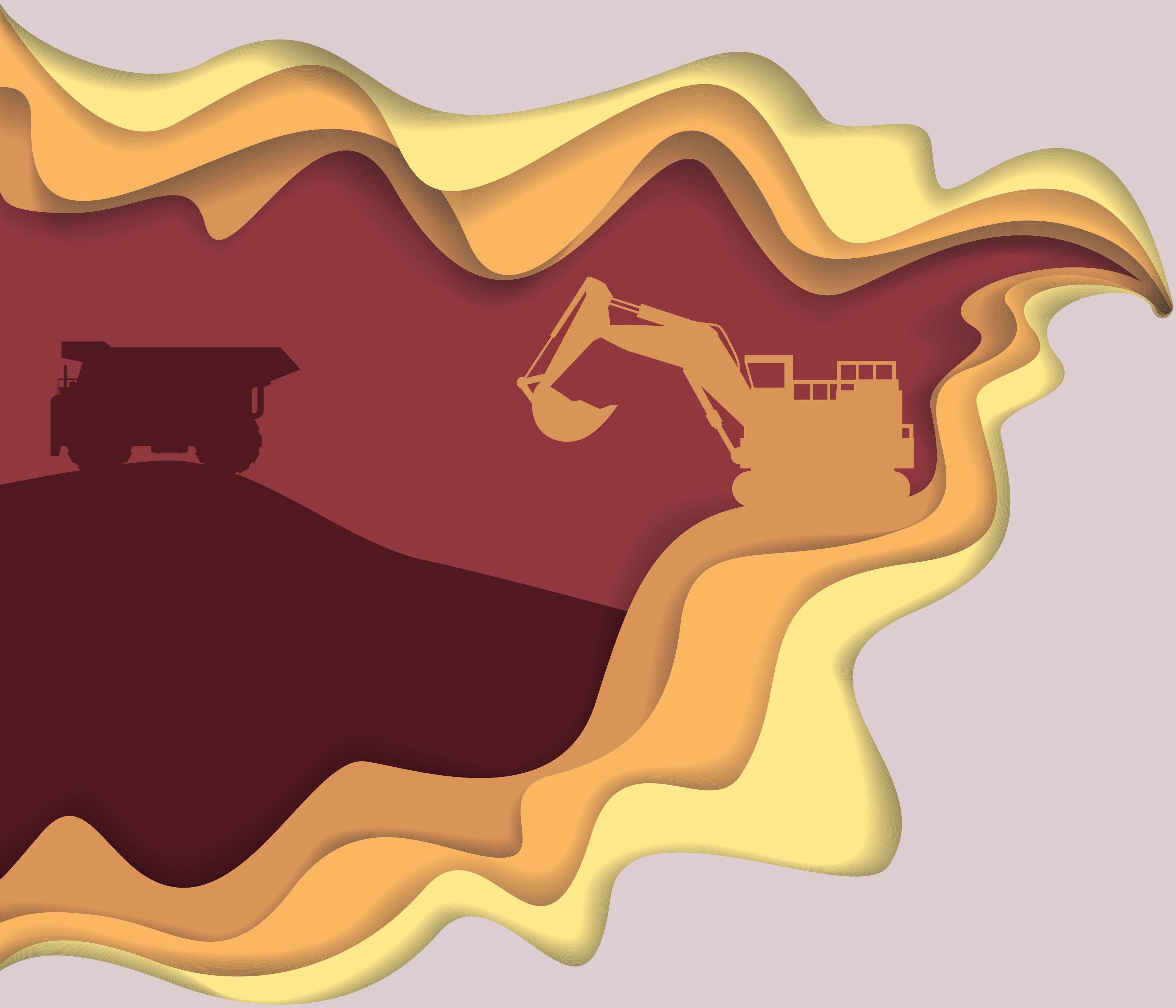
Unearthing injustice: A global approach to transition minerals



Commissioned by Friends of the Earth Scotland

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Friends of the Earth Scotland campaigns for a world where everyone can enjoy a healthy environment and a fair share of the Earth's resources. Climate change is the greatest threat to this aim, that's why we're calling for a just transition to a 100% renewable, nuclear-free, zero-fossil-fuel Scotland.

London Mining Network holds London-based companies to account by working closely with mining-affected communities.

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Contents

Abbreviations

BGS	**British Geological Survey**
BF-BOF	**Blast furnace – basic oxygen furnace**
CfD	**Contracts for Difference**
CO_2	**Carbon dioxide**
CO_2e	**Carbon dioxide equivalents**
CCPu	**Climate Change Plan update**
DRC	**Democratic Republic of Congo**
EAF	**Electric arc furnace**
EOL	**End-of-life**
EPR	**Extended Producer Responsibility**
ESG	**Environmental, Social and Governance standards**
ESJTP	**Energy Strategy and Just Transition Plan**
EU	**European Union**
GJ	**Gigajoule**
GW	**Gigawatt**
GWh	**Gigawatt hour**
ICE	**Internal combustion engine**
IEA	**International Energy Agency**
IOC	**Iron Ore of Canada**
ISDS	**Investor State Dispute Settlement**
OEMs	**Original equipment manufacturers**
OECD	**Organisation for Economic Co-operation and Development**
NPF	**National Planning Framework**
NSET	**National Strategy for Economic Transformation**
RPP	**Report on Policies and Proposals**
SQM	**Sociedad Quimica y Minera**
UK	**United Kingdom**
USA	**United States of America**

Executive summary

Transition minerals are vital to the energy transition away from fossil fuels. While Scotland must transform its energy systems to meet its climate goals, to do so without minimising demand for transition minerals will compromise the aims of the transition and risk failure of delivery of a renewable energy system.

The social and environmental damage created by transition mineral supply chains is extensive and serious, including human rights and labour abuses, environmental destruction and rampant exacerbation of climate injustice. As countries around the world seek to decarbonise their energy systems, demand for transition minerals is predicted to increase rapidly, alongside the associated social and environmental harm.

However, by creating a strategy based on a global just transition and demand reduction, including circular economy principles, the Scottish Government could create a fairer and more materially sustainable future.

Report aim and method

This report aims to raise awareness of transition minerals, the environmental and social impacts created through their use, their essential role in Scotland's energy transition and how supply chain justice and demand reduction, including circular economy opportunities, can reduce their harmful impacts.

The report focuses on the supply of lithium and steel,[1] demonstrating the fundamental importance of these materials to Scotland's energy transition and the significant human rights and environmental injustices created through the way they are extracted. Lithium is essential to the electrification of transport. Steel, and the iron ore from which it is made, is not generally considered a transition mineral because of its relative abundance, but it will be important in the energy transition in Scotland as it is the main material required for wind turbine construction. The global supply chains of both materials are mapped, and case studies based on countries supplying Scotland with lithium and steel, exploring the social and environmental impacts of extraction, processing and manufacturing, are shared.

It explores solutions to reducing the impacts of lithium and steel, including implementing supply chain justice and demand reduction, guided nationally by consumption reduction targets and circular economy principles.

Key findings

Transition minerals are those materials which are vital to the energy transition away from fossil fuels. There is no single definition of 'transition minerals' but the metals cobalt, lithium, manganese, nickel and rare earth elements are commonly included because their use is expected to dramatically increase because of the energy transition. A number of other metals – including iron, copper, and aluminium – can also be included as they are also vital to the energy transition, even if there is less of an estimated relative increase in their use. Transition minerals must be mined and processed before they can be used in products.

Governments and mining companies the world over are not meeting their minimum responsibilities to protect human life and the environment.

This is causing widespread human rights abuses, social harm and environmental damage which is pushing planetary boundaries to breaking point.

Mining is associated with conflict because mineral resources are located in a fixed place, which means any existing communities face disruption. Mining is an extremely energy intensive process and most mining operations rely on fossil fuel based energy sources. Mining generates large amounts of waste, which is often toxic. Mining waste is usually stored permanently in tailing dams, which have seen a number of tragic failures.

Governments and companies around the world are racing to stockpile minerals. The resulting critical mineral strategies are creating an avoidable competition for resources which is exacerbating demand for and injustices around transition minerals.

Scotland's climate and energy policies and plans, such as the Energy Strategy and Just Transition Plan, will increase demand for transition minerals. Policies which are fundamental to Scotland's future, including the Climate Change Plan and National Planning Framework, do not take into account the transition minerals required to fulfil their aims. This lack of consideration of material requirements by policy makers means there is a risk of failure to meet these policy goals. Additionally, if the social and environmental impacts of Scotland's material demands are not also addressed, there is a risk that the reason for the transition in the first place will be undermined.

Lithium

Lithium is vital for the energy transition because it is the main component in rechargeable batteries used in electric vehicles and battery storage. In 2022, 74% of the lithium consumed worldwide was used in lithium-ion batteries. Global demand is rising and some experts are predicting potential shortages as soon as 2025.

Australia and Chile are the leading suppliers of lithium and other countries in South America will become ncreasingly important in its supply in the future. Lithium that is consumed in Scotland is most likely to come from these sources, often via international trade routes involving different stages of the battery supply chain (**Figure E1**).

Lithium mining has extensive social and environmental impacts. There is evidence of human rights abuses by mining companies, and lithium mining activities have violated the rights of Indigenous peoples. Lithium mining requires large amounts of water in water-stressed areas, which can limit supply for local communities and wildlife. Lithium mining is more carbon intensive than coal mining.

Steel

With nearly 2 billion tonnes of steel produced globally each year, steel is the world's most commonly used metal and is a vital part of any strategy for creating a low carbon, just future. There are three major stages of steel production: iron ore extraction, steel production and manufacturing into products. The main producers of iron ore are Australia, Brazil and China, which together supply two thirds of the world's steel. The different stages of steel and wind turbines used in Scotland are produced in different regions of the world, as part of a global supply chain (**Figure E2,** page 7).

Steel is important in the manufacture of onshore and offshore wind turbines. Scotland's plans for a massive expansion of wind turbines will require a huge increase in steel supply. Scotland's steel comes from a combination of UK produced steel and imports, with iron ore and steel being imported from a wide range of countries including Brazil and Canada.

There are well documented extensive and serious ocial and environmental impacts associated with iron ore extraction and steel production, including labour exploitation and human rights abuses. Steel production generates 7% of global carbon emissions.

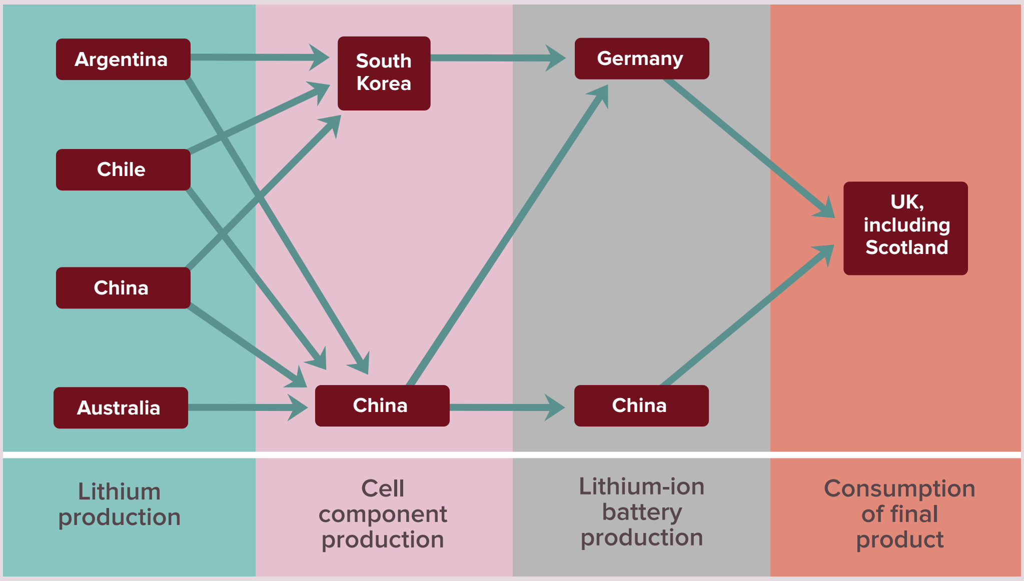
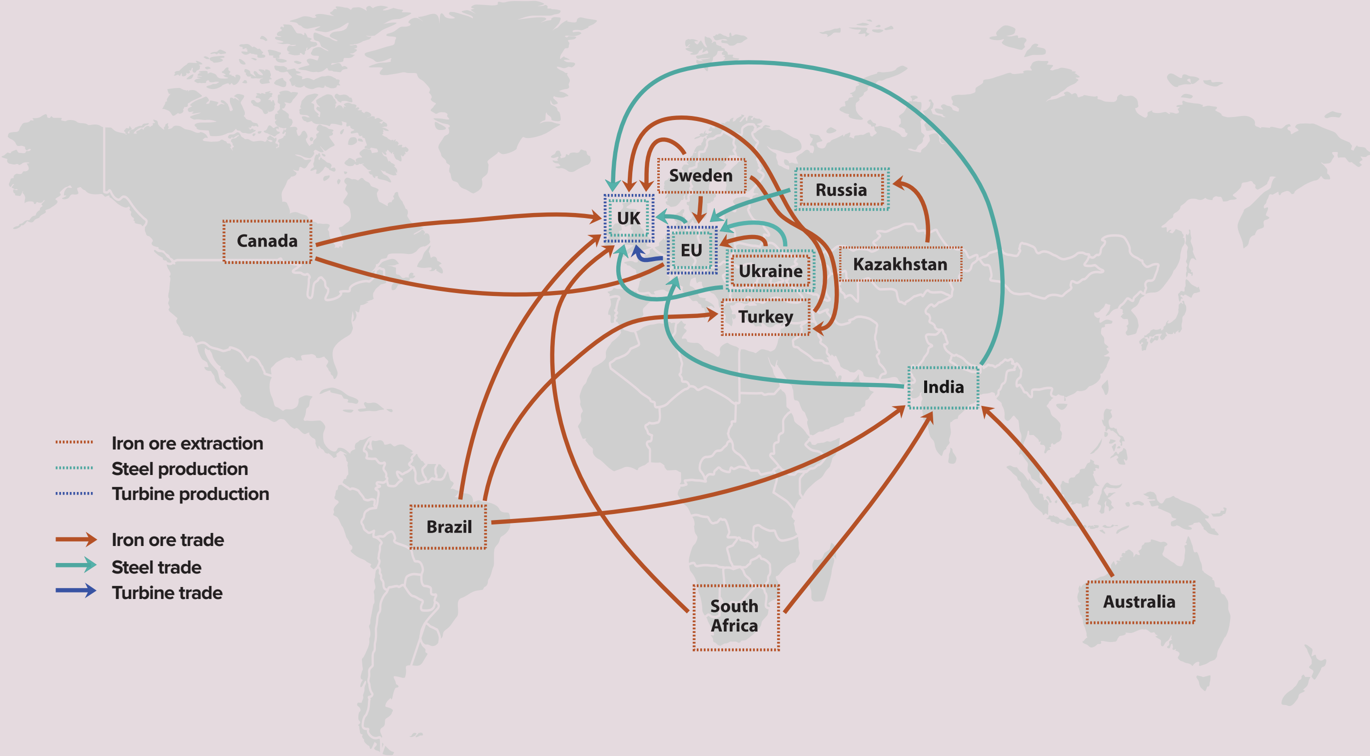


Figure E1 Simplified supply chain of lithium-ion battery production for the UK market, including Scotland, for 2021

Figure E2 Simplified supply chain for wind turbines used in Scotland, 2020[176]



The waste from iron ore mining is toxic and permanently stored behind often poorly constructed tailing dams, which are some of the largest geoengineered structures on Earth. In Brazil, two major dam failures in four years from iron ore mines have resulted in "immeasurable"[2] damage, including the deaths of hundreds of people.

Demand reduction and circular economy opportunities

While the impacts of mining can and should be minimised, they cannot be eliminated. Mining will always carry the risk of significant social and environmental impact. This means reducing demand will always be essential to reducing the impacts of mining.

Different decarbonisation paths have different implications for material demand, with policies focused on material demand reduction and public services over private ones offering the potential for greater savings. For example, displacing cars with buses could significantly reduce Scotland's demand for lithium. Replacing Scotland's 2.5 million fossil fuel cars and 4,400 buses, like for like, would require 20,200 tonnes of lithium in total.

If the proportion of bus journeys in Scotland increased to 30%, lithium requirements would be 13,800 tonnes (32% less).[3]

The current global recycling rate for lithium, which is a finite resource, is 1%. More robust regulation is needed to ensure effective lithium recycling is implemented in the near future and increased investment is required to overcome cost barriers.

In Scotland, reducing funding for socially harmful end uses, such as unnecessary or unsustainable construction applications, could cut steel demand.

