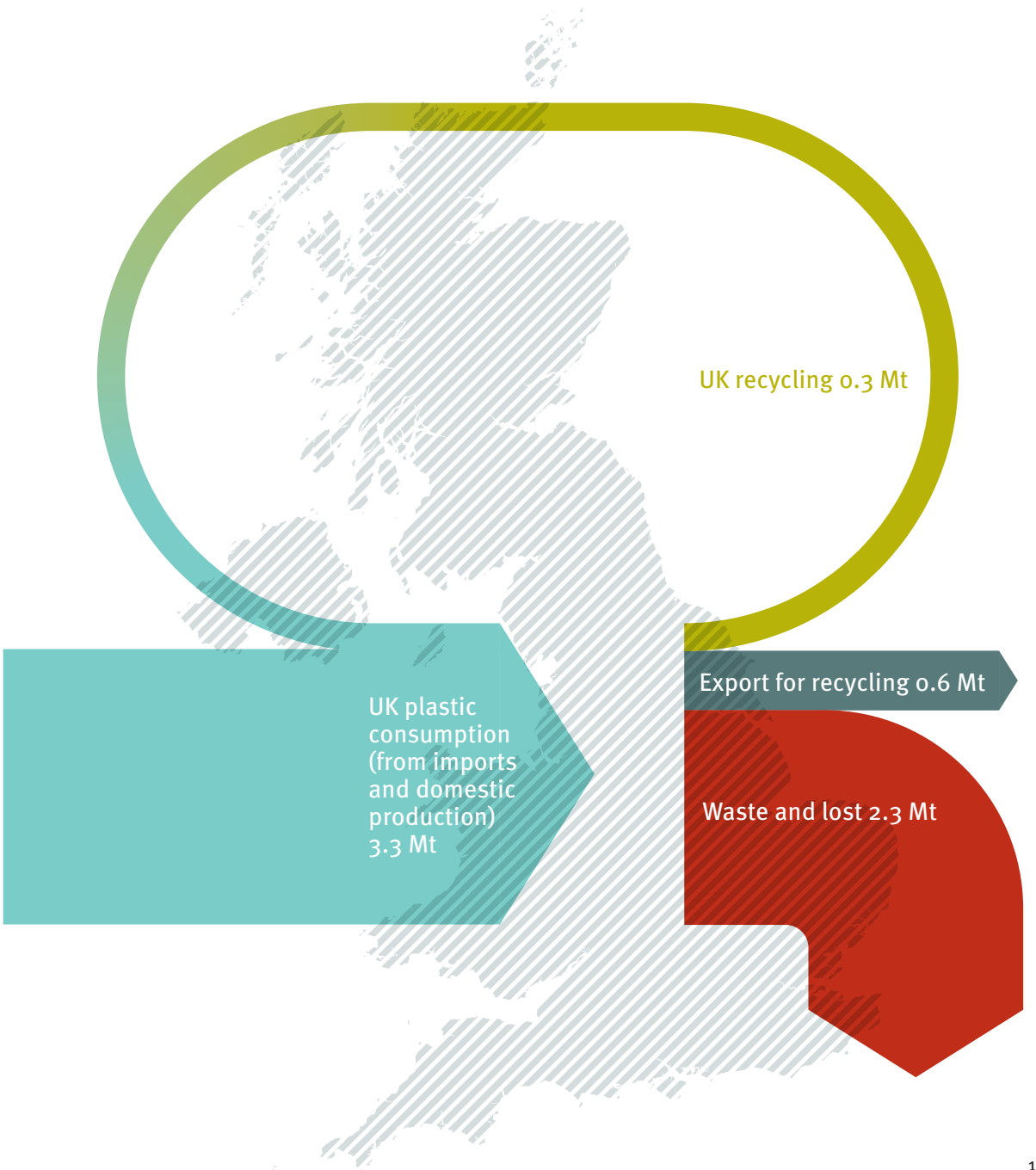
The UK does not have an adequate system to capture, recycle and reuse plastic materials. Just a third of plastic is collected for recycling and only nine per cent of all plastics are recycled domestically.[14] Around two thirds of the plastics that are collected are sent abroad, with no guarantee that they will be recycled.[15] The vast majority is wasted.

Previous Green Alliance research has shown the UK could support a total of 45 high quality, closed loop plastic recyclers, if plastics were designed better for recycling and collection systems were improved.[16]

Businesses have recently shown they are willing to play their part: at least 80 per cent of the plastic packaging supply chain has signed up to the voluntary commitments of the UK Plastic Pact, including a target to include 30 per cent recycled content in all plastic by 2025.

New policy is needed to ensure much more plastic is recovered and recycled in the UK.

Current plastic flows in the UK economy[17]



Effective pull measures for plastics

An effective secondary plastics market could keep an additional 2.3 million tonnes of recyclable plastic in the UK, bringing recycled content up to 71 per cent of demand. To realise this potential, the government will have to introduce new measures in different parts of the plastic value chain, and for applications other than just packaging.

Three types of pull measures for plastic:

Recycled content targets: Unlike existing recycling targets, recycled content targets would support the use of secondary plastic in domestic production and manufacturing processes. At the moment, some products have a high share of recycled content, like Ecover's 100 per cent recycled bottle, but most products contain little, if any, recycled plastic.[18]