Scotland's Energy Strategy and Just Transition Plan does not consider the material demand created by its proposed policies, such as increasing wind turbine capacity dramatically and the extensive material demands of hydrogen production. Policy makers need to understand the material requirements associated with Scotland's huge potential wind capacity in order to make informed choices about the most sustainable and just energy systems. The Scottish Government must also coordinate with the UK and European governments to create the required capacity in the most efficient way.

Scotland could take advantage of the large supply of scrap steel produced within the country and the low carbon electricity grid to produce some of the greenest steel in the world. This would require significant investment and planning by the Scottish Government to develop a modern steel plant and associated wind turbine production. Such a move could create much needed decent, green jobs which are essential to the just transition.

Conclusions and recommendations

It is not possible to create a sustainable and fair future that avoids the worst impacts of climate change without careful consideration of the impacts of transition minerals and minimising their use.

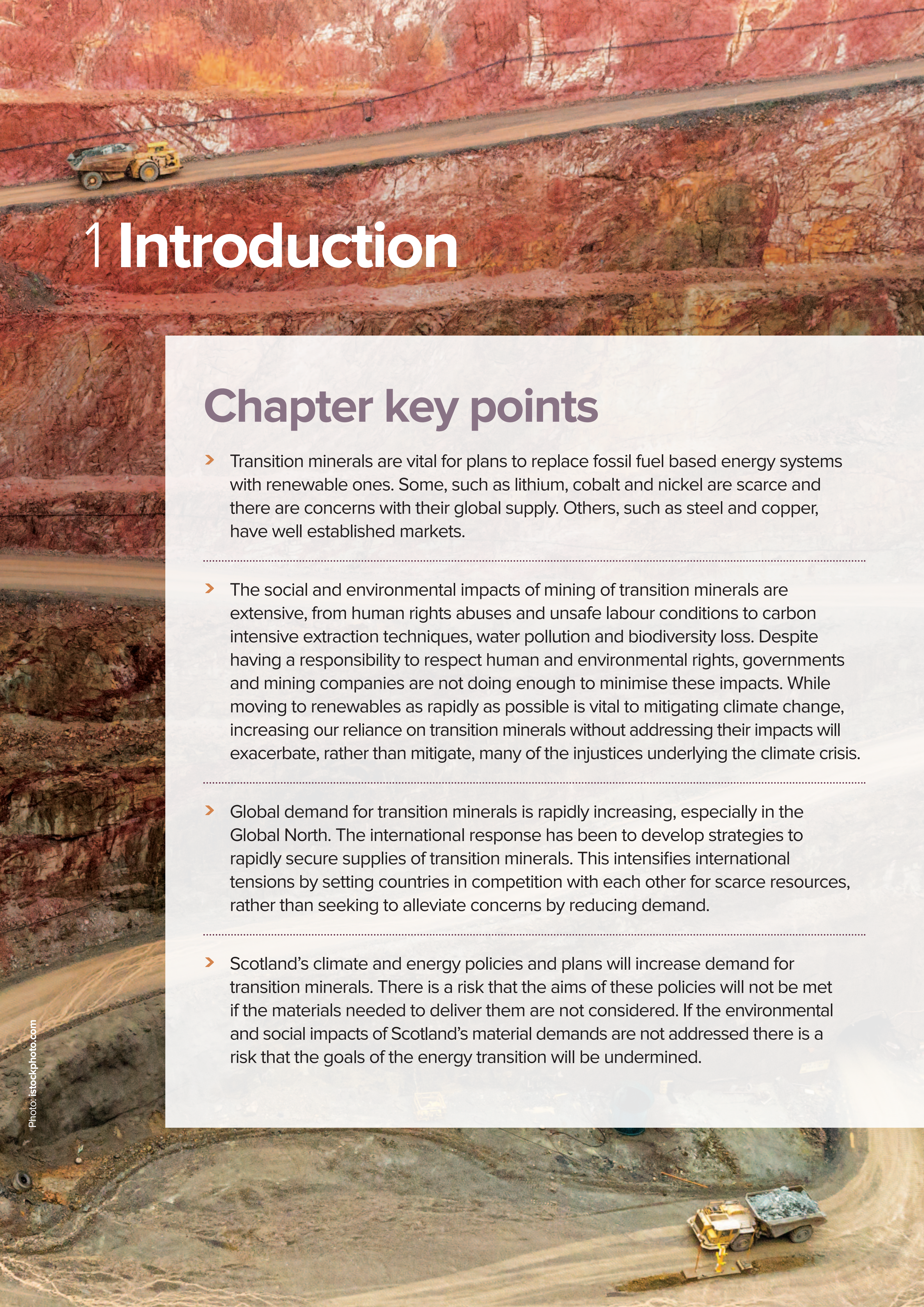
The Scottish Government must create a resource justice strategy for Scotland, which includes within it a plan for fair and sustainable consumption of transition minerals. The aim of the resource justice strategy should be to ensure Scotland's consumption of materials is sustainable and just as soon as possible and no later than 2045. The approach should be guided by statutory and science based consumption reduction targets, with 2030 interim targets to ensure action begins as soon as possible. Successfully meeting these targets will require policies which focus on demand reduction, the development of clear and transparent datasets and the implementation of a collaborative policy process.

The resource justice strategy should include specific requirements to ensure Scotland's consumption of transition minerals is sustainable and just as the energy transition progresses. Other material policies, such as Scotland's Circular Economy Strategy and Waste Route Map, should also be part of the Resource Justice Strategy framework. Existing policies should be adapted to reflect the Resource Justice Strategy and those policies under development should embed the Strategy's overarching principles.

The resource justice strategy should be based on five key pillars

1. **Commitment to a globally just material transition**
2. **Consumption reduction targets**
3. **Demand reduction policies**
4. **Clear and transparent data**
5. **Fair and collaborative policy process**

These recommendations must be adopted urgently and completely to allow Scotland to create a more sustainable and fairer future for all, where material consumption is minimised.



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1 Introduction

Chapter key points

- Transition minerals are vital for plans to replace fossil fuel based energy systems with renewable ones. Some, such as lithium, cobalt and nickel are scarce and there are concerns with their global supply. Others, such as steel and copper, have well established markets.

- The social and environmental impacts of mining of transition minerals are extensive, from human rights abuses and unsafe labour conditions to carbon intensive extraction techniques, water pollution and biodiversity loss. Despite having a responsibility to respect human and environmental rights, governments and mining companies are not doing enough to minimise these impacts. While moving to renewables as rapidly as possible is vital to mitigating climate change, increasing our reliance on transition minerals without addressing their impacts will exacerbate, rather than mitigate, many of the injustices underlying the climate crisis.

- Global demand for transition minerals is rapidly increasing, especially in the Global North. The international response has been to develop strategies to rapidly secure supplies of transition minerals. This intensifies international tensions by setting countries in competition with each other for scarce resources, rather than seeking to alleviate concerns by reducing demand.

- Scotland's climate and energy policies and plans will increase demand for transition minerals. There is a risk that the aims of these policies will not be met if the materials needed to deliver them are not considered. If the environmental and social impacts of Scotland's material demands are not addressed there is a risk that the goals of the energy transition will be undermined.

1.1 Report aim and structure

The aim of this report is to raise awareness of transition minerals, the environmental and social impacts created through their demand, their essential role in Scotland's energy transition and how principles of supply chain justice, demand reduction and the circular economy can reduce their impacts. It focuses on the supply of two of the most important materials: lithium and steel, demonstrating the fundamental importance of these materials to Scotland's current and future economy and the significant human rights and environmental injustices created through their extraction. Scotland must take responsibility for reducing these impacts to create a sustainable and fair future, and this can be done by embracing circular economy and global just transition principles through key government policies.

Section 1 explains what transition minerals are and how the international race to secure them is exacerbating environmental and social injustices around their extraction. The methodology used to investigate lithium and steel trade flows for Scotland is explained.

Section 2 gives an overview of lithium uses in the energy transition and how supply chains are mapped before outlining the key social and environmental concerns. Case studies examine the impacts of lithium mining in two countries linked most closely with supply of lithium to Scotland: Chile and Australia.

Section 3 outlines the uses of steel, why it is considered a transition mineral[4] and where it is sourced from. It describes trade flows of steel to Scotland and examines case studies of iron ore extraction in Brazil, Turkey and Canada.

Section 4 considers the opportunities to reduce Scotland's demand for transition materials by actively deploying demand reduction strategies and creating a circular economy in Scotland, where minerals are used as sparingly and efficiently as possible.

Section 5 presents the final conclusions and recommendations for policy makers.

1.2 What are transition minerals?

Transition minerals are those materials which are vital to replacing fossil fuels energy systems with renewable ones, either for generating, storing or transmitting that energy. There is no single definition of what materials constitute 'transition minerals' but the metals cobalt, lithium, manganese, nickel and rare earth elements are commonly included because their use is expected to dramatically increase because of the energy transition. A number of other metals – including iron, copper, aluminium, graphite, silver, tin and zinc – can also be considered transition minerals as they are also vital to the energy transition, even if there is less of an estimated relative increase in their use.

The supply chains of these transition minerals are global, with many minerals coming from countries in the Global South,[5] often then processed elsewhere, especially in China, and then sent to economies in the Global North.

Transition minerals are obtained by refining and processing mined materials into metals and alloys, which can be incorporated into the manufacturing of products such as wind turbines and electric vehicles or transmission infrastructure and battery storage. Every stage of the supply chain is associated with social and environmental impacts.

1.3 The social and environmental impacts of mining

Mining is associated with conflict because mineral resources are located in a fixed place, which means any communities already settled in an area identified as a possible mining site face disruption, often leading to community relocation and dispossession. The often significant scale of mining projects can exacerbate these injustices and larger mining projects are often associated with greater levels of injustice.

Despite the claims of mining companies that they work with local communities, the Responsible Mining Index found that the performances of even the best-scoring companies fall considerably short of societal expectations in all areas, including community wellbeing, working conditions and environmental responsibility.[6]

Common social issues include loss of land and displacement of communities, loss of livelihoods, food and water insecurities, health impacts, and safety issues for workers. Conflicts often arising from these issues include gross human rights abuses, including murder, torture, forced labour and slavery, threats, gender violence and militarisation.[7]

Mining is an extremely energy intensive process and most mining operations rely on fossil fuel based energy sources. For example, in the mining and quarrying sector in Australia, between 60% and 70% of energy needs are directly met by fossil fuels.[8] This energy is required to power extraction machinery, for on-site trucks, and for crushing and separating the ore.

In addition to greenhouse gas emissions, mining also has considerable impacts on ecosystems, air and water, although these will vary hugely depending on the type of mineral and mining process. Mining is a leading cause of deforestation.[9] Water needs for mining and processing transition minerals are often very high, leading to concerns about water stress and wastewater treatment. There are around 1,600 mining operations in key biodiversity areas and a further 2,000 in protected areas, including 33 in world heritage sites.[10]

Mining generates large amounts of waste. In 2019, it is estimated that the world's 3,500 large-scale mining operations produce over 100 billion tonnes of solid waste.[11] Much of this waste is toxic and, in some cases, even radioactive. Mining waste is usually stored permanently in tailing dams, which are often poorly constructed and maintained. The failure rate of tailing dams (1.2%) is estimated to be over 100 times higher than that of conventional water dams (0.01%).[12]

Of the 705 cases of mining-related conflicts listed on the Environmental Justice Atlas, 72% refer to projects involving potential transition minerals.[13] Many of those conflicts result from a plethora of impacts from environmental destruction, biodiversity loss, air and water pollution, loss of land and livelihoods, health impacts and numerous forms of human rights violations.[14] Copper mining is synonymous with large-scale pollution, from Chile and Peru to West Papua and Indonesia, and rare earth elements with egregious mining and processing pollution in China and increasingly Myanmar.[15]

These issues are not just confined to the mine site. All along what can be complex supply chains, involving processing, refining or smelting, through to production or assembly, there can be further environmental impacts and workers rights violations. The global mineworkers' union IndustriALL has documented a shocking rise in rights violations along these supply chains, concluding that this makes mandatory due diligence a top priority for trade unions.[16]

1.4 Due diligence obligations and standards

Companies have a responsibility to respect human rights wherever they operate in the world. One of the places that these responsibilities are laid out is in the UN Guiding Principles on Business and Human Rights, as endorsed by the UN Human Rights Council in 2011, which requires that companies 'do no harm'.[17]

This process to track and minimise harm is known as corporate due diligence. As awareness of the impacts of corporations grows, this due diligence manifests itself in an increasing number of standards and certification schemes, which often involve measures to increase control of supply chains and review by independent experts. The Organisation for Economic Co-operation and Development (OECD)'s *Due Diligence Guidance for Responsible Business Conduct* is a widely cited example of a due diligence guide for mining practice.[18] In 2022, the European Commission adopted a proposal on a Corporate Sustainability Due Diligence Directive,[19] which is more ambitious than existing standards.

Yet, efforts to develop and standardise due diligence practices remain largely voluntary and led by industry. The overwhelming evidence of widespread and continued failure of voluntary due diligence standards and certificates to protect people and the environment from the impacts of mining show that voluntary schemes cannot replace binding, democratically developed legislation with mandatory compliance for companies.[20, 21, 22, 23] Rather than asking companies to regulate themselves, strong due diligence legislation, with mandatory compliance standards and independent verification is vital to create a more sustainable and just future for all.[24]

1.5 Transition or critical minerals?

To fully understand the political issues around mineral supply chains it is important to define some key concepts. Phrases such as critical minerals, strategic minerals and energy transition minerals are frequently used interchangeably, yet speak to different ideas and priorities (see the box with key definitions below).

Key definitions

Transition minerals are vital for replacing fossil fuels with renewable energy, including for generating, storing or transmitting that energy.

Critical minerals are considered vital for the economic wellbeing of specific economies, yet whose supply may be at risk and for which there are no existing or commercially viable substitutes. They may include materials which are not necessary for the energy transition but for which supply chains have known concerns. Critical minerals can be a politically charged term, sometimes used to imply a focus on the energy transition, when what is really being considered is minerals that are necessary for other aspects of the economy, including arms manufacture.

Strategic minerals are considered vital for economic, military or technological development, yet may rely on potentially hostile foreign sources.

There is considerable overlap in these terms, for example, all of them include some concerns around supply risks. Despite this overlap in meaning, the terms represent opposing strategies for how nations and regions are approaching the growing global demand for these materials. The critical minerals strategies being developed are based on plans to secure as much resources as required, often regardless of social and environmental concerns. However, such approaches can also increase international tensions by setting countries in competition with each other for scarce resources, rather than seeking to alleviate concerns by reducing demand.

Examples of critical mineral policies

An increasing number of national and regional governments – including the UK, the USA, Japan, Canada, Australia and the EU – have sought to define critical minerals, and develop policies to address that criticality. These strategies are based on increasing domestic supply through 'onshoring' and technological advances, and attempting to ensure access to minerals from other countries, either through resource diplomacy or trade policy designed at preventing states from putting restrictions on mineral exports. For example, the stated goals of the UK's first Critical Mineral Strategy, published in 2022, were "to accelerate growth of the UK's domestic capacities, to collaborate with international partners and to enhance international markets".[25] While there is sometimes reference to improving recycling and environmental standards, the strategies are largely aimed at securing supply for their national economies, often in response to the perceived threat of China's dominance over key supply chains.

The UK Government's Critical Minerals Strategy focuses on safeguarding the 'security' of minerals important to the national economy where supply is perceived to be at risk. The strategy includes only a passing reference to issues such as deforestation and human rights abuses, and advances no coordinated action aimed at improving this situation. Concerningly, it refers to Anglo American, one of the world's largest multinational mining companies headquartered in London, as 'industry leading' on ESG issues. This is despite accusations it has systematically failed to fully disclose or address serious environmental and social abuses in its mining activities.[26]

The aspect of accelerating domestic capabilities, known as 'onshoring', can create jobs and inward investment, particularly in the upstream part of the supply chain. However, considerations of worker health and safety and environmental impacts need to be considered.

There is an increasing interest in reviving a UK mining industry, particularly focused on lithium in Cornwall. In Scotland, Aberdeen Minerals are seeking 'raw materials for the decarbonisation of the UK'[27] and Walkabout Resources, an Australian based mineral developer, has three mineral exploitation licences covering 750 km^2 in Dumfries and Galloway.[28] UK-based mining may be subject to the same environmental issues as international mining operations. Concerned residents in Cornwall have already formed an action group over the proposed project in Wheal Vor, while citizens in Northern Ireland have been protesting a proposed gold mine which has tried to claim 'transition' status.[29]

Linked to onshoring are attempts to form 'pacts' with states regarded as 'friendly' for sharing supply. The UK has already announced a joint working group with Australia to 'deepen collaboration on critical minerals', a strategic cooperation deal with Canada including on 'critical minerals and supply chains', a cooperation pledge on critical minerals with Saudi Arabia,[30] and a Minerals Security Pact proposed by the US State Department.[31] As will be explored in this report, there are a wide range of social and environmental injustices associated with mining in Canada, Australia and the USA and so minerals sourced from these countries should not necessarily be seen as any more 'ethical' than those sourced from countries in the Global South.

The proposed EU Critical Raw Materials Act similarly aims to fast track onshoring by forcing states to speed up permitting for new mines and processing plants.[32] This raises concerns given pre-existing conflicts over proposed mining for 'critical minerals' within the EU, including lithium mining in Portugal and rare earth elements in Sweden.[33] In the EU accession state of Serbia, thousands blockaded highways to protest a proposed lithium mine that protestors argue would be environmentally damaging and benefit the mining company, Rio Tinto, an Anglo-Australian multinational and the second largest mining corporation in the world, at the expense of local communities.[34] Rio Tinto is continuing to consider mining options for the site, despite the Serbian Government revoking its licence and stating there was no way forwards for the mining project.[35]

The EU has also used trade policy to suppress mineral rich states from implementing export restrictions on minerals. For example, Indonesia recently implemented a ban on the export of nickel ore to ensure that the ore is processed in local smelters, with the eventual goal of creating an integrated steel supply chain and manufacturing lithium-ion batteries. This would ensure more value is captured in Indonesia instead of exporting ore at low prices on international markets, although the potentially serious environmental consequences of such a change must be considered. The EU, as part of their Critical Minerals Strategy, challenged the policy through World Trade Organisation dispute mechanisms,[36] claiming Indonesia's policy 'unfairly limited EU producers' access to nickel ore'.[37] The WTO ruled against Indonesia meaning the country will have to lift its ban.

This report proposes a different approach from these critical minerals strategies, which increase inequalities and global tensions without reducing supply.

The framing and methodology have been chosen to reflect the importance of a just energy transition within the Scottish economy and concept of a circular economy. This is one reason we focus on the steel supply-chain used in off-shore wind turbines and the lithium used in batteries to store such energy. It is arguable that although the transition will lead to an increase in the amount of steel required, the abundance of iron ore across different, often allied countries, means that it is not necessarily critical. However, even if correct, this ignores the sheer volume of materials involved in steel production and the resulting impacts, which are essential to consider in relevant policies.

Transition mineral strategies, presented as an alternative to critical mineral strategies, focus on minimising demand for those minerals and tackling widespread injustices across transition mineral supply chains. Ideally, transition mineral strategies should be embedded in a wider materials strategy, as minerals, and their products, are only one part of a wider framework of the commodities needed to live high quality, sustainable and just lives.

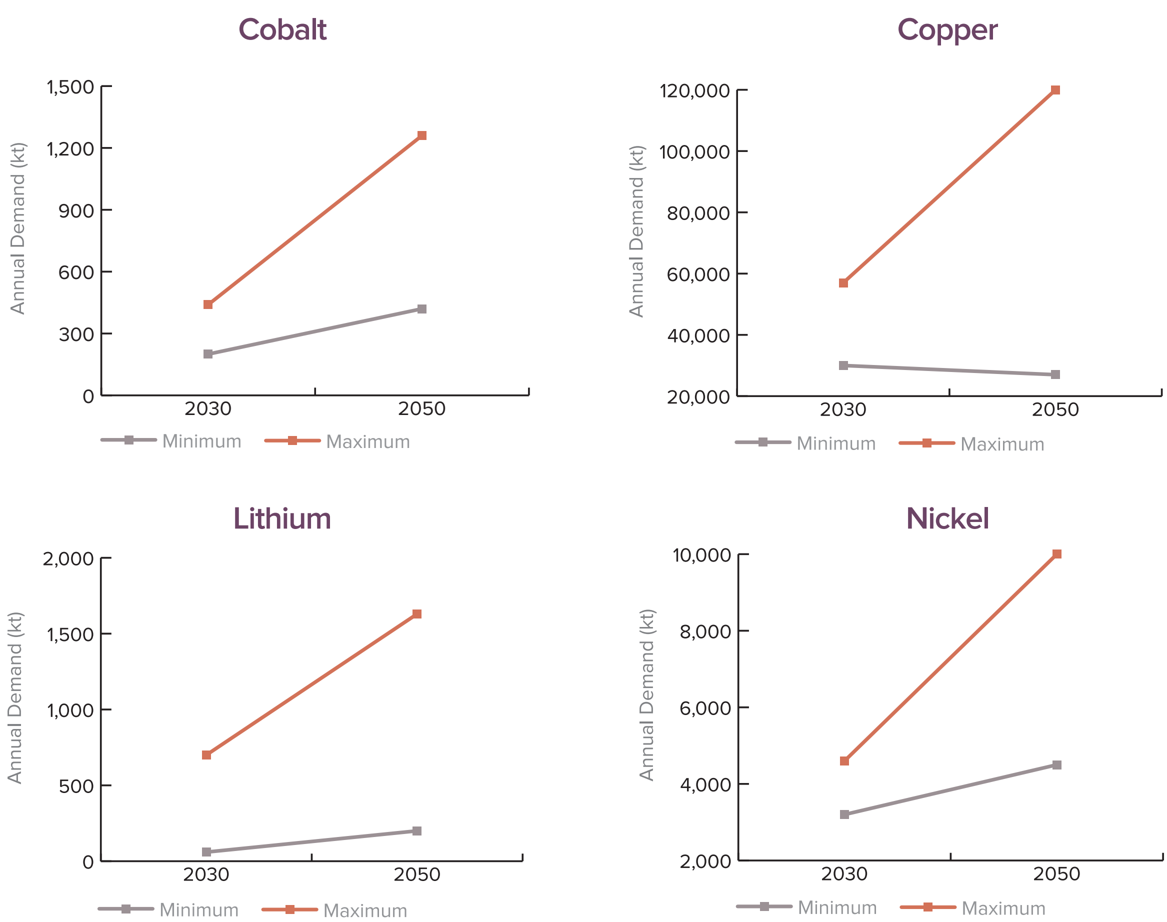
1.6 Why are transition minerals relevant to Scotland?

The need to transform our energy systems

The Paris Agreement stresses the need to keep a global temperature rise below 1.5 degrees Celsius by 2050 in order to avoid catastrophic climate change. Rapidly transitioning our energy sources from fossil fuel based systems to renewable ones is vital to decarbonisation strategies across the world. This is a monumental challenge. The chances of success greatly depend on scaling back the energy consumption of the world's wealthiest, while ensuring reliable energy access for the more than 2.5 billion people lacking access to electricity or clean cooking[38] and 1.4 billion living in extreme poverty.[39] One academic study found that doing so could reduce overall global energy use by 60%.[40]

There are a wide range of estimates of the additional amount of minerals the energy transition will require, based on assumptions and ambition, but all show significant increases because of the need to transition from fossil fuels to renewables (see **Figure 1.1**). A UK parliamentary report estimated lithium demand in 2050 could be between 6 and 50 times greater than 2015 levels; cobalt 3 to 10 times greater, and rare earth elements 2 to 28 times greater.[41]

Figure 1.1
The minimum and maximum estimates of annual global demand for a selection of transition minerals in 2030 and 2050, in kt, adapted from Watari *et al*[42]



Although it is crucial to tackle the climate crisis, if a national strategy relies only on becoming increasingly reliant on transition minerals then it will exacerbate, rather than mitigate, the environmental and social injustices underlying the crisis.

The recent energy crisis caused by increases in fossil fuel prices is not just about energy, but is fundamentally a resource-use crisis.[43] We are experiencing a number of crises that can be linked to increasingly unequal and unsustainable use of natural resources, which has more than tripled since 1970 globally, and is on a continued growth path regardless.[44] The International Resource Panel notes "90% of biodiversity loss and water stress are caused by resource extraction and processing. These same activities contribute to about half of global greenhouse gas emissions."[45]

Scotland's policies have material demands

Scotland is no exception to the global trend in requiring millions of tonnes of transition minerals, as it plans to meet its climate commitments through a transformation of its energy system and electrification of its transportation and industry. Transition minerals will be needed for every wind turbine, the growing electricity network and energy infrastructure plans as well as heat pumps and electric vehicles.

The Scottish Government's delivery of these plans is set out in several key policies that will shape Scotland's material requirements for the future, the most relevant of which are examined below.

The Climate Change Plan updates are a key area where the issue of transition minerals need to be considered. The 2020 Climate Change Plan Update laid out strategies for decarbonisation across all major sections of the economy, updating previous plans and policies to reflect the increased targets enshrined in the Climate Change (Emissions Reductions Targets) (Scotland) Act 2019.[46] However, there is no consideration of how these plans in each sector will impact on demand for transition minerals and how this demand can be minimised. The plans also do not consider how supply chain justice could be embedded in each sector through expanding public ownership, leveraging public procurement and implementing due diligence legislation. The forthcoming Climate Change Plan is an opportunity to rectify this.

In January 2023, the Scottish Government began consulting on a draft **Energy Strategy and Just Transition Plan**. In the draft strategy there is disappointingly little mention of a global just transition,[47] beyond passing reference to the Global Renewables Centre and an existing £36 million commitment to a Climate Justice Fund. There is little mention of what materials, including transition minerals, will be required to fulfil the Energy Strategy. This lack of consideration of material requirements for this policy, and others, both risks fuelling injustice globally and is a major risk to delivery as the pace and scale of change will be affected by the supply of materials.

The **National Strategy for Economic Transformation** should be modified to consider transition minerals. The strategy repeatedly emphasises the goal of economic growth and aims to 'maximise opportunities for the use of Scottish manufactured components and ensure that high-value technology and innovation that is developed in Scotland can be manufactured in Scotland'.[48] If implemented, such a strategy could greatly increase both total demand for materials within the Scottish economy and demand for transition minerals. To minimise demand and therefore avoid adverse supply chain impacts the Government should consider which areas of the economy need to grow to deliver social goods, and where unnecessary consumption can be decreased to ensure that overall material demand is decreased.[49]

The National Planning Framework 4, published in 2022, puts 'the twin global climate and nature crises at the heart of [its] vision'.[50] The strategy lists a just transition as one of its key principles and refers to the need for a circular economy. Future versions should accommodate the concepts of a global just transition and minimising consumption of transition minerals.

The Circular Economy Bill is an opportunity to set out the ambition and framework of Scotland to create a materially just and sustainable economy by 2045. Central to this framework would be the introduction of consumption reduction targets. This would address gaps in Scotland's existing climate targets, which are currently undermining our efforts to reduce Scotland's climate impacts.

Scotland's existing climate targets ignore imports

Targets to reduce Scotland's climate emissions are central to Scotland's climate change policy framework. However, these targets only focus on domestic emissions, ignoring those used to make goods imported to Scotland, including all transition minerals. Emissions from imports made up 58% of our carbon footprint in 2019 and the proportion of our carbon emissions associated with imports is increasing every year.[51]

Perversely, the fact that our existing climate targets focus only on emissions created in Scotland can lead to higher global emissions and negative economic impacts for Scotland by incentivising the offshoring of high carbon activities – sending both emissions and jobs overseas. For example, when Ravenscraig steel mill closed in 1992, 3.5 million tonnes of carbon were wiped off Scotland's carbon balance sheets.[52] But Scotland's demand for steel is growing, leading to imports of goods which may be more carbon intensive to produce than the original Scottish products.

Introducing consumption reduction targets that would mirror and complement existing domestic climate targets would give decision makers better oversight of Scotland's global impacts and promote solutions with genuine global reduction capabilities, such as low carbon domestic alternatives to high carbon activities.

1.7 Report methodology

This report uses supply chain mapping to investigate the global impact of Scotland's consumption and the wide range of communities that are impacted. We seek to trace the consumption of lithium and steel in Scotland's economy, looking particularly at their uses in renewable energy technologies, back through the supply chain to the point of extraction. To do this we use a trade-flow analysis, looking at the key countries from where each mineral or commodity is imported at each stage of the supply chain.

The report focuses on the supply chains of two materials which are indispensable for the energy transition. Lithium is essential for the rechargeable lithium-ion batteries used in consumer electronics, but also for the energy storage needed to deliver decarbonisation. Steel is used as a base for many solar panels and is the main material used in the construction of turbines needed to produce wind, wave and tidal energy. Global steel supply chains are vast, so we have chosen to focus on steel for wind turbine supply chains. We selected these two materials based on their importance to the Scottish economy and government policy and the prevalence of human rights abuses and social and environmental exploitation across their supply chains.

There are important differences between the two materials; supply of lithium is relatively scarce as demand is expected to greatly outstrip current extraction levels, between 13 to 51 times 2020 extraction levels by 2040 according to the International Energy Agency (IEA),[53] recycling rates are low and a large proportion is used to produce renewable energy technologies. Iron, the metal used to produce steel, is abundant, the global steel market is the largest for any single mineral, recycling levels are relatively high and it is used to produce a much wider range of commodities. Yet injustices are widespread across both their supply chains.

Throughout the report we seek to put the voices of communities and workers impacted by mineral extraction and exploitative labour practices at the forefront.

We have used case studies to do this by highlighting specific examples of injustice and the resistance of impacted communities connected to supply chains for Scotland.

There are some limitations in accurately conducting supply chain mapping because of gaps in data and the opaque nature of global supply chains. Trade data is often reported at the UK level and not disaggregated by nation. Where imports to Scotland are tracked, they are often included in larger groups. Iron and steel, for example, are often listed together despite important differences in where each is imported from. Aside from data limitations, complexities arise because of the number and scale of companies and countries involved in supply chains and the processing of ore from a range of sources in a single smelter to produce a homogeneous product.[54]

2 Lithium

Chapter key points

- Lithium is vital for the energy transition because it is the main component in rechargeable batteries used in electric cars, consumer electronics and in battery storage. Demand is growing rapidly and is expected to increase by 13–51 times from 2020 to 2040, depending on how rapidly decarbonisation takes place. Demand is predicted to exceed supply, meaning potential shortages as soon as 2025.

- Australia and Chile are the current leading global suppliers of lithium. In the future, other countries in South America are likely to increase the amount they are supplying. Lithium that is consumed in Scotland is most likely to come from these sources, often via international trade routes.

- There is evidence of social and environmental impacts, including human rights abuses, connected with the lithium mining supplying the Scottish economy. In Chile, there is evidence of corruption, worker exploitation and mines depleting water sources for Indigenous communities and wildlife.

- Lithium mining requires large amounts of water in water-stress areas, this can limit supply for local communities and wildlife. The carbon emissions from lithium mining are greater than coal mining.

Photo: istockphoto.com

2.1 Use of lithium as a transition mineral

Lithium is a soft, silvery metal that has been extracted commercially for over a century, with a wide range of end uses. The most common today is in rechargeable batteries known as lithium-ion batteries. Lithium is mined and processed into either lithium carbonate or lithium hydroxide for use in batteries.

An estimated 74% of lithium globally is used to produce lithium-ion batteries,[55] a percentage that is likely to increase as the transition to renewable energy continues to take place. There are three main uses of lithium-ion batteries: electric vehicles, energy storage and consumer electronics. In 2021, electric vehicles globally constituted 74.4% of lithium-ion battery demand, consumer electronics 13.8% and energy storage 11.8%.[56]

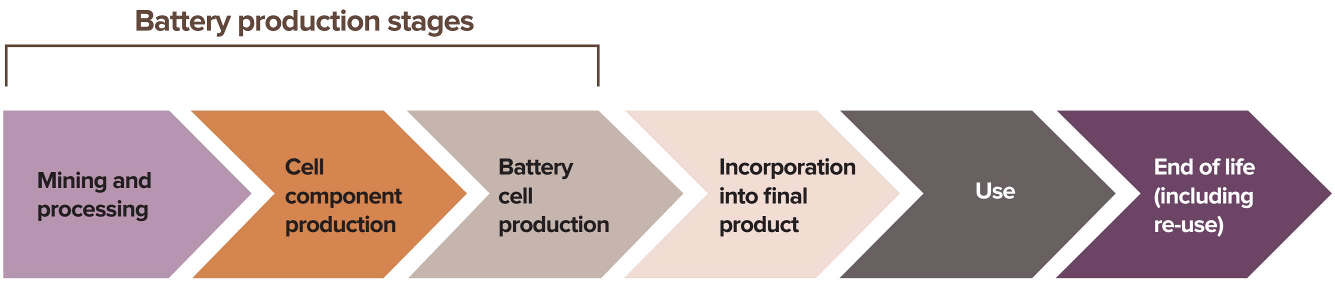
These uses of lithium do not always directly relate to the energy transition and there are other uses of lithium which are even less relevant.

Single-use vapes each have a lithium-ion battery, with an estimated 1.16 million bought each month and 108,000 thrown away each week across Scotland. Over a year, this is enough lithium to produce around 99 electric car batteries.[57]

There are three main stages in the production of lithium-ion batteries: the mining and processing of minerals, cell component production, and battery cell production (see **Figure 2.1**). Cell component production involves manufacturing the cathode, anode and an electrolyte which connects the two. Anodes are typically made from graphite and the electrolyte combines organic carbonate solvents with dissolved lithium salts.[58] The cathode is the cell component which has the greatest demand for transition minerals.