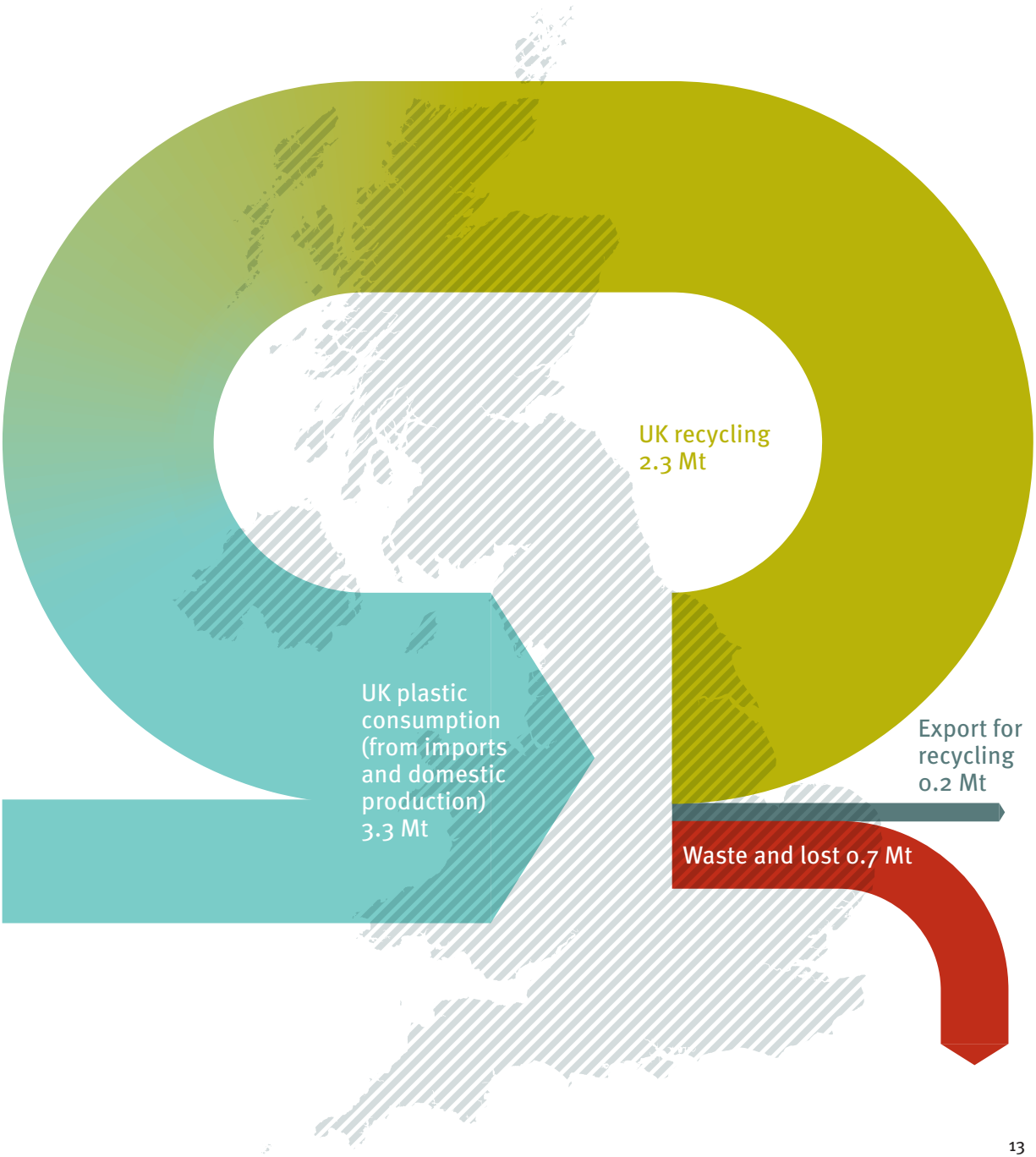
Through the UK Plastic Pact, the plastic packaging supply chain has targeted 30 per cent recycled content. The pact is a good forum for addressing quality concerns and working through supply chain challenges, but it would be more effective for businesses if the government were to set staged mandatory targets for all sectors using plastics. This would avoid the same problem experienced with the Dairy Road Map when businesses returned to using virgin plastic when the price fell in 2014, damaging reprocessing business prospects.[19]

Short term support for plastic recyclers: Recycled content targets alone might have the effect of locking the UK into importing recycled plastic, which might benefit the environment but would not lead to more jobs in the domestic supply chain. To avoid this, the government should learn from its success in commercialising renewable energy, achieved through time limited subsidy support. Following long term government policy and investment, renewables are now the cheapest form of new power in the UK.

The underlying reason for supporting recycled content supply is the same as for renewables: recycled plastics have lower environmental impacts and a smaller carbon footprint than virgin plastics. Short term subsidies to commercialise innovation and enable UK industry to scale up could be a smart investment. California's policy of funding in-state plastic reprocessors and users of recycled content is a model that could be adapted for the UK.[20]

A market stabilisation fund: Fluctuations in material prices have prevented the development of recycled plastic facilities. A price stabilising mechanism could derisk investments in reprocessing infrastructure. There are several options for how this could be done, one being to set up a fund into which those selling recyclate pay when prices exceed an upper threshold and from which they can draw from when market prices fall.

How plastic flows could change with pull measures[21]



Steel

The case for action

Steel is intensively used in construction, vehicles and machinery, and is responsible for a quarter of global industrial greenhouse gas emissions.[22] It can be produced in two ways: using a blast furnace, which turns iron ore and coal into primary steel, or by an electric arc furnace, which melts scrap steel into secondary steel.

The UK mostly uses blast furnaces, for which it imports 12.3 million tonnes of iron ore.[23] Despite the domestic availability of highly recyclable scrap steel, the UK exports most of this material (7.3 million tonnes) and only recycles two million tonnes domestically through electric arc furnaces.[24]