There are several different types of lithium-ion batteries which contain cathode materials using different mixes of minerals although all have relatively similar proportions of lithium in them. The most commonly used include lithium nickel manganese cobalt, lithium nickel cobalt aluminium and lithium iron phosphate. Many of the other minerals used in lithium-ion battery production, in particular cobalt and nickel, are associated with environmental and social concerns.

Figure 2.1: Lithium-ion battery life cycle



Cobalt and nickel as transition minerals

According to the IEA, cobalt demand will grow 8 – 25 times and nickel demand will grow 6 – 19 times between 2020 and 2040.[59]

Cobalt mining is widely associated with serious human rights abuses and exploitation. Like lithium, the majority of demand is driven by batteries; in 2019, 55% of global cobalt supply was destined for batteries.[60]

72% of the world's cobalt production comes from the Democratic Republic of Congo (DRC),[61] mostly from multinational corporations, such as Glencore, but with a substantial minority being produced through artisanal mining. Child labour and extremely dangerous conditions are associated with artisanal cobalt mining in the DRC as well as allegations of modern slavery. Cobalt makes its way from formal and informal mining sources in the DRC through supply chains to the products of major international corporations. In 2017, Amnesty International found that all the companies it assessed, including Apple, Samsung, Microsoft, Tesla and General Motors, failed to conduct human rights due diligence in line with international standards and most were unable to answer any questions about where their cobalt came from.[62] There is also extreme exploitation of people working for corporate mining companies and the work has significant health and safety issues, including widespread respiratory and dermatological issues for miners.

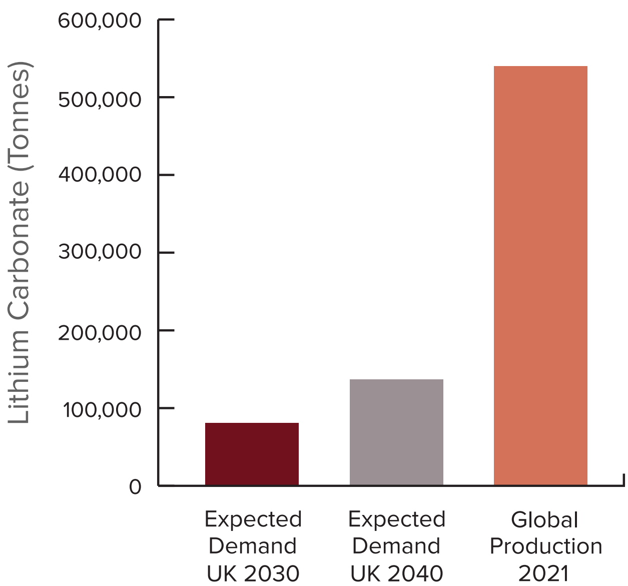
Nickel is also used in many lithium-ion batteries, alongside its major end uses in stainless steel, alloys and electroplating. Nickel mining is associated with high levels of environmental destruction. 40% of nickel reserves are located in protected areas or areas with high biodiversity levels, and 35% in locations with high water stress.[63] There are also many cases of community conflicts over nickel mining, such as the case study of nickel mining in the Philippines outlined in War on Want's 'A Material Transition' report.[64] The report details human rights abuses, displacement and irreversible environmental damage resulting from nickel mining, and the criminalisation and targeting of Filipino land and environmental defenders who have been resisting nickel mining expansion.

2.2 Current and future demand of lithium

In 2021, 106,000 tonnes of lithium was produced globally, with 540,000 tonnes of lithium carbonate compound produced from this raw material.[65] This in turn was used to make lithium-ion batteries.[66] Growing demand for lithium-ion batteries means that demand for lithium is expected to greatly outstrip current production levels over the coming years as the world seeks to move away from fossil fuels. Globally, the International Energy Agency (IEA) forecasts lithium demand to increase by 13–51 times from 2020 to 2040, depending on how rapidly decarbonisation takes place.[67] Many analysts predict supply will fail to keep pace with demand, meaning potential shortages as soon as 2025.[68]

It is estimated that the UK's demand for lithium-ion batteries will rapidly expand from the current level of 10.7 Gigawatts per hour (GWh) per annum to over 100 GWh in 2030 and nearly 200 GWh in 2040, with the vast majority of that demand being driven by private cars and light commercial vehicles.[69] This would mean annual demand for lithium carbonate would increase to over 80,500 tonnes in 2030 and over 136,500 by 2040 (**Figure 2.2**).[70]

Figure 2.2 Expected increase in lithium carbonate demand in UK and comparison to current global production



In 2022, Scotland consumed an estimated 142 tonnes of lithium.[71] The bulk of this consumption, 82%, went towards private cars with just four tonnes, 3%, being consumed by grid storage.

2.3 Major lithium producers

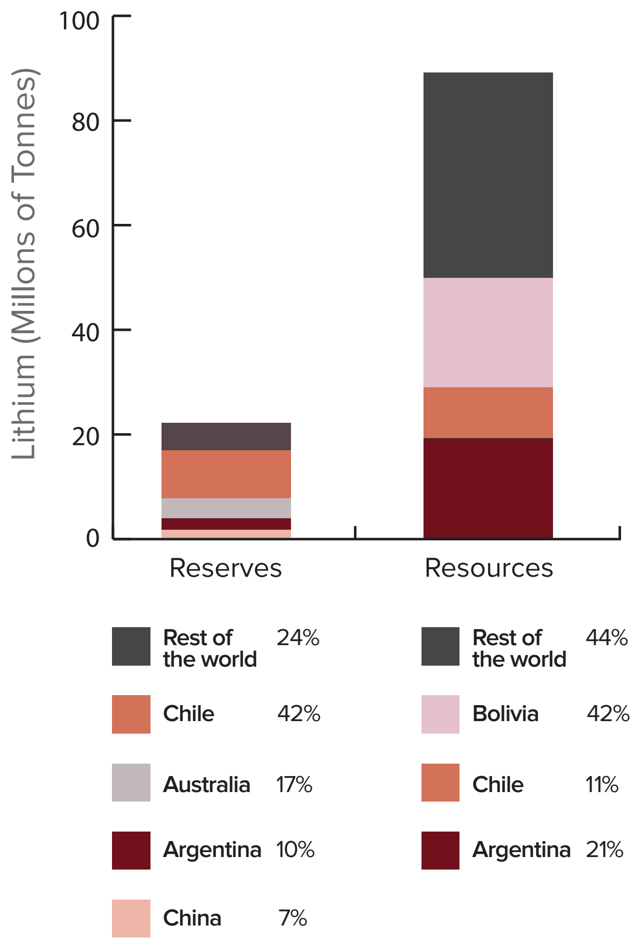
Of the 106,000 tonnes of lithium produced globally, Australia, Chile and China were the three biggest producers, producing 52%, 25% and 13% respectively.[72]

In the future, South America is expected to become more dominant in the supply of lithium as many of the reserves and resources come from this region. Reserves are minerals that are deemed economically recoverable today, while resources are the total amount of minerals in the Earth's crust that may be recoverable either today or in the future. There are an estimated 22 million tonnes of lithium reserves globally, nearly half of which come from Chile. The level of known resources stands much higher at 89 million, with over half these resources being located in the lithium triangle: Bolivia, Argentina and Chile (**Figure 2.3**).[73]

Demand will not exceed existing resource levels, but greatly increasing extraction levels would necessarily mean immense social and environmental abuses and trampling over the right of communities to say no to extractive projects.

Lithium has never been commercially extracted within the UK, although within the past few years more systematic efforts at exploration have been made. Exploration is most advanced in Cornwall, where Cornish Lithium have drawn up plans for the extraction of lithium from geothermal water and hard rocks. However, scaling to commercial extraction and getting the necessary planning permission is still quite a long way off. Lithium resources have also been observed in hard rocks in north-east Scotland, with the British Geological Survey noting the area as a 'priority target for further investigation'.[74]

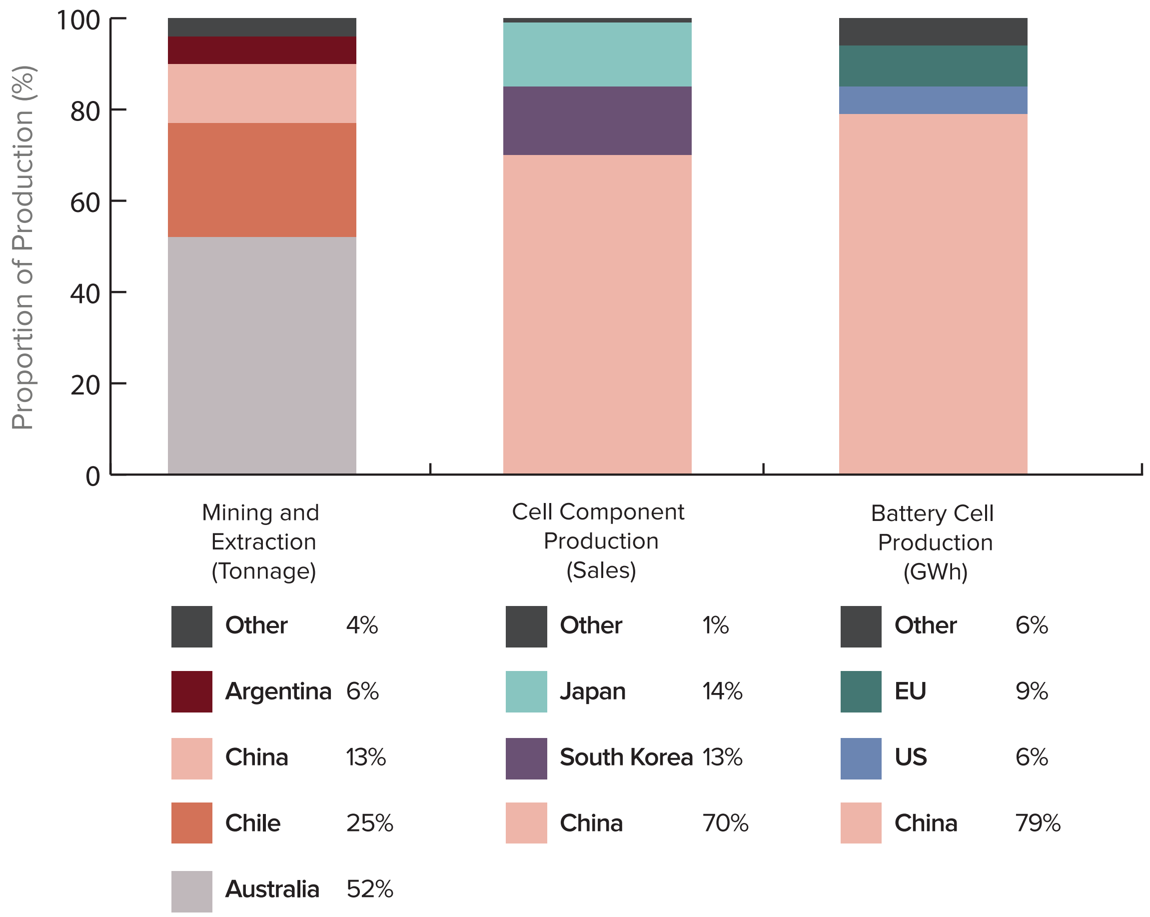
Figure 2.3 Global distribution of reserves (economically recoverable today) and resources (economically recoverable today and in the future) of lithium



2.4 The global lithium-ion battery supply chain

The different stages of the supply chain for lithium-ion batteries span the globe. **Figure 2.4** demonstrates where production takes place at three key stages of the supply chain for lithium-ion batteries: the extraction of lithium, cathode production and lithium-ion battery cell production.

Figure 2.4 Countries involved in each stage of Lithium-ion battery production[75]

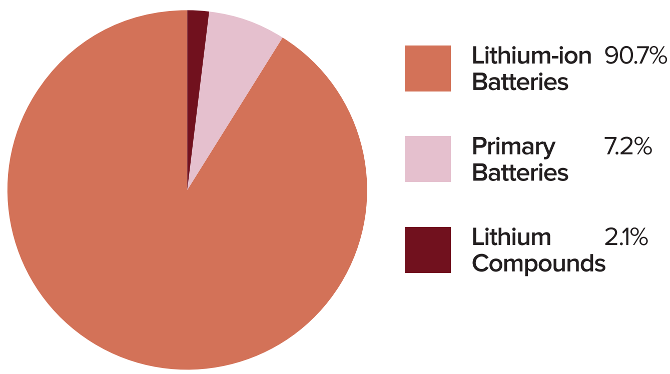


2.5 Mapping the UK's, including Scotland's, lithium supply

To improve understanding of the supply chains for Scotland's lithium consumption, this report uses a trade-flow analysis which maps country-level imports to determine where the lithium consumed in the economy is first extracted from and the key stages of the supply chain along the way. One key limitation is that global trade data is only reported at the UK level, not for Scotland specifically. As a result, the analysis looks at imports to the UK.

Figure 2.5 shows that over 91% of the UK's lithium imports are of lithium-ion batteries. Industrial scale UK manufacturing of lithium-ion batteries is very limited, and so demand for raw lithium compounds such as lithium carbonate and lithium oxide is low.

Figure 2.5 UK lithium imports by battery supply chain stage in 2021, from UN Comtrade data in US$[76]



The UK's lithium-ion battery manufacturing capacity is currently just 2 GWh,[77] just 0.1% of the total global capacity of 2,068 GWh.[78] This is set to increase, with a 12 GWh gigafactory planned by Envision AESC in Sunderland[79] and a 0.5 GWh megafactory planned in Dundee by AMTE Power where production could start by 2026.[80] There were also plans by Britishvolt to build a £3.8 billion gigafactory in Blyth but this collapsed in January 2023 when the firm announced they had entered administration and made their 300 staff redundant with immediate effect.[81] This is the opposite of what a just transition should look like.

Not all of these lithium-ion batteries will be consumed in the UK because electric vehicles, a key driver of demand for lithium-ion batteries, are largely exported rather than sold for domestic consumption. In 2022 alone, the UK manufactured over 234,000 electric or hybrid vehicles,[82] yet the total electric vehicle ownership rate in the UK is just over 250,000.[83] In Scotland, there are about 50,000 electric vehicles.[84] Approximately 80% of all cars manufactured in the UK are exported, mainly to the EU, with 44.7% of the export value being driven by electrified vehicles.[85] Scotland, however, only has one car manufacturer, which produces just 250 electric vehicles, per year.[86]

UK's import of lithium-ion batteries

In 2021, the UK imported $1,278 million worth of lithium-ion batteries. Nearly a quarter (24.8%) were imported from Germany, a fifth (21.4%) from China, and significant quantities from the USA, Japan and Hungary.[87]

Germany does not manufacture cell components but instead imports them from China, South Korea and, to a lesser degree, Japan. Tracing lithium production back through China and South Korea indicates where lithium used in UK batteries is most likely being extracted from.

Figure 2.6 shows lithium imports to China and South Korea, demonstrating that Australia and Chile are the dominant sources.

Figure 2.6 Lithium imports in 2021 to China and South Korea, from UN Comtrade data in US$ [88, 89]

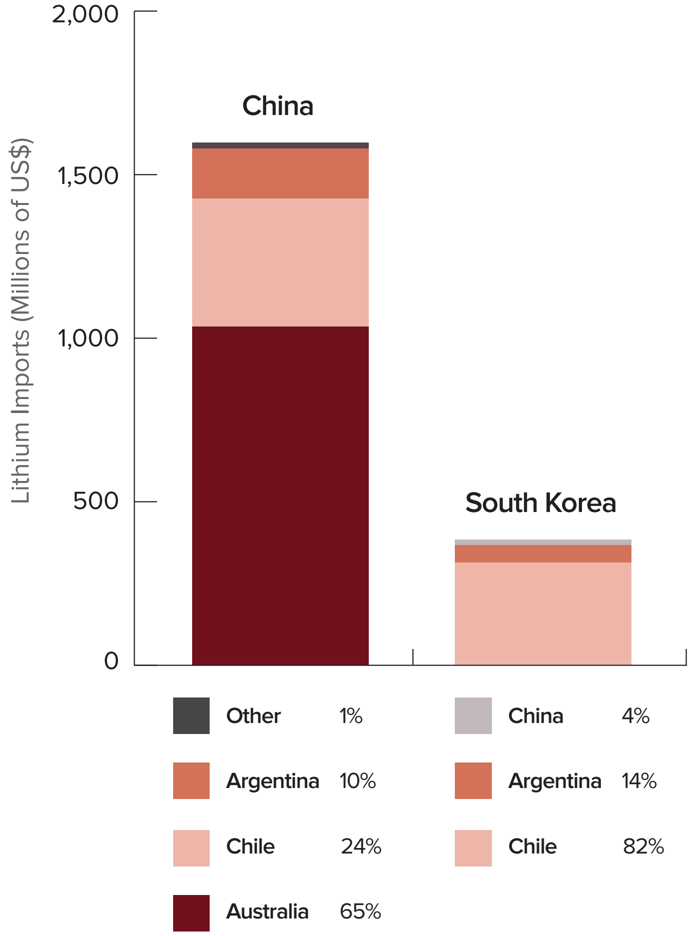


Figure 2.7 shows a simplified supply chain for the UK's consumption of lithium-ion batteries, mapping trade flows through three key stages of production.[90] It appears the UK supply chains for lithium are similar to global supply chains, drawing mainly on resources from the world's largest lithium producers.

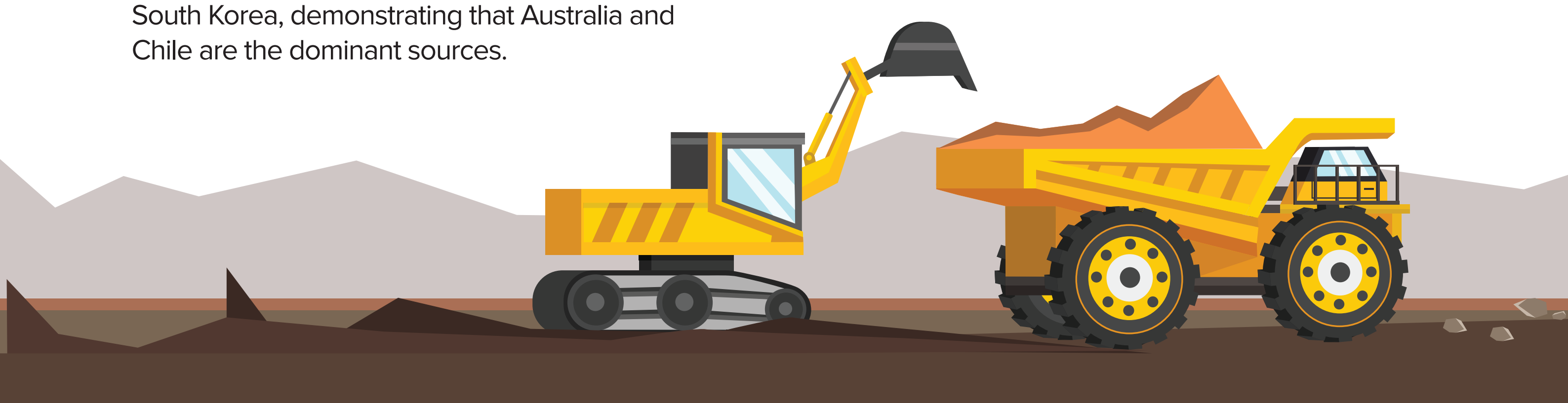
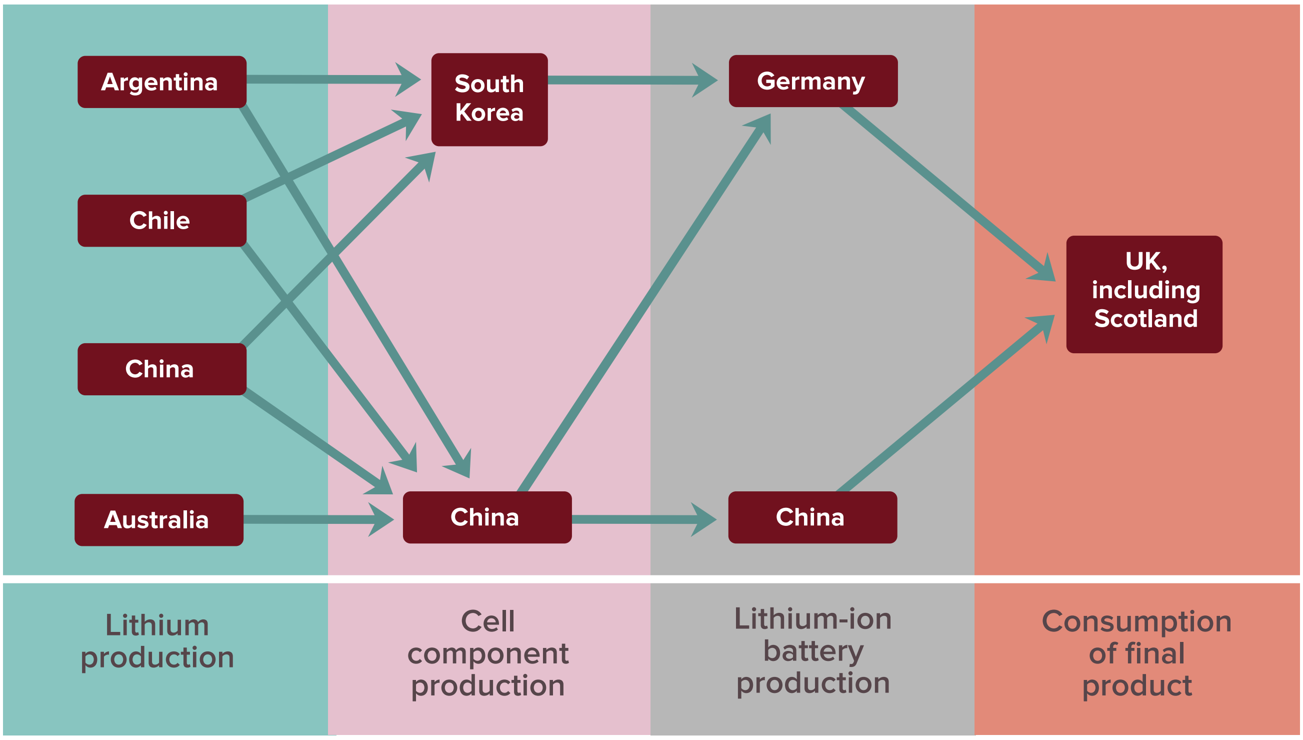


Figure 2.7 Simplified supply chain of lithium-ion battery production for the UK market, including Scotland, for 2021



2.6 Lithium extraction techniques

Lithium is extracted commercially from two main sources: hard rock mining of mineral ores and salt-flat brines, although extraction from clay is being developed, particularly in the USA.

Hard rock mining of mineral ores mainly takes place in Australia, with smaller operations in Brazil, Zimbabwe and North America. There are five different mineral ores from which lithium is extracted but the dominant one is spodumene. Spodumene is mined generally through open pit mining, before being crushed and further processed to produce a spodumene concentrate. This concentrate is then processed into a lithium compound. The concentration process is chemical and energy intensive, involving roasting at extremely high temperatures, milling and acid leaching.

Lithium extraction from salt-flat brines, known as salars, largely takes place in the 'lithium triangle', a geographic region of salt flats in the Andes between Bolivia, Argentina and Chile. The dominant method used in extracting lithium from brines is solar evaporation. Drilling is used to access underground salar brine deposits, from which salt-rich water is pumped up to the surface and into nearby evaporation ponds. Over several months the water slowly evaporates, eventually leaving behind a concentrated brine product. This concentrated brine then gets transported to a recovery facility to produce the final lithium carbonate product.

Lithium carbonate is one of many lithium compounds that can be produced, with each compound having different end uses. Lithium carbonate and lithium hydroxide are the two key lithium compounds used in rechargeable lithium-ion batteries.

2.7 Social and environmental concerns with lithium supply

Social and environmental injustice is widespread across lithium-ion battery supply chains. Extracting lithium is an environmentally destructive process, regardless of whether it is extracted from brines or hard rock.

It is estimated that 75% of lithium mining occurs in areas of high water scarcity.[91] In brine extraction, these are primarily related to the huge quantities of water needed to extract the lithium in highly arid regions and the leaching of chemicals from evaporate ponds causing soil and air contamination.

There is a disturbingly wide range of estimates of how much water is used during the extraction process, from as low as 0.4 m^3 per tonne of lithium to as high as 2,000 m^3 per tonne.[92] The IEA estimates that an average of 330 m^3 of water is required per tonne of lithium extracted.[93]

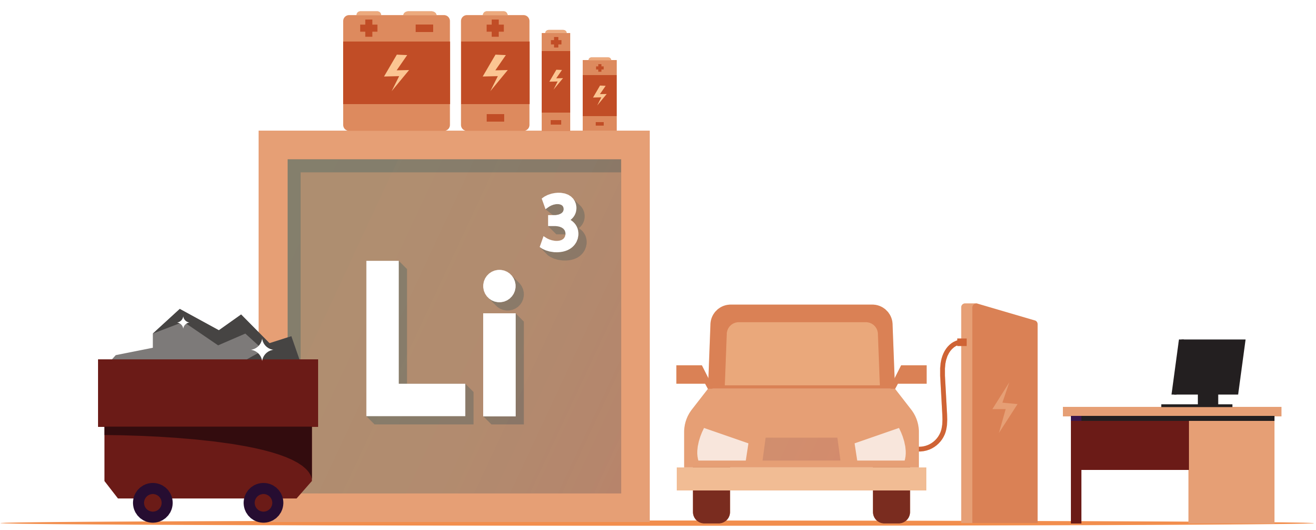
Extraction in Argentina's Salar de Hombre Muerto, for example, uses 380 m^3 of water per hour and has already 'caused irreversible environmental damage by completely drying up the Trapiche River floodplain'.[94] This represents a huge threat to local Indigenous communities, such as the Indigenous Kolla Atacameña population, whose livelihoods are primarily based on livestock raising, agriculture, textile handicrafts and salt extraction and so are greatly impacted by the mining project. There are also allegations that there has been a lack of 'free, prior and informed consultation (FPIC) with the Atacameño del Altiplano Indigenous community, which ancestrally inhabits the Salar, and criminalisation of Indigenous protest, in clear violation of the national constitution and international treaties'.[95]

Hard rock mining requires huge amounts of energy which releases greenhouse gas emissions and contaminates groundwater, rivers and soil. In 2021, the Trump administration greenlit a $1 billion open pit lithium mine in Nevada which would be built on Indigenous land. This has led to mounting local opposition including from the People of Red Mountain, a group of Indigenous peoples from the Fort McDermitt Paiute Shoshone tribe. The mine would encompass a vast area of almost 18,000 acres and when in full operation would require an average of over 14.5 m^3 of water per minute in one of the driest areas of the USA which already suffers from severe droughts.[96]

There are also environmental issues with the processing of lithium. The processing of lithium compounds such as lithium carbonate requires toxic chemicals such as hydrochloric acid, which when released through leaching, spills or air emissions can harm communities, ecosystems and food production.[97]

Processing also contributes to greenhouse gas emissions. Lithium sourced from hard rocks requires an average of 9.6 tCO_2 per tonne of lithium carbonate equivalent produced, while 2.8 tCO_2e is required for producing a tonne of lithium carbonate from brines.[98] This is higher than industry estimates of emissions from coal mining (0.19-0.25 tCO_2e per tonne).[99] The bulk of these emissions are associated with the processing stage. This is significantly higher than the emissions per tonne associated with refining copper and the production of steel, or of extracting coal, although the quantities involved with lithium are much lower.[100]

Lithium mining is also associated with biodiversity loss, soil degradation and ground destabilisation.[101]

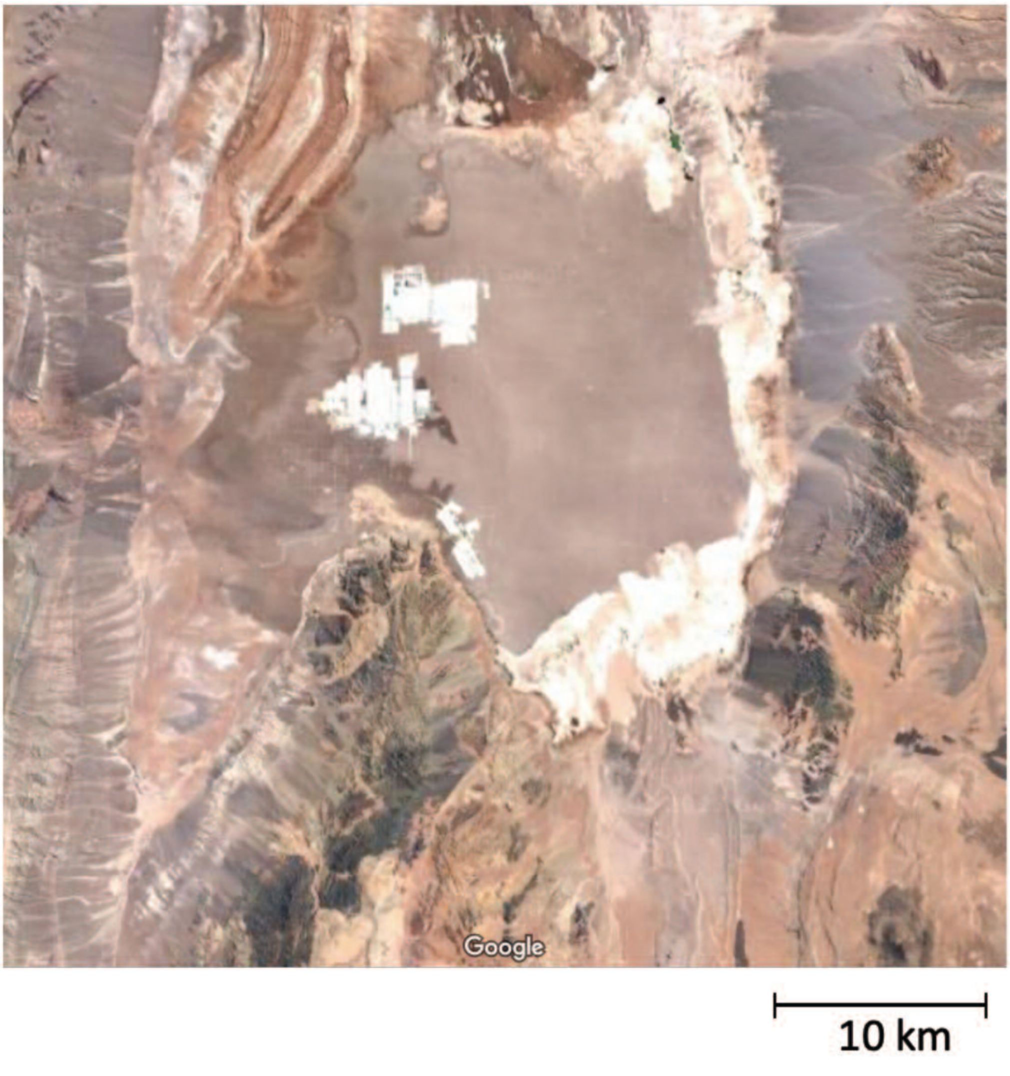


2.8 Case studies: Lithium extraction in Chile and Australia

Lithium brine extraction in Atacama, Chile

Chile is the world's second largest producer of lithium and, as the main analysis shows, lithium-ion batteries used in Scotland are likely to contain lithium from Chile, processed in China.

Figure 2.8 Satellite image of lithium brine extraction sites in Salar de Atacama region of Chile in 2018, showing evaporation ponds using brine pumped from below the surface[102]



Northern Chile forms part of the so-called "lithium triangle" (alongside Argentina and Bolivia) with substantial reserves in the form of brine. This area has been described as the "Saudi Arabia of lithium",[103] but it is really better known, beyond its extractive potential, as the "Puna de Atacama" or Atacama Plateau.