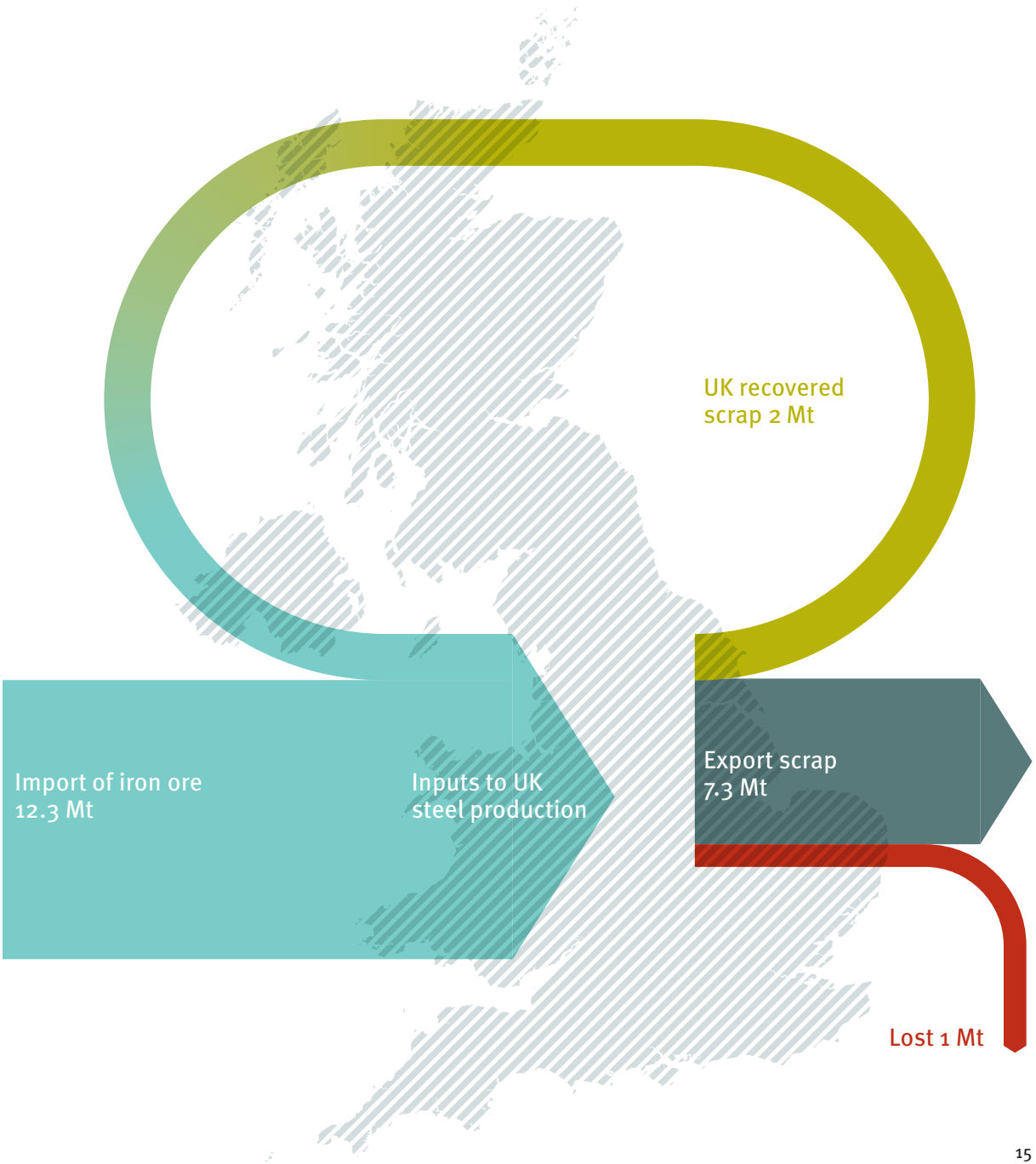
UK primary steel production has been in steady decline. Production has dropped nearly two thirds since 1970.[25] This is largely due to a lack of innovation at home and fierce competition from abroad, particularly China. Establishing an effective secondary market to expand high value recycled steel production using electric arc furnaces could be an opportunity to revitalise the industry.

Electric arc furnace steel production has structurally lower capital costs and would benefit from plentiful domestic scrap steel (expected to treble by 2050), which is currently exported at minimum value.[26] This means steel producers should be able to switch to electric arc furnace steel without very large upfront costs, and with confidence that their raw material – scrap steel – is available. Given their operational flexibility, compared to blast furnaces, electric arc furnaces would be well suited to meeting demand for the smaller product volumes required by UK manufacturers.[27] And because the steel produced this way is done in batches, producers could also benefit from low cost energy at times when renewable power is plentiful.

Importantly, although steel produced using electric arc furnace is not always cheaper than that from blast furnace, electric arc furnaces can make complex and specialist steels that are worth more than standard steel and, combined with low capital costs and flexible operations, are more likely to make UK steel competitive.

Finally, recycled steel produces about a quarter of the carbon emissions of virgin steel, so it would also futureproof the steel industry, which will need to decarbonise over the coming decades.[28]

Current steel flows in the UK economy[29]



Effective pull measures

Creating an effective secondary market could keep an additional 4.1 million tonnes of scrap steel in the UK as raw material for industry, cutting imports of iron ore by 5.1 million tonnes and emissions from steel production by about 30 per cent. It would also boost local steel production and industrial competitiveness through the development of high value secondary steel products.

The cost of steel produced by electric arc furnaces is similar overall to blast furnace steel (both fluctuate with input material prices).[30] Reusing steel in construction on the other hand could potentially lower material costs by over £300 per tonne.[31] But the use of recycled and reused steel is restricted by limited innovation and poor supply chains. For example, a lack of these effective supply chains, as well as of materials testing systems and design for disassembly in current steel applications, hinders progress and weakens the economic case for reuse under current UK economic and legislative conditions.[32]