Thanks to lithium's designation as a strategic resource in 1979, only two companies enjoy permits to exploit the metal – Chile's Sociedad Quimica y Minera (SQM) and the US company Albemarle, although other companies are now starting to explore. There have been accusations of corruption thanks to the close relationship they, especially SQM, have with the Chilean Government.[104]

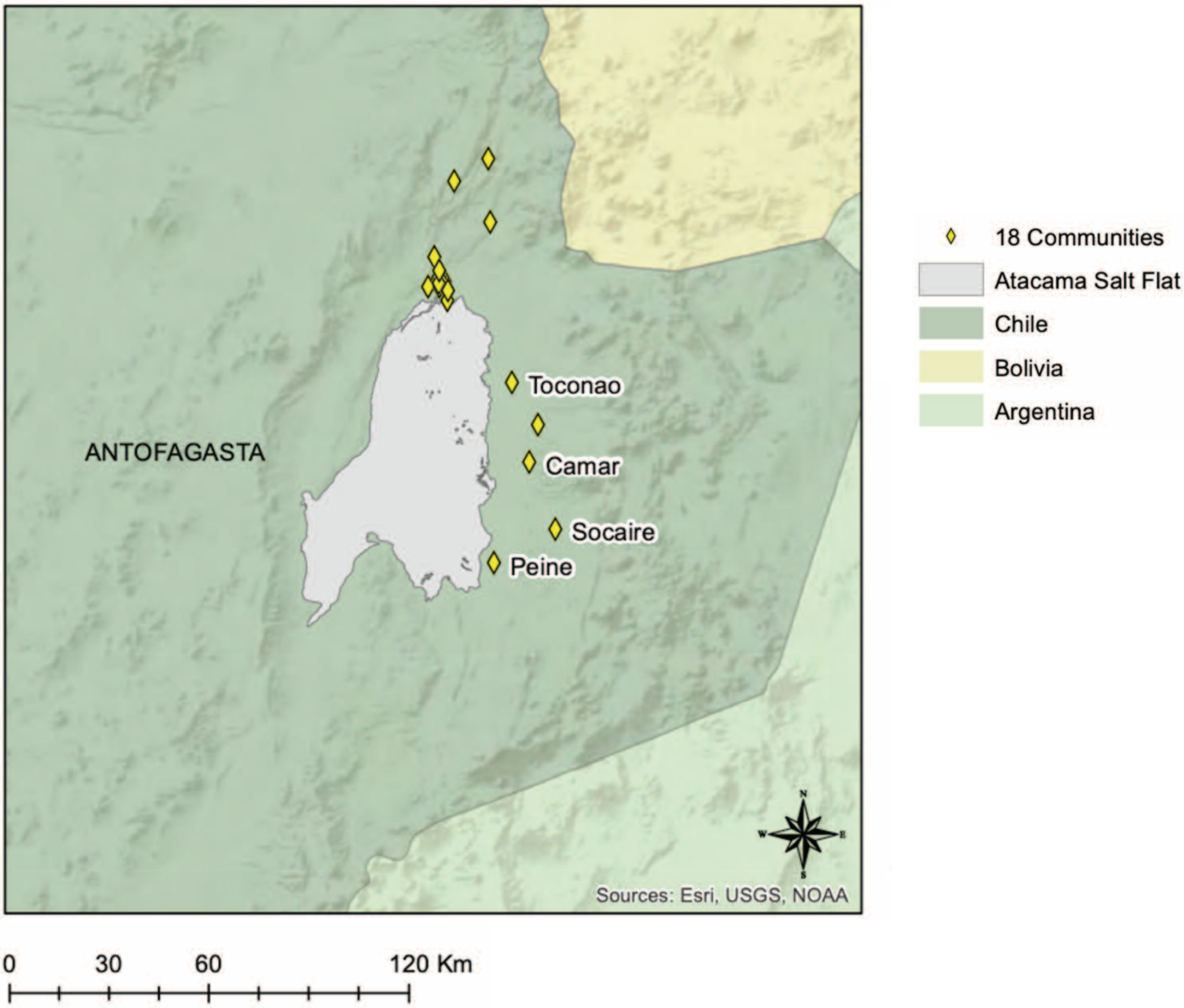
Mining impacts

There are a number of significant impacts from lithium brine extraction in Chile. The most obvious concerns brine evaporation, which uses vast quantities of water in an already parched environment. Mining activities are said to have consumed 65% of the Salar de Atacama region's water.[105] It has also left salty mounds of waste on the salt flats that contaminates the environment with an array of toxic chemicals, associated with the brines or pond linings. Research is being undertaken into the natural carbon sequestration potential of the Puna de Atacama wetland, and any damage that mining may cause.[106]

This situation is exacerbated by climate breakdown-induced drought and the effects of other development such as tourism and extracting and processing copper, of which Chile is the world's top producer.

Such large-scale depletion of salt water from the aquifers endangers various native species, including unique wetlands where fauna and flora – including migratory birds, the Andean fox, numerous small mammals – coexist in fragile circumstances. A recent study found a link between lithium mining and a decline in two flamingo species.[107]

Figure 2.9 Selected Atacameno Communities that live near the Atacama Salt Flats in Chile[108]



The mining practices in the region mean that freshwater is less accessible to the 18 Indigenous Atacameño communities that live on the Atacama's perimeter.[109] Although the companies argue they are only using brine not suitable for human use, the salt flats are inextricably connected to the wetlands and rivers that support all life in this arid region.[110] The Atacameño and other Indigenous peoples are permitted to use far less water than the mining companies.

These environmental harms are made worse as the Chilean Government has not always enforced Indigenous people's right to free, prior informed consent, as required under ILO Convention 169. As a result, there have been ongoing protests and court cases from the local communities attempting to assert this right to consent.[111] Communities have campaigned against SQM and Albemarle over unauthorised operations and inadequate environmental monitoring, utilising direct action tactics including road blockades and hunger strikes.[112]

Unionised workers have also protested against exploitative working conditions. In 2021, workers settled a dispute at Albermale's Salar de Atacama facility after opposing a contract which restricted union freedom and discriminated against the plant's most vulnerable workers.[113]

On the Maricunga Salt Flat, also in Chile, various companies are developing projects on the lands of the Colla People. Mining activities have disrupted their ancestral ceremonies, violating their Indigenous rights. The project developers, Minera Salar Blanco, a company established in 2016 to explore and develop lithium mining opportunities in the Atacama region, assert they undertook a 'lengthy process of social engagement', but the communities assert that they did not gain the consent of all those affected. The nearby Sales de Maricunga project, run by a consortium of three Chilean, Taiwanese and Japanese companies, offered no consultation at all.[116]

We have Indigenous consultations in which, if they come and ask you as an Indigenous person and part of the territory they are interested in exploiting, 'Do you agree with what we want to do?' and as Indigenous people, we say no, then this consultation process is considered done and fulfilled... there is little that we can do to stop projects that seek to extract lithium from the Maricunga Salt Flat.

Lesley Muñoz Rivera of the Indigenous Colla Community, Comuna de Copiapó and member of OPSAL[114, 115]

Hard rock lithium mining in Australia

Australia is the primary producer of lithium in the world and Australian-listed mining companies dominate the lithium extraction market globally.[117] Lithium-ion batteries used in Scotland and the rest of the UK are connected to this source through China, where the majority of lithium is processed.

Extraction of lithium from hard rock pegmatites is energy, carbon and water intensive. In Australian open pit mines, such as Greenbushes, the process first involves drilling and breaking up the rock with explosives. This stage, in itself, is no different to other open pit methods for extracting metals.

After the ore is mined, it is crushed onsite, then roasted – this is the most energy intensive stage. Finally, sulphuric acid leaching is applied to extract the product known as 'spodumene', which is shipped (mainly to China) for further processing into battery-grade lithium hydroxide. The leaching stage is the most environmentally damaging, due to the high risk of chemical contamination into groundwater.[118] Tailings are also an issue: the ore extracted in Australia's lithium mines currently produces up to 94% waste rock.[119]

Domestic expansion

The Australian Federal Government has enacted major policy changes to make Australia a 'global critical minerals powerhouse'.[120] Lithium is at the forefront of this ambition. Most extractive expansions are happening in Western Australia, in areas already impacted by decades of grand-scale mining. Greenbushes, near Perth, is the world's biggest hard rock lithium mine. The area contains a sacred site of the First Nations Noongar people – the Blackwood River and its tributaries.[121] The operation is now being expanded, with an extended open pit, two new processing and crushing plants, a new tailings dam, a tailings retreatment plant, explosives storage and other infrastructure. This will destroy 350 hectares of state forest with unknown flow-on impacts on the river systems.[122]

Another operation under expansion is Pilgangoora (Pilbara Minerals). The Pilbara region is fraught with mining-related violations against Indigenous communities, from dispossession to cultural heritage destruction.[123] There are altogether five operating lithium mines in Western Australia[124] (including the Finniss project see below), with several areas being explored for new lithium projects, especially in the Kalgoorlie-Goldfields region and around Greenbushes.[125]

Lithium ore processing is also being expanded domestically in Australia with support from the Federal Government's Critical Minerals Strategy,[126] which is prioritising the "onshoring" of battery metals supply chains in order to increase Australia's energy security and reduce trade dependence on China. Australia's first lithium hydroxide refinery was opened near Perth in August 2021.[127]

The Core Lithium's Finniss Project

Core Lithium's Finniss Project is Australia's newest lithium operation, and the only outside of Western Australia. Situated south of Darwin Port in the Litchfield-Finniss region of the Northern Territory, the site commenced production in October 2022 and includes an open pit mine, an underground mine, and a concentrator plant. The project will have a lifespan of 12 years and is expected to produce 16 million tonnes of ore over that time.[128] Aside from existing operations, the region is covered by an additional 500km2 of lithium exploration tenements.

The Finniss project has gained significant attention from investors, due to its deemed important role in Australia's push to increase production for batteries and green energy. It was granted Major Project Status in 2021,[129] giving it access to federal government funds and streamlining.

The Northern Territory Environment Centre (NTEC) has raised numerous concerns, particularly regarding the underground mine. These include unacceptable risks of impacts on surface and groundwater in an area prone to floods and cyclones, lack of company transparency about closure management plans, and lack of thorough fauna and flora studies in the area.[130] In a 2023 submission to Australia's Critical Minerals Strategy Discussion Paper, the NTEC says "Currently, the Litchfield-Finniss region... is being turned into a sacrifice zone for the extraction of lithium."[131]

This situation is not helped by allegations of corruption within the mining regulation department of the Northern Territory Government. In 2021, regulators submitted complaints to the Independent Commission on Corruption (ICAC), alleging that they were being asked to "cut corners and force through mines at all costs".[132]

Community opposition is growing.

A 2022 ABC report interviewed pastoralists concerned about contaminated run-off observed around the Core Lithium site.[133] A group called the Friends of Litchfield-Finniss, now with over 1000 members, opposes lithium extraction due to violations of landholders' rights and the environmental risks of mining close to Litchfield National Park, an area of significant ecological and cultural value.[134]

In 2021, six Traditional Owners of the Larrakia Nation filed a lawsuit against the regional Native Title representative body over alleged mishandling of royalty agreements with the company. This was withdrawn in February 2022, a month before works to develop the mines began.[135]

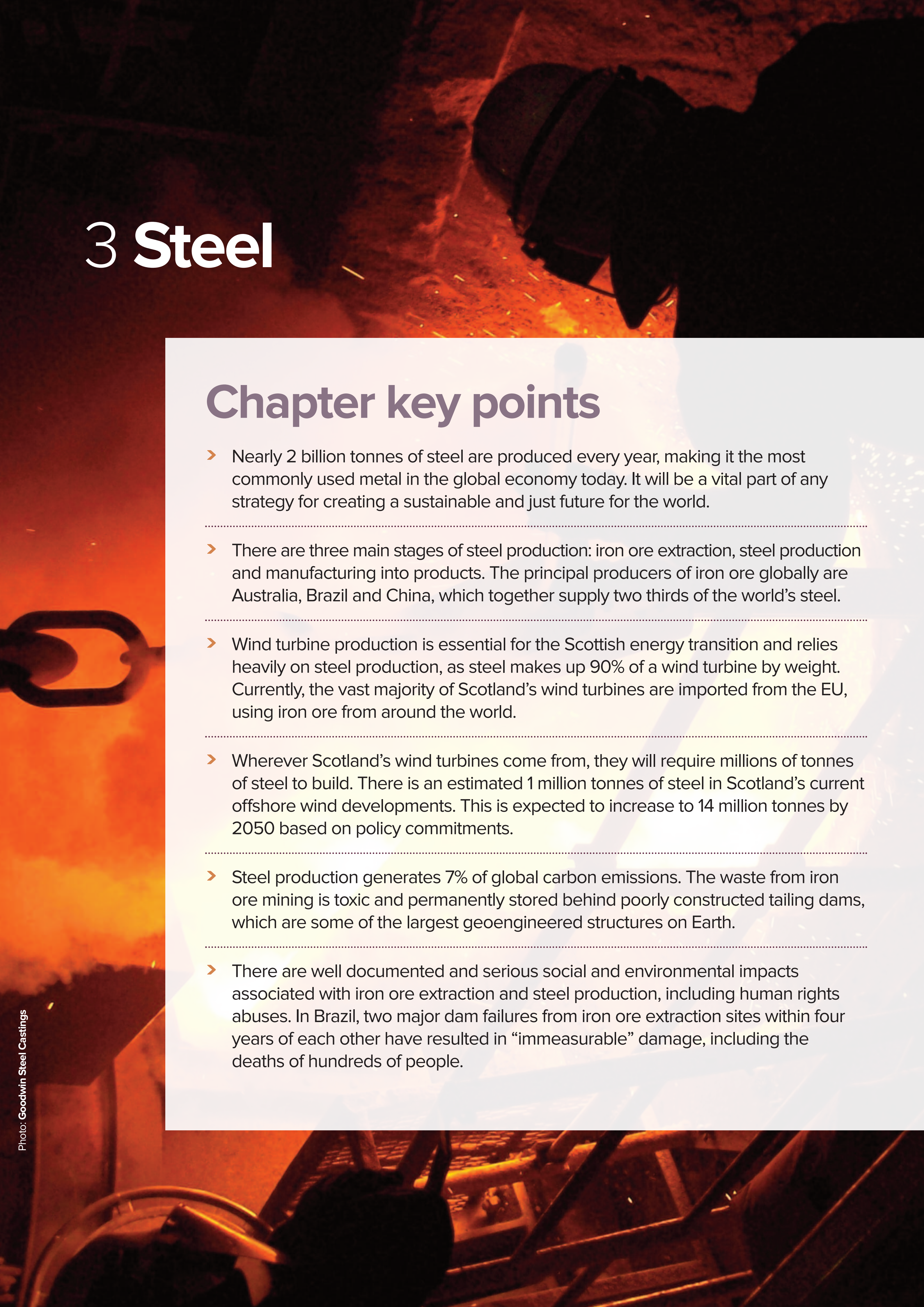


Photo: Goodwin Steel Castings

3 Steel

Chapter key points

- Nearly 2 billion tonnes of steel are produced every year, making it the most commonly used metal in the global economy today. It will be a vital part of any strategy for creating a sustainable and just future for the world.
- There are three main stages of steel production: iron ore extraction, steel production and manufacturing into products. The principal producers of iron ore globally are Australia, Brazil and China, which together supply two thirds of the world's steel.
- Wind turbine production is essential for the Scottish energy transition and relies heavily on steel production, as steel makes up 90% of a wind turbine by weight. Currently, the vast majority of Scotland's wind turbines are imported from the EU, using iron ore from around the world.
- Wherever Scotland's wind turbines come from, they will require millions of tonnes of steel to build. There is an estimated 1 million tonnes of steel in Scotland's current offshore wind developments. This is expected to increase to 14 million tonnes by 2050 based on policy commitments.
- Steel production generates 7% of global carbon emissions. The waste from iron ore mining is toxic and permanently stored behind poorly constructed tailing dams, which are some of the largest geoengineered structures on Earth.
- There are well documented and serious social and environmental impacts associated with iron ore extraction and steel production, including human rights abuses. In Brazil, two major dam failures from iron ore extraction sites within four years of each other have resulted in "immeasurable" damage, including the deaths of hundreds of people.

3.1 Use of steel in the energy transition

Steel is a strong and durable alloy of iron and carbon, often with other constituents such as manganese, chromium, tungsten or vanadium. It is the world's most commonly used metal, used in construction, energy infrastructure and many consumer products from cars to clothing. There is often no substitute for its use. Iron ore, the raw material which is used to make steel, has a huge footprint given it is the world's third most extracted commodity by volume – after crude oil and coal – and the second most traded commodity. It accounts for 90% of all the metals mined in the world.[136]

In contrast to lithium, demand for steel is less closely tied to one technology; it is relatively abundant and so supply is not constrained, and the supply chains are sprawling and complex. However, it is equally crucial to the energy transition given its indispensable function in the construction of renewable energy technologies such as wind turbines, the base of many solar panels and of motors used in electric vehicles.

Iron ore is often excluded from critical minerals lists because of its well established and large scale supply chains. However, its contribution to carbon emissions, and the widespread presence of social and environmental injustices in steel supply chains, means it is a material that the Scottish Government must account for in its circular economy and just transition strategies.