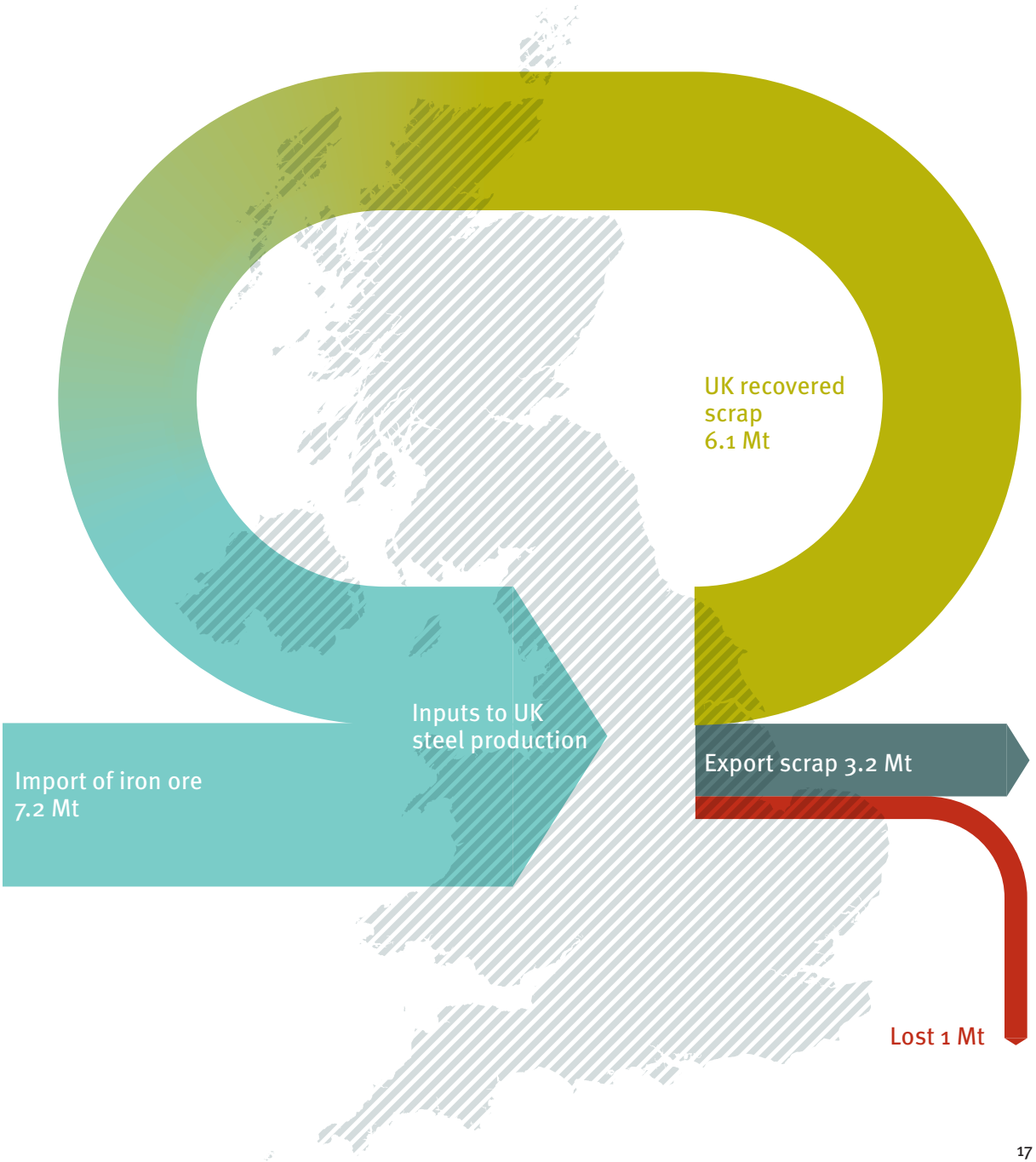
Two types of pull measures for steel:

Standards for recycled or reused content: At the moment, recycled content in steel varies widely depending on the sector, with construction having an average of almost 40 per cent recycled content, compared to 16 per cent in automotive applications.[33] Increasing recycled content across all manufacturing sectors could support demand for 3.1 million tonnes of additional recycled steel (from 3.4 million tonnes of scrap steel), a scale that would justify investment in new electric arc furnace facilities.[34]

Similarly, standards could be introduced to encourage greater reuse of steel components within the construction sector, where scrap supply is expected to grow. Currently, only around five per cent of structural steel is reused, although up to 50 per cent could be. Reaching this potential would result in a further 0.7 million tonnes of scrap steel being reused domestically.[35]

Public procurement: The government has substantial purchasing power in infrastructure that could drive demand for recovered steel. California is already spending $10 billion annually on low carbon infrastructure materials, including steel.[36] The UK government is planning to use an average of 0.6 million tonnes of steel per year in new infrastructure development over the next five years, and infrastructure spend is expected to continue to grow at 2.6 per cent per year after 2019. A requirement for recycled and reused steel in this development could drive significant UK supply chain investment.[37]

Potential steel flows with pull measures[38]



Critical raw materials

The case for action

Critical raw materials are economically important metals and minerals, vital to the manufacture of new low carbon technologies. Electric vehicles (EVs), wind power and stationary battery storage all use critical raw materials, including cobalt, found in lithium-ion batteries, and rare earth elements, particularly neodymium, praseodymium and dysprosium, vital in the manufacture of wind turbines and EV motors. Bloomberg New Energy Finance suggests that "a risk of cobalt shortages in the early 2020s… could slow down some of the rapid battery cost declines we have seen recently."[39]

The UK imports 100 per cent of its supply of these materials, and their extraction often creates significant human and environmental costs abroad. This may expose industry to supply disruptions and reputational risks. Cobalt, for instance, has been associated with human rights abuses in the Democratic Republic of Congo, which provides more than half of the world's supply.[40] Mining a tonne of some rare earth elements, meanwhile, can produce up to 2,000 tonnes of hazardous waste, harmful to both people and the environment.[41]

Today, once these materials reach end of life in the UK, they are either exported for recovery abroad or lost in the recycling process. The UK has the opportunity to act now to create secondary markets for critical raw materials to support its strategic low carbon industries.

Cobalt and rare earth element flows in the UK economy in 2035 under business as usual[42]

Effective pull measures

EVs, wind power and stationary battery storage in the UK could require 2.2 kilotonnes of rare earth elements and 19.6 kilotonnes per year of cobalt by 2035.[43] Low carbon technologies expected to reach their end of life by then could supply over a third of domestic rare earth element demand and nearly half of domestic cobalt demand. However, these materials are not currently recovered through recycling or reuse in the UK.

This could change. Rising volumes of end of life technology containing cobalt and rare earth elements would support economies of scale for domestic recovery infrastructure, if the UK builds it. And existing investments in innovation for better recovery, including via the Faraday Challenge, could support a new domestic supply chain.[44,45]

Two types of pull measures for critical raw materials:

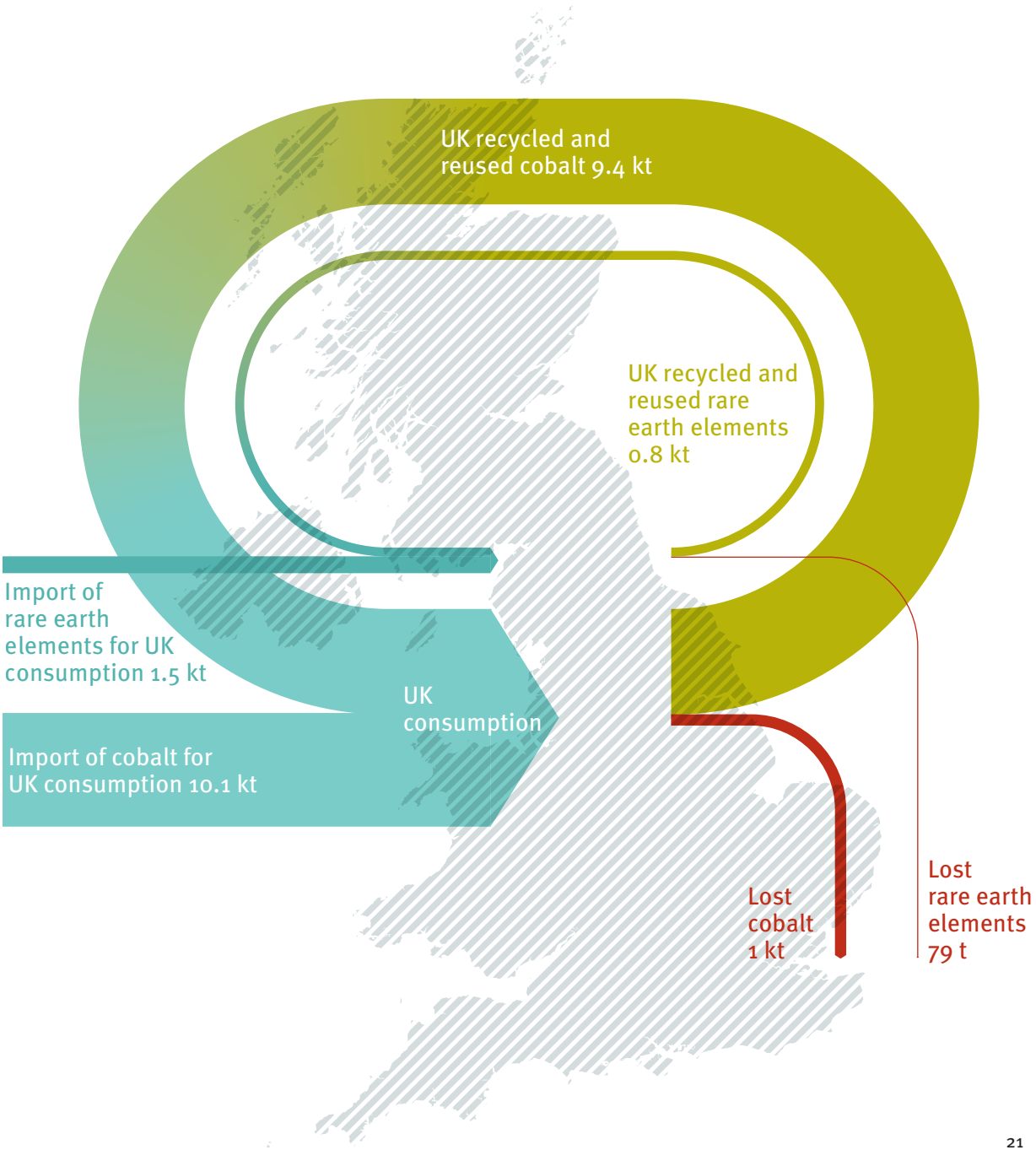
Standards for recycled or reused content: Setting future requirements for recycled content could unlock investment in recycling infrastructure and enable reverse logistics to support the use of recycled cobalt in batteries. By 2030, end of life batteries could support between 13 and 33 recycling plants, rising to between 42 and 91 plants by 2035.[46] These plants could supply a quarter of the cobalt required to meet the UK's demand for low carbon technologies in 2030 and nearly half by 2035.[47]

Similarly, targets for the rare earth elements, used in permanent magnets in EVs and wind turbines, could encourage design for disassembly, reuse or recycling.[48,49] Domestic recovery could supply more than a third of the UK's demand for rare earth elements by 2035, supporting the growth of the offshore wind industry, which is expected to rise to 51GW by 2050.[50]

Finally, standards could ensure that used EV batteries are repurposed for stationary battery storage applications. When batteries reach the end of their useful life in a vehicle, typically after eight years, they still have about 80 per cent of their capacity left. Given the expected large uptake of EVs, the UK could meet all its forecast deployment of battery storage in 2030 and 2035 by repurposing EV batteries.[51] Leading companies are already investigating reuse for large battery storage operations, including Nissan and Renault, which are testing it for a 100MW battery storage system using recovered batteries.[52]

Public procurement: Central government and local councils manage almost 75,000 vehicles and could reward battery and vehicle manufacturers that opt for recovered content.[53] Furthermore, local authorities wanting to develop distributed storage capacity could make repurposed EV batteries a procurement requirement.

Potential cobalt and rare earth element flows in 2035 with pull measures[54]



A roadmap to better resource management

UK businesses will need long term policy visibility to develop the necessary infrastructure to supply the market with recovered material. Single measures used in isolation will not be effective. For instance, if the government were to mandate recycled content as a pull measure on its own, it could lock the economy in to importing more recycled materials. This would mean the UK would lose out on the opportunity to develop a domestic market through a series of measures deployed together.