3.2 Current and future demand for steel

Over 1.95 billion tonnes of steel were produced in 2021 alone.[137] Global demand is rising, with an annual growth rate of 3.8% in 2020/21,[138] and global production is predicted to grow to 2.2 billion by 2026.[139] In that year over half, 52%, was used in construction and infrastructure with the other uses including mechanical equipment, motorised vehicles, other transport and consumer products.[140]

Steel is already crucial to the Scottish economy with one study estimating that over a million people in Scotland are employed directly in major steel-using industries.[141] **Table 3.1** shows that the main sectors using steel in Scotland by turnover are the energy sector, construction, general manufacturing, aerospace and shipbuilding.

While demand for steel in renewable energy technologies is set to increase significantly, there are many end uses of steel across the economy not related to the energy transition and where demand could be scaled back. Shipbuilding, the fifth biggest market for steel in Scotland, is 'primarily structured to be able to meet the capability demands of the Royal Navy'.[142] Huge quantities of steel are therefore used in manufacturing combat vessels,[143] offshore patrol vessels, as well as Type 45 destroyers and aircraft carriers manufactured by the aerospace industry.[144]

A just transition would mean winding down socially harmful end uses for steel, such as military ones, to ensure that overall demand for steel is minimised even while demand for renewable energy technologies increases.

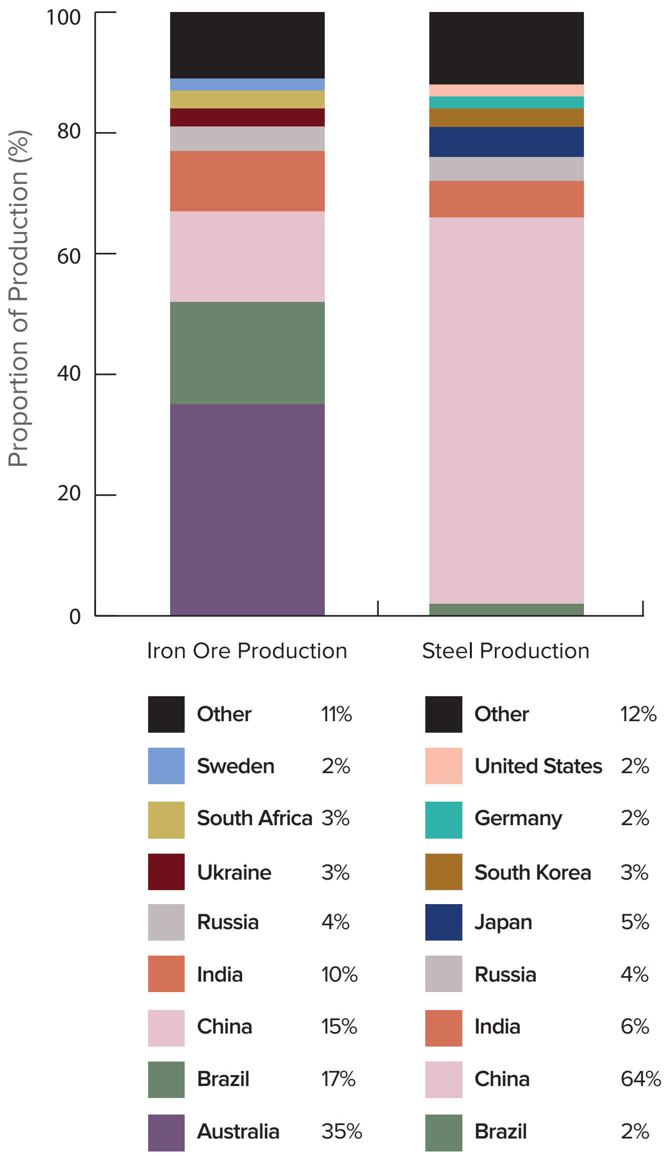
Table 3.1
The scale of Scottish steel markets in 2017 [145]

Sector	Employees	Turnover (£m)	% of Scottish Turnover
Shipbuilding	7,700	1,556	0.7
Construction	137,200	18,374	7.7
Aerospace	4,600	2,293	1.0
Energy	67,000	43,817	18.31
Oil and gas[146]	17,800	7,792	3.3
General Manufacturing	50,000	8,558	3.6

3.3 Major iron ore and steel producers

There are three key stages in steel supply chains: the extraction and processing of iron ore, the production of steel and the manufacture of steel products. **Figure 3.1** shows the main producers of iron ore and steel globally in 2021.

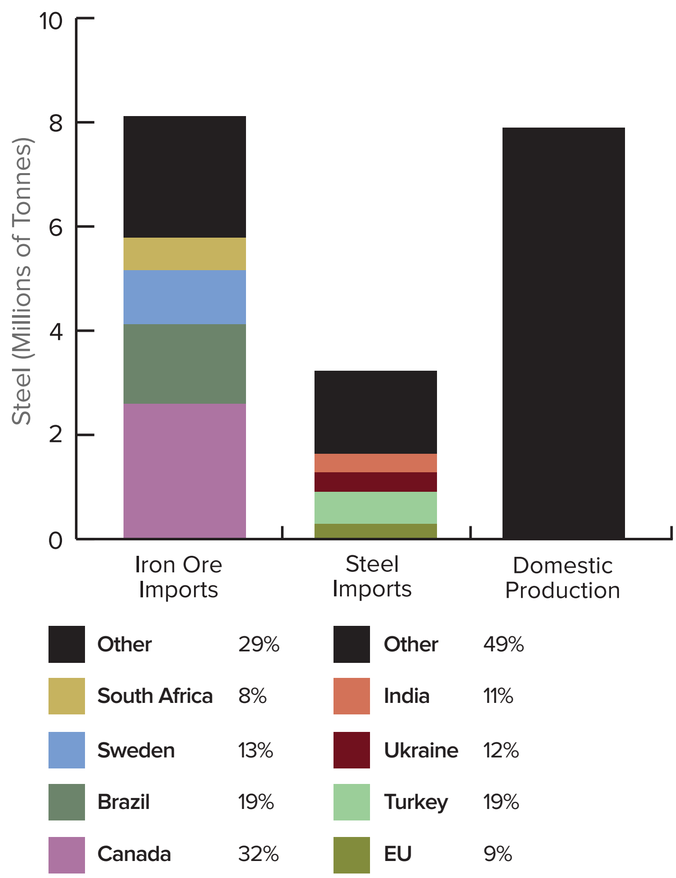
Figure 3.1 Main global producers of iron ore and steel in 2021[147, 148]



The UK is not a globally significant steel producer, with 7.9 million tonnes of steel produced annually,[149] 0.42% of world production. In Scotland, just 6,000 tonnes of steel was produced in the past three years, using material supplied from the rest of the UK.[150] 3.5 million tonnes of steel produced in the UK is exported while a large number of steel and manufactured products using steel are imported.

Of the 5.7 million tonnes of steel used annually in UK construction and infrastructure, 47% is produced domestically and the remainder is imported.[151] Therefore, in tracing Scotland's steel consumption UK iron ore imports, steel imports and domestic production must be considered. The countries which the UK imports both commodities from are outlined in **Figure 3.2**.

Figure 3.2 UK iron ore imports,[152, 153] steel imports[154] and domestic production, in 2021, in tonnes



3.4 Scotland wind turbine current and future demand

Wind turbines require many raw materials, including rare earth elements, copper, boron and nickel. However, 90% of the mass of a wind turbine is made from steel and steel makes up 82% of the embodied greenhouse gas emissions of a wind turbine.[155] This means that wind turbine supply is directly linked to steel production and supply. Wind turbine production, and therefore steel production, is critical to renewable energy generation and the future of the energy transition more broadly.

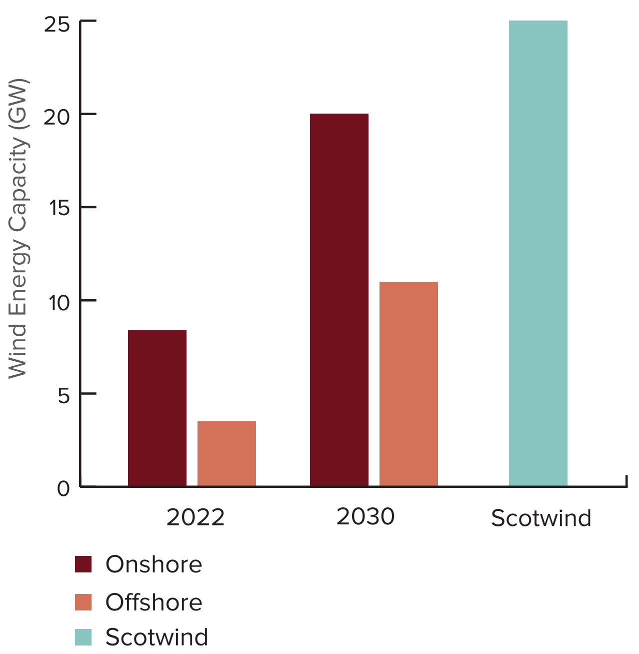
Scotland wind energy capacity

Wind is the dominant renewable energy generation source in Scotland, and that is set to continue over the coming decades. In the second quarter of 2022, onshore and offshore wind collectively generated 76% of Scotland's renewable electricity.[156] Looking to the future, wind energy makes up 94% of renewable energy projects under construction.[157]

Offshore wind in particular is an energy source where Scotland has become a global leader. Scotland has nearly 2 GW of operational offshore wind generation, 3.65 GW consented and 2 GW under construction.[158] Generation is set to grow rapidly, with the ScotWind leasing round alone set to deliver an additional 25 GW of capacity over the next decade.[159] The ScotWind leasing project was heavily criticised for its lack of a fair and open approach, which resulted in the development raising only a third of what was originally expected and a lack of supply chain investment.[160]

While onshore wind is also crucial to Scotland's energy strategy, offshore wind constitutes the majority of projects under construction and so this section will mainly focus on the supply chains for offshore wind.[161] **Figure 3.3** shows that both onshore and offshore wind turbine capacity is expected to more than double by 2030 if current policy commitments are met.

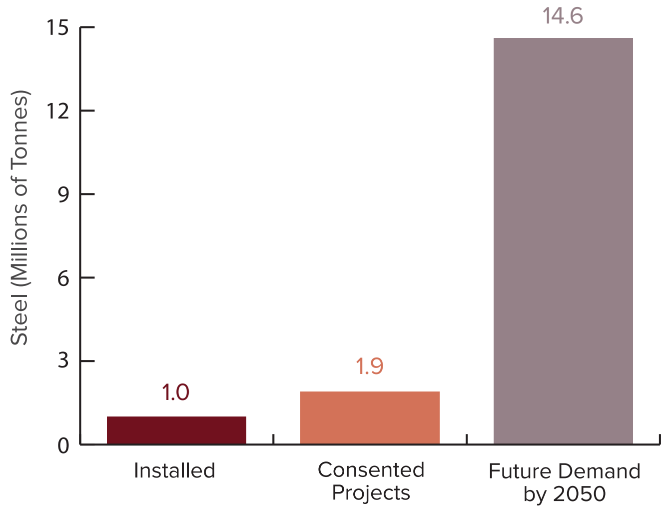
Figure 3.3 Current and future onshore and offshore wind turbine capacity in Scotland[162]



Increasing wind capacity leads to increasing steel demand

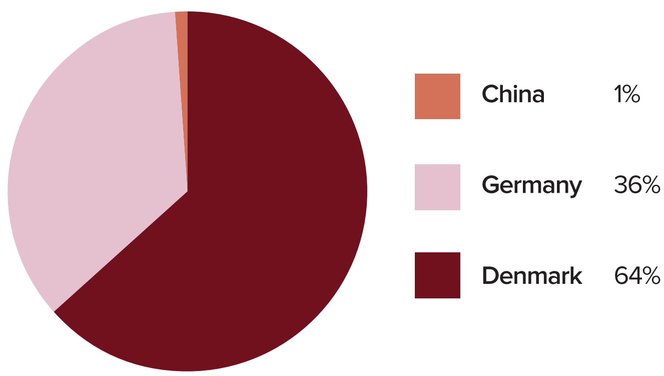
Growth in offshore wind production will mean a huge increase in demand for steel. Over 1 million tonnes of steel is already embedded in Scotland's existing offshore wind turbines.[163] **Figure 3.4** shows demand for steel is expected to grow by 1400% by 2050.[164]

Figure 3.4 Current use of steel in Scottish offshore wind turbines and future demand projections for 2050



The vast majority of wind turbines in the UK are imported. **Figure 3.5** shows that Denmark and Germany are the dominant markets from which Scotland imports turbines. Although China is the world's biggest manufacturer of offshore wind turbines, this is almost entirely for domestic consumption and until 2021 no Chinese offshore wind turbines had been installed outside of the country.[165]

Figure 3.5 UK wind turbine imports, in 2021, in US$



At present, a small proportion of wind turbine parts used in Scottish offshore wind projects are manufactured in the UK. When accounting for both the wind turbine base (foundations in fixed bottom turbines and substations in floating turbines) and the turbine, the UK currently manufactures just 7.2%, and Scotland just 3.2%, of its wind turbines.[167] In recent years, big offshore wind turbine manufacturing companies have started to build factories in the UK to supply domestic offshore wind projects. These include Siemens Gamesa, with a blade manufacturing factory in Hull, MHI Vestas with another in Newport, Isle of Wight, with more plants in the pipeline, including SeAH's planned monopile construction plant at Teeside Freeport which won planning permission in 2022.[168, 169, 170, 171, 172] There is limited turbine manufacturing capacity in Scotland, but Global Energy Group has announced plans for a factory at the Port of Nigg in the Highlands which will manufacture offshore wind towers.[173]

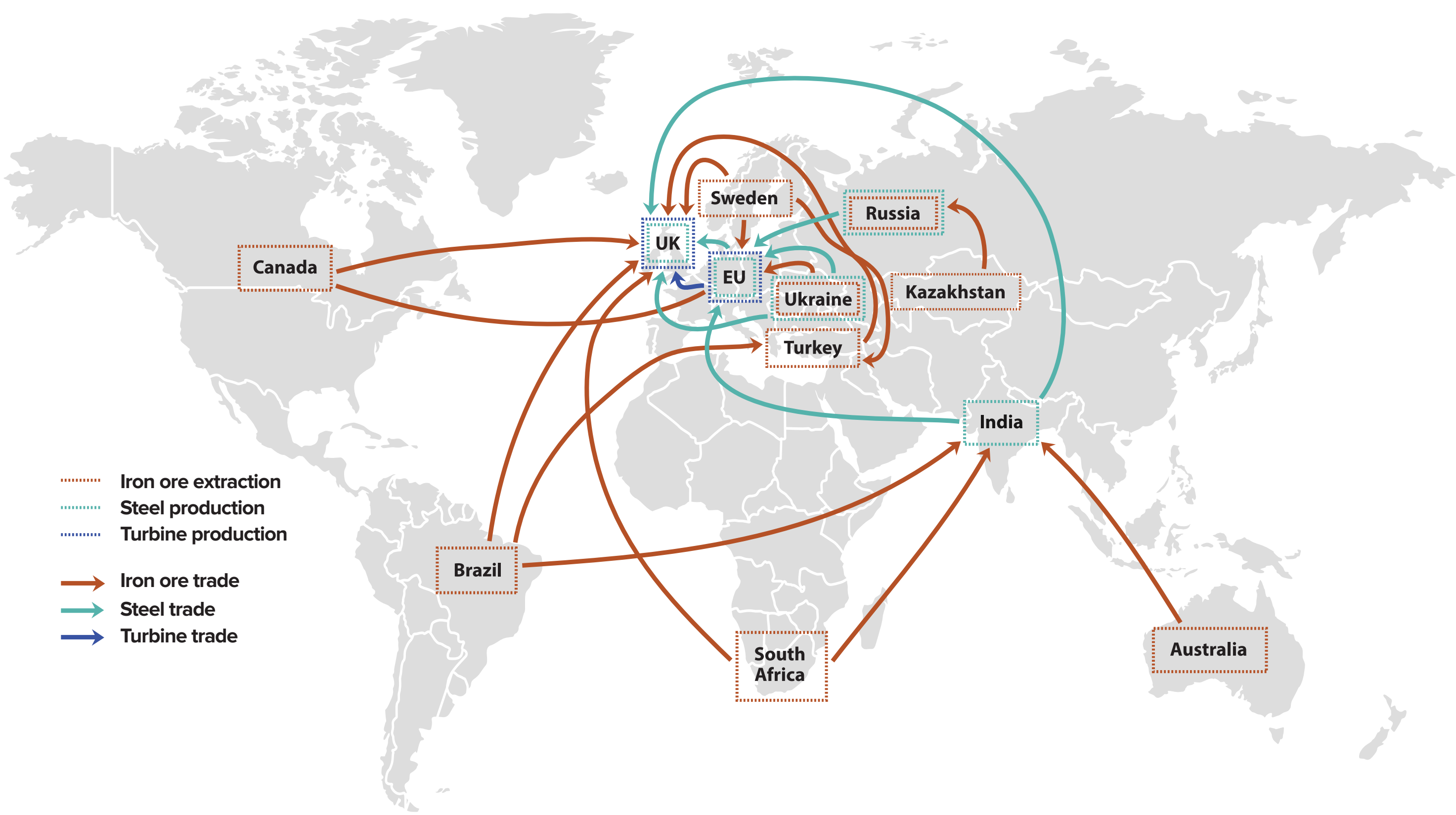
The proportion of turbines, foundations and substructures being produced in the UK and Scotland is likely to increase significantly in the coming years. In part, this is because a higher ratio of floating turbines compared to fixed base turbines are manufactured in the UK and the proportion of offshore wind energy generated by floating turbines is set to rapidly increase in the coming decades. The main reason, however, is UK government policy. In 2020, the UK Government announced the 'offshore wind sector deal'[174] which seeks to bolster UK manufacturing in offshore wind supply chains. The deal set a target for offshore wind projects to include 60% UK content, a figure which includes not only turbine manufacture but installation, operation and maintenance, development and project management and decommissioning. UK and Scottish content for Scottish wind turbines currently stands at 48% and 44% respectively.[175]

3.5 Mapping Scotland's steel supply chains for wind turbines

The global supply chain of steel is vast and complex. The different stages of steel and wind turbines used in Scotland are produced in different regions of the world, as part of a global supply chain. Scottish offshore wind turbines are mainly made in the EU and UK, using steel produced and iron ore mined from global sources.