To be effective, pull measures should be implemented as part of a long term strategy built on three principles:

1. Greater certainty for supply chain investors

Policy should support investment in capital intensive plants which have lengthy payback periods. Businesses in the reuse, remanufacturing and reprocessing sectors have to trust that the UK's approach will provide the required high quality feedstock and an outlet for the recovered material over the long term. Pull measures should lead to investment in UK factories, rather than simply encouraging higher imports of recycled material.

2. Collaborative problem solving

Effective measures should create the conditions under which whole industries can work together to overcome technical barriers and invest in innovation. The sectors considered in this report have begun addressing the barriers. However, in the absence of government action, technical solutions are not being developed or deployed at the rate they could be, for a number of reasons, as shown by the following examples:

Plastics: If used in food applications, recycled polymers must be made from 99 per cent food contact material. Currently there is no commercialised system for identifying food grade polypropylene (PP), as it is a versatile material used for many other applications. WRAP has conducted research with industry to overcome these barriers and enable greater use of reprocessed PP, but the technology has not been disseminated due to a lack of demand for recycled polymers.[55]

Steel: Recycled steel made with an electric arc furnace is more likely than virgin steel to contain dissolved nitrogen, making it less suitable for high end automotive sheet steel. The Electric Steelmaking Research Centre is developing a process of low nitrogen steelmaking whose commercialisation could be encouraged by greater demand for recycled steel in high value automotive applications.[56]

Critical raw materials: Recycling technologies for many critical raw materials, including rare earth elements, are at an early stage of development. There is currently no commercial scale operation for recycling the permanent magnets used in EVs and wind turbines, for instance. But a 2016 academic review suggests that "globally increasing efforts" in research and development, supported by demand for recovered material, could create a viable option "in the near future".[57]

3. Rising ambition over time

Experts from each of these industries, consulted in our workshops (see annex two) and in private interviews, assured us that these and other barriers could be overcome with a roadmap approach. The Dairy Roadmap offers an example of how increased ambition can be achieved. It faltered in 2014 and 2015 because the milk industry reneged on voluntary commitment to increase recycled content, but the staged targets – rising from ten per cent by 2010, to 30 per cent by 2015 and 50 per cent by 2020 – could be used as a model. As part of the roadmap, WRAP supported the industry through research into improving the quality of recycled material and the development of design guidance.

We recommend replicating this phased approach to developing the market for recovered materials, bringing researchers, designers, producers, retailers and reprocessors together to overcome barriers. And investors should be offered sufficient guarantees that the government will consistently aim for greater and greater development of the circular economy.

Annex one

Examples of pull measures

Policy option	How it works	Comments
Reporting and labelling	Manufacturers and retailers are required to specify the recycled content or other environmental impact of their products and packaging	Informed consumption has not proven effective in a consumer context, but informed investment or business purchasing could be more so. This would be especially true if investors were more concerned about risks associated with resource use and scarcity. For this to work, information must be verified, for example through existing product certification schemes.
Green public procurement	Public bodies specify recycled content or other environmental measures for the goods they purchase	Public bodies have large purchasing power, with the UK public procurement market worth £260 billion in 2015, which was 13.6 per cent of GDP.[58] The UK government has already identified the forward commitment procurement model, where it provides the market with advance information of future needs, as particularly useful in supporting environmental goods.[59] This has not yet been used to create demand for secondary materials.
Standards for recycled content	Materials sold must contain a minimum proportion of recycled content	The UK plastic packaging supply chain has recently created a voluntary agreement to use 30 per cent recycled content by 2025.[60] Such agreements are most effective if backed by regulation to ensure action by all businesses, and the approach could be widened to other materials. Supply chain auditing will be needed for monitoring and enforcement.
Producer responsibility fees	Extended producer responsibility regimes are adjusted to reward the use of recycled content or remanufacturing	At the moment, producers have little incentive to use recycled material or to ensure their products (or parts of products) are designed to be reused or remanufactured. This could be changed through a bonus-malus regime that would see producers pay less for using recycled material, or for increasing reuse or remanufacturing in sectors including vehicles and electrical and electronic equipment. To be effective, charges or rewards must be large enough to incentivise change.
Subsidy	Payment is made either to reprocessors who recycle material or to manufacturers that use recycled or reusable materials	As with renewable energy, the idea behind subsidies for recycled or reused materials would be to encourage innovation leading to a stable market. Once the market is established and secondary materials can compete on cost grounds with virgin material, subsidies could decrease or disappear. California's Plastic Market Development programme, which pays up to $150 per tonne to plastics reprocessors and manufacturers using recycled plastics, has been credited with increasing in state plastic reprocessing by 3,000 per cent.[61]

Policy option	How it works	Comments
Price stabiliser	A government or central fund tops up the price obtained for reprocessed material when the price of virgin material falls below a certain level	The volatility in virgin material prices affects the economic viability of recycling operations. Rather than introducing a consistent material tax, the government could introduce a compensating adjustment to help when virgin prices fall below a certain level. This could be done by the government itself or through a central fund that those selling recyclate pay into when prices exceed an upper threshold, and which they draw from when it goes below a lower threshold. Alternatively, hedging mechanisms, such as forward contracts or options, modelled on those used in financial markets, could be replicated to support recyclate use.
VAT variation	The Treasury offers lower VAT for products or businesses that incorporate a minimum proportion of recycled, reused or remanufactured material	Reducing VAT for recycled content or reuse and repair activities is in line with previous select committee recommendations. In 2014, the government's Environmental Audit Committee recommended that the government should "introduce differential VAT rates based on lifecycle analysis of the environmental impact or recycled content of products, and tax allowances for businesses that repair goods or promote reuse".[62] Sweden has shown it is possible to reduce VAT for repairing goods within the EU and the European Commission recently proposed that member states should have more flexibility in changing VAT rates.[63,64] Leaving the EU should give the UK greater ability to vary VAT.
Environmental taxes	Virgin material is taxed on the basis of its greater environmental impact compared to secondary resources	The price of virgin material does not reflect its true cost because environmental impacts, like climate change and pollution from mining (externalities), are not factored into the final price. Therefore, taxes on virgin materials would encourage a shift to secondary production. These would need to be fairly distributed along product supply chains and would be most effective if they rose over time, as with the Landfill Tax Escalator or the Aggregates Levy. The latter taxes primary extraction with the aim of incentivising recycling of aggregate in the UK.

Annex two

Attendees at our expert workshops

Plastic

Nick Cliffe
Innovate UK

Linda Crichton
Defra

Sam Downes
National Infrastructure Commission

Tim Elliott
Eunomia

Stuart Foster
RECOUP

Tony Heslop
BASF

Pat Jennings
CIWM

Helen Jordan
British Plastics Federation

Jakob Rindegren
Environmental Services Association

Eddy Taylor
Laing O'Rourke

Steel

André Cabrera Serrenho
University of Cambridge

Robert Fell
British Metals Recycling Association

Antonia Grey
British Metals Recycling Association

Chris McDonald
Materials Processing Institute

Sam Pentony
EEF and UK Steel

Michael Sansom
The Steel Construction Institute

Nick Silk
Tata Steel

Anna Surgenor
UK Green Building Council

Eddy Taylor
Laing O'Rourke

Critical raw materials

Peter Clark
Knowledge Transfer Network

Robert Fell
British Metals Recycling Association

Antonia Grey
British Metals Recycling Association

Caroline Guest
HSSMI

Norah Lewis
WRAP

Patrick Mahon
WRAP

Edward Morrell
Seren AG

Endnotes

Full methodology for the numerical analysis for each material is available online at www.green-alliance.org.uk/completing_the_circle_methodology.php

1 China's National Sword programme aiming to improve the quality of recyclate began in February 2017, and the country notified the World Trade Organisation in July 2017 of its intention to ban 24 grades of "foreign garbage" including unsorted paper and all plastics in 2018. As part of the operation, stringent contamination limits for material that the country continues to import also came into effect in March 2018. In April 2018, the country added that it would ban the import of 16 further types of material for recycling, including metal and electrical appliance scrap, including cable and wires and stainless steel.

2 According to the Resource Association's *Costs of contamination report 2012*, poor quality and inconsistent collections cost UK reprocessors at least £51 million annually. The two plastic reprocessors that took part in the survey – Closed Loop Recycling and ECO Plastics – both went into administration in 2015 for a number of reasons, including contamination costs. (The two plants were later bought by new owners and are both operating again at least to some extent.)

3 Green Alliance and WRAP, 2015, *Employment and the circular economy: job creation in a more resource efficient Britain*

4 Green Alliance, 2014, *Wasted opportunities: smarter systems for resource recovery*

5 Library of the European Parliament briefing, 2013, 'China's export restrictions on rare earth elements'

6 Ibid

7 O Larcher, A Rollat and N Barthel, from Solvay, France, 'Solvay latest developments in rare earth recovery from urban mines', presentation at the European Commission conference on 13 November 2015, 'Exchange of good practices on metal by-products recovery'

8 *The Guardian*, 26 March 2015, 'UK's biggest plastic milk bottle recycler on brink of collapse'

9 NERC, 2015, *British geological survey 2015: risk list 2015*

10 Government Office for Science, 14 December 2017, *From waste to resource productivity: report of the government chief scientific adviser*

11 HM Government, 27 November 2017, *Industrial strategy: building a Britain fit for the future*

12 Green Alliance and WRAP, 2015, op cit

13 Green Alliance, 2017, *Lean and clean: building manufacturing excellence in the UK*

14 Valpak and WRAP, 2016, *Plastic spatial flow analysis*

15 Ibid

16 Green Alliance, 2014, op cit

17 A full methodology for each of the three materials is available on our website. See Green Alliance, 2018, *Completing the circle methodology* at: www.green-alliance.org.uk/completing_the_circle_methodology.php

18 Letsrecycle, 16 February 2018, 'Ecover launches 100% recycled PET plastic bottles'

19 *The Guardian*, 26 March 2015, 'UK's biggest plastic milk bottle recycler on brink of collapse'

20 Green Alliance, 2017, *Recycling reset: how England can stop subsidising waste*. California uses unclaimed deposits from its bottle return scheme to pay in state reprocessors and users of recycled plastics up to $150 per tonne.

21 Green Alliance, 2018, op cit

22 JM Allwood, JM Cullen and RL Milford, 2010, 'Options for achieving a 50 per cent cut in carbon emissions by 2050' in *Environmental Science and Technology*, 44, pp 1,888-1,894

23 UK Steel, 2016, *Key statistics 2016*

24 Scrap exports data from World Steel Association, 2017, *Steel statistical yearbook 2017*; domestic scrap recycling data from UK Steel, 2016, *Key statistics 2016*

25 House of Commons Library, 18 December 2017, 'UK steel: decades of decline'

26 Serrenho et al, estimate there will be 29.9 Mt of available scrap in the UK In 2050; see AC Serrenho et al, 2016, 'The influence of UK emissions reduction targets on the emissions of the global steel industry', *Resources Conservation and Recycling*, 107, 174-184. Pauliuk et al, estimate that global supply of end of life scrap will triple from current volumes; see S Pauliuk et al, 2013, 'The steel scrap age', *Environmental Science and Technology*, 47, pp 3,448-3,454

27 BEIS, 2017, *Future capacities and capabilities of the UK steel industry*. The analysis noted: "The fact that producers are often unable to service small volumes has also meant that the role of the stockholder has become increasingly important in the UK steel industry. This has potentially significant implications for the UK steel industry as stockholders become the key target customers of importing mills who require that channel to be able to serve sophisticated or small customers in the UK. This growth in the UK stockholding segment has exacerbated the disconnect between producer and consumer and can inhibit continuous improvement and new product development."