Figure 3.7 shows a simplified supply chain for offshore wind turbines used in Scotland. It includes the three stages of the production supply chain – iron ore extraction, steel production and wind turbine manufacturing – and the main countries involved.

Figure 3.7 Simplified supply chain for wind turbines used in Scotland, 2020[176]



Brazil is a crucial player in the supply chain given that it is a major iron ore exporter to the UK and EU as well as to Turkey, which exports large quantities of steel to the UK and EU.

The data for steel and iron imports is complex and **Figure 3.7** gives an indication of the main countries involved, rather than a comprehensive analysis. For simplicity, we assume that the turbines imported from Denmark and Germany are manufactured in those countries. While both countries are big manufacturers of wind turbines, it is likely that some of the turbine parts will be imported from other countries.

There is just over 1 million tonnes of steel in Scotland's operational offshore wind turbines. It is estimated that the ScotWind offshore wind development will require three million tonnes of steel alone.[177] By 2050, it is estimated that to achieve the expected growth of offshore wind it will require approximately 14.7 million tonnes of steel and 1.5 million tonnes of ductile iron casting.[178]

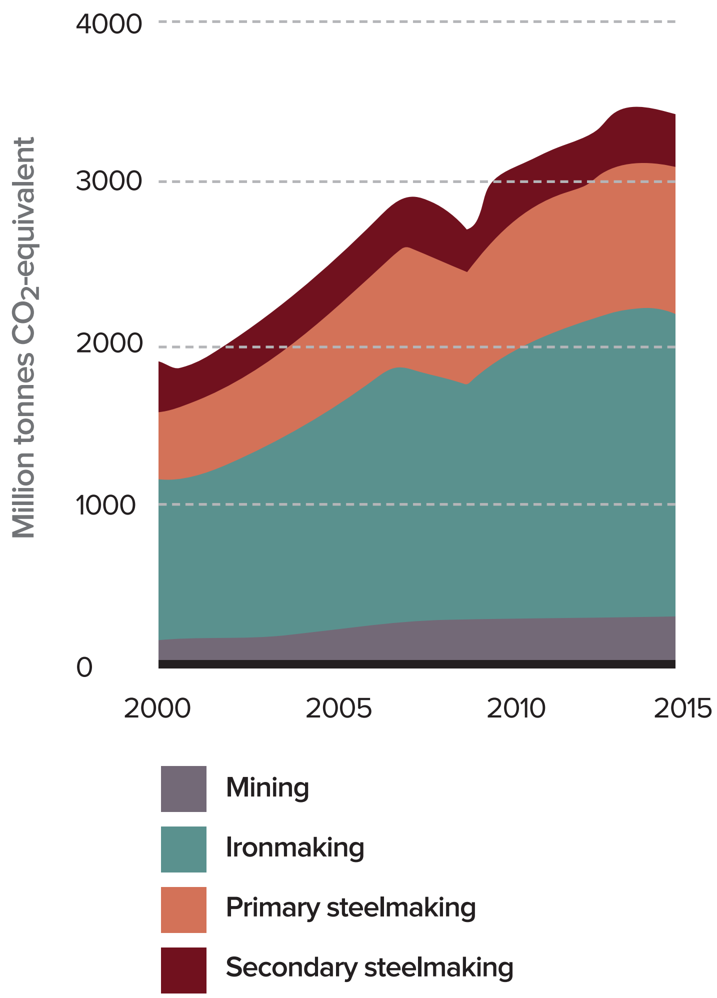
3.6 Social and environmental concerns with steel supply chains

Climate emissions

Iron and steel production contributes 7% of global greenhouse gas emissions.[179] Emissions from steel are so significant both because the world produces a vast quantity of steel every year, compared to other materials, and because the process of making steel is almost always carbon intensive. Therefore, there is an urgent need to decarbonise steel production.

The vast majority of carbon emissions in the steel supply chain are emitted in the steelmaking process itself rather than in the extraction of iron ore or transport (**Figure 3.8**). There are two main methods through which steel is produced: blast furnace-basic oxygen furnaces (BF-BOF), accounting for 73% of global steel production, and electric arc furnaces (EAF), accounting for 26%.[180]

Figure 3.8 The global carbon emissions from steel production by supply chain stage, 2000–2015, $MtCO_2e$[181]



BF-BOF is the older and dominant method of steel production, where iron ore is combined with large quantities of coal to create pig iron in a blast furnace. Pig iron is then placed in an oxygen furnace alongside some scrap (recycled) steel to create crude steel. This process is highly energy and carbon intensive, requiring around 20.8 GJ of energy and emitting 2.2 tonnes of CO_2 to produce one tonne of steel.[182] There are limited options for decarbonising BF-BOF production given the need for coal as a reductant in the process. In addition, BF-BOF relies heavily on new iron ore as only a limited amount of scrap steel, around 18%, can be used.

EAF furnaces, in contrast, can take up to 100% scrap steel meaning demand for iron ore in this method of production could be dramatically reduced, if there is a steady supply of suitable scrap steel. EAF plants utilise electricity rather than coal, although some EAF plants use hydrogen or natural gas as reductants instead of electricity. The CELSA EAF plant in Wales emits 86% less carbon emissions than a traditional BF-BOF plant.[183]

The emissions associated with EAF production are much lower than BF-BOF but vary depending both on the choice of reductant and the electricity source. Scotland's national grid has one of the lowest carbon intensities of any country. This means, if scrap steel could be recycled in an EAF, in Scotland, this could be done producing less carbon emissions than almost any other country using the same approach.[184]

Hydrogen is often suggested as a solution to decarbonising steel production. However, at present 98% of hydrogen production is 'grey hydrogen', being produced through natural gas and coal. 'Green hydrogen', produced through an electrolysis process that splits water with electricity, accounts for just 2%. Currently green hydrogen requires far more energy than electrification and is a more expensive option.[185]

The material demands of hydrogen

Hydrogen is being positioned as a central component of Scotland's strategy to decarbonise its economy despite the ability of hydrogen to be able to meaningfully contribute to emissions reductions being uncertain.[186] The Scottish Government has a target to scale up hydrogen production from virtually zero to 5 GW in 2032 and 25 GW in 2045.[187] This will require vast amounts of materials, including transition minerals. The lack of consideration of how these materials will be sourced and the impacts of this demand are important and substantial gaps in the policy making process, and a risk to the delivery of emissions reductions targets.

All of the main stages of hydrogen production have material requirements, from the energy infrastructure needed to supply the energy to make hydrogen to the hydrogen production facilities and the products adapted to hydrogen use.

The material requirements of the energy sources used to produce hydrogen depends on whether this energy comes from renewables or fossil fuels. If Scotland were to meet its ambition of 5 GW of hydrogen by 2030 using only energy from renewables (so called 'green hydrogen'), it would need 25.5 TWh of renewable energy capacity – that's the equivalent of 80% of Scotland's current renewable energy generation. Blue hydrogen, made from fossil fuels, would be even more materially intensive, because it would rely on fossil fuel extraction and carbon capture and storage technology.

The production of hydrogen itself will require major growth in demand for nickel and rare earth elements for use in electrolysers.[188] The infrastructure required to produce and store hydrogen will create additional material demands as well.

Hydrogen using products and sectors, from transport and heating to industry, will have to be adapted or replaced to make use of this new fuel. This will require materials – for example, copper and platinum group metals will be needed in fuel cell electric vehicles, which use hydrogen as a fuel.

The IEA estimates that low-emission hydrogen production will be one of the main drivers for increasing demand for transition minerals by 2050.[189]

Scotland must consider the material consequences of its hydrogen plans if it is to create realistic and sustainable policies.

Issues associated with iron ore extraction

Aside from the significant climate impacts, iron ore dominates other metals in terms of how much is produced, its impacts on human health and the environmental pollution the mining process creates.[190]

Mining for minerals is a leading cause of deforestation,[191] even in or near protected areas. One recent study found that half of global metal ore extraction in 2019 took place at 20 kilometres or less from protected territories.[192] Between 2001–2019, iron ore was associated with the fourth highest levels of deforestation of any mineral, after coal, gold, and bauxite.[193]

Iron ore is usually mined in open pits, because of its relatively low value by volume. This generally leads to greater impacts regarding land disturbance, water and dust-borne air pollution. There are issues of acid mine drainage, where water and oxygen interact with sulphur bearing rocks, which have exceedingly long-lived effects. Climate change itself is likely to increase the risks at mining sites of water stress, flooding and impacts from extreme heat.[194]

Tailings dams are structures used to permanently store waste from mining. They are some of the largest geotechnical engineered structures on Earth.[195] Iron ore mining results in the most waste in terms of overburden (rock moved) and tailings (processed, often liquified, mine waste) of any metal. Tailings dams can cause catastrophic problems through leakage or collapse.[196] The wide range of habitats from forest, to desert to tundra means iron ore mining is associated with varied concerns around biodiversity, deforestation and water-stress.

According to the Environmental Justice Atlas, 98 of all their 705 mining cases of community conflicts mapped involved iron ore mining, second only to copper (with steel involving 43 cases).[197] As an example in Chhattisgarh, India, large scale iron ore mining has resulted in rivers delivering drinking water to 100 villages being turned red, wide scale deforestation and soil erosion which has greatly impacted crop cultivation.[198]

A recent academic study mapping of transition minerals and their potential impacts on Indigenous and land-connected peoples includes iron ore.[199] It notes concern on how far iron ore projects will overlap with Indigenous land, particularly impacting food security.

Given so much mining is taking place on Indigenous lands in Australia and Brazil, there are numerous incidents of rights abuses against Indigenous peoples. A particularly conspicuous example is Rio Tinto destroying sacred caves belonging to aboriginal traditional owners at Juukan Gorge in the Pilbara in 2020 without their consent.[200] It is a clear example of the relative power imbalance between the companies and the communities.

Issues in processing and manufacturing of steel

Steel production can be highly polluting. Coke ovens (essential for creating that input to the steel making process) emit air pollution, including naphthalene that is highly toxic and can cause cancer. Waste products from the coking process are also highly toxic and contain a number of carcinogenic organic compounds as well as ammonia, arsenic and cadmium.[201]

The steel industry is the third-largest contributor to air pollution in India, and one of the largest causes of industrial pollution with highest rates of carbon dioxide emissions.[202] The industry has been linked with water pollution with effluents from refining. Water pollution levels in Urla, Raipur, have been reported as higher than the limits set by water quality standards.[203]

The Russian city of Magnitogorsk is home to a giant steel works. It is ranked the third most polluted city in Russia. Levels of the carcinogen benzopyrene in the city measure 23 times the allowed concentration and millions of cubic metres of industrial waste water have reportedly been pumped into the Ural River.[204]

China produces more than half of all of the world's steel. Handan, in the province of Hebei, is listed as one of the 10 most polluted cities in China. Handan is a highly polluted steel hub, where a toxic chemical leak turned the Zhuozhang river brown and resulted in increased fish mortality rates.[205] Cuts in steel production have proved necessary to decrease impacts on the affected local population, especially on days with heavy smog.[206]

In the province of Xinjiang, steel production is associated with forced labour of the Uyghur people. The Chinese government has accelerated steel production from the Uyghur region, with Baowu Group dominating, and admitting it is involved in the government's "work deployment program", i.e. forced labour.[207] The grave issues around large-scale, state-sanctioned forced labour are exacerbated by government controls that activists say makes supply chain due diligence from the region effectively impossible. In 2020, five audit firms pulled out of the region for this reason.[208]

Figure 3.9 The village of Bento Rodrigues, Brazil, where 19 people were killed in November 2015 after the collapse of a tailings dam built as part of the Germano iron ore mine owned by Samarco resulted in a toxic mudflow. Photograph taken by Nilmar Lage.

3.7 Steel case studies: Brazil, Canada and Turkey

Iron ore extraction in Brazil

Brazil is the second biggest iron ore miner in the world, digging up 410,000 tonnes of usable ore, with the second biggest reserves, after Australia.[209] It is also the second largest global iron ore exporter. In 2021, Brazil exported 358 million tonnes of iron ore, which accounted for 74% of the Brazil mining sector's global mining revenue. This provided a revenue of over R$ 250 billion (US$44.9 billion). The UK imports iron ore directly from Brazil for steelmaking and Brazilian iron ore is linked to Scottish offshore wind plants through trade with the EU, Turkey and India, all major steel import destinations for the UK.

Mining is a major cause of deforestation in the Brazilian Amazon, with 9% of forest loss caused by mining. The vast majority of this occurs outside of mining concessions, being linked to increased infrastructure and an increasing workforce, as well as making charcoal for pig iron.[210] As of early 2022, proposed mining projects overlapped with 15% of total Indigenous lands in the Amazon, with the lands of just 21 isolated groups covering 97% of those projects (although the recent change of President in Brazil is likely to reverse at least some of this).[211]

The Greater Carajás project in Pará State is a good example of such deforestation and rights abuses in action. It commenced in 1982 under the military dictatorship to open up the Eastern Amazon to development. Vale estimates it will extract up to 6.5 billion tonnes of iron ore.[212] The huge complex, involving open pit mines, processing and export via rail to the coastal port of São Luís, has led to the appropriation of 27,000 hectares of land, deforestation of 4,100 hectares of native Amazon forest, the consumption of 13.7 million cubic metres per year of water and the production of 4.3 billion tonnes of waste. It is associated with serious rights violations including deforestation, land grabbing, conflicts, violations against Indigenous peoples and the persecution of human rights defenders.[213]

Figure 3.10 Floods and mudslides in Minas Gerais, Creative Commons licence

Tailing dam disasters in Brazil

Brazil has been home to two major iron ore tailings (mine waste) dam failures within the last decade. The Fundão Dam at Samarco's mine in Mariana, Minas Gerais State, ruptured on 5 November 2015 releasing more than 40 million cubic metres of iron ore tailings into the Doce River. It contaminated 668 kilometres of the basin, impacting four states and reached the Atlantic Ocean. The disaster is regarded as the worst industrial accident in Brazil's history. It destroyed the village of Bento Rodriquez close to the mine causing 19 deaths and displacing more than 500 families.[214] Samarco was jointly owned by the Brazilian company Vale, and the world's largest mining company Anglo-Australian BHP (then BHP Billiton). Both companies have been entangled in subsequent arguments over clear-up, compensation as well as legal cases following the disaster (including a class action civil suit in the UK courts).[215]

Despite Vale's then CEO Fabio Schwartsman vowing "Mariana never again",[216] a second disaster occurred just four years later, on 25 January 2019 involving a company dam at Córrego do Feijão in Brumadinho, also in Minas Gerais State.

Approximately 12 million cubic metres of tailings flooded the Ferro-Carvão brook and reached the Paraopeba River. The tailings were mainly composed of iron, aluminium, manganese, and titanium but also had high levels of uranium, cadmium, lead, arsenic, and mercury.[217] The disaster caused 244 deaths and 26 missing people, including workers and those from the nearby communities of Córrego do Feijão and Parque da Cachoeira.

According to one study "The human, social and environmental impacts of this catastrophe are immeasurable".[218]

As with Samarco, disputes with local communities and legal action have followed the disaster, including criminal charges against company executives.[219]

These disasters, within four years of each other, are a reminder of the risks involved with iron