28 Electric arc furnace sites in the UK have an average carbon intensity of 0.6 tCO_2e per tonne of recycled steel, while integrated sites (blast furnace production) have an average of 2.2 tCO_2e per tonne of virgin steel. See WSP and DNV-GL, 2015, *Industrial decarbonisation & energy efficiency roadmaps to 2050: iron and steel*, p 36; recycled steel is also associated with raw material savings: over 1,400 kg of iron ore, 740 kg of coal, and 120 kg of limestone are saved for every 1,000 kg of steel scrap made into new steel, see: World Steel Association, 2018, 'Steel and raw materials: fact sheet'

29 Green Alliance, 2018, op cit

[30] Based on expert opinion from Chris McDonald, Materials Processing Institute.

[31] The Steel Construction Institute, no date, *Structural steel reuse*, www.steel-sci.info/reduce-and-progress.html

[32] Ibid

[33] Global averages based on: KE Daehn et al, 2018, 'How will copper contamination constrain future global steel recycling?', *Environmental Science and Technology*, 51 (11), pp 6,599–6,606

[34] Electric arc furnace facilities can range from small scale plants of sub 0.5 Mt per year, generally focused on a single product, to larger facilities with an output of 2 Mt per year, covering a broader market scope.

[35] D Cooper and JM Allwood, 2012, 'Reusing steel and aluminium components at end of product life', *Environmental Science and Technology*, 46, 10,334-10,340; J Cullen, 7 June 2016, *Steel reuse in construction*, presentation

[36] According to Buy Clean California, http://buycleancalifornia.org/

[37] BEIS, 15 December 2017, *Steel procurement pipeline;* BEIS, 2017, *Future capacities and capabilities of the UK steel industry,* technical appendices, p 57

[38] Green Alliance, 2018, op cit

[39] Bloomberg, 21 May 2018, 'E-buses to surge even faster than EVs as conventional vehicles fade'

[40] Amnesty International, 2017, *Time to recharge: corporate action and inaction to tackle abuses in the cobalt supply chain*

[41] *The Guardian*, 20 March 2014, 'Rare earth mining in China: the bleak social and environmental costs'

[42] Green Alliance, 2018, op cit

[43] We assume that government will bring forward the ban on new sales of diesel and petrol to 2030 – see methodology at www.green-alliance.org.uk/completing_the_circle_methodology.php for similar analysis based on EV deployment as modelled by the Committee on Climate Change

[44] *Waste Management World*, 25 August 2017, 'Axion to report on lithium ion battery end-of-life research'; University of Birmingham, 23 January 2018, 'The Faraday institution announces £42 million for energy storage research'; Gov.uk, 29 November 2017, *Future electric vehicle batteries: long-lasting, cleaner, better*; P Purnell et al, 2018, *Developing technology, approaches and business models for decommissioning of low-carbon infrastructure*

[45] See, for instance: BloombergQuint, 22 March 2018, 'Lithium miner eyes even greater riches in piles of battery waste'; Bloomberg, 1 December 2017, 'How to mine cobalt without going to Congo'; and Bloomberg, 11 January 2018, 'Hype meets reality as electric car dreams run into metal crunch'

[46] There could be between about 460,000 and over 1.16 million EV batteries reaching end of life by 2030, rising to about 1.5 and 3.2 million by 2035. The ranges are based on two estimates: the lower option is based on the Committee on Climate Change analysis that 60 per cent of new vehicle sales in 2030 will be EVs. The higher number assumes that the ban on new petrol and diesel vehicle sales will be brought forward to 2030. The number of recycling plants is calculated assuming each plant capacity is equal to the current 35,000 EV batteries capacity of Umicore's recycling plant in Belgium, see: http://csm.umicore.com/en/recycling/battery-recycling/our-recycling-process

[47] Assuming a rate of EV uptake in line with the Committee on Climate Change projections the following share of demand can be met by recycling and reusing cobalt: 18 per cent of demand in 2030, and 34 per cent of demand in 2035.

[48] Fraunhofer press release, 1 September 2015, 'Recycling permanent magnets in one go'

[49] The University of Birmingham, for instance, is currently conducting research into developing the technology to recycle rare earth magnets.

[50] Based on National Grid, 2017, *Future energy scenarios*, 'Two degrees' scenario

[51] Ibid

[52] Reuters, 7 June 2017, 'Renault plans foray into energy market with mega battery'

[53] *The Daily Telegraph*, 17 July 2014, 'Government cars go electric'; Fleet news, 9 February 2015, 'UK council fleet drops below 50,000 vehicles'

[54] Green Alliance, 2018, op cit

[55] WRAP, 2016, *Recycling of food grade packaging using fluorescent markers*. This is the latest report from WRAP's project to promote food grade recycled polypropylene (rPP) in packaging, which has so far been through six phases.

[56] Materials Processing Institute, 2 May 2016, *Electric steelmaking – the new paradigm for UK steel manufacturing*

[57] Yongxiang Yang et al, 'REE recovery from end-of-life NdFeB permanent magnet scrap: a critical review' in *Journal of Sustainable Metallurgy*, March 2017, Volume 3

[58] European Commission DG Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), 19 December 2016, *Public procurement indicators 2015*

[59] BEIS, November 2011, *Forward commitment procurement: practical pathways to buying innovative solutions*

[60] WRAP, 26 April 2018, *UK businesses make world-leading pact to tackle plastic pollution*. Using more recycled content is one of the commitments of the UK Plastic Pact, launched by WRAP. Businesses accounting for 80 per cent of the plastic packaging supply chain at the time of launch have also promised to "eliminate problematic or unnecessary single-use plastic packaging", make 100 per cent of plastic packaging reuseable, recyclable or compostable and ensure 70 per cent of plastic packaging is recycled or composted by 2025.

[61] Californians Against Waste, 2016, 'AB 1005 (Gordon) – California Plastic Recycling'

[62] Environmental Audit Committee, 2014, *Growing a circular economy: ending the throwaway society*

[63] *The Guardian*, 19 September 2016, 'Waste not want not: Sweden to give tax breaks for repairs'

[64] European Commission, 18 January 2018, *Proposal for a council directive amending Directive 2006/112/EC as regards rates of value added tax*

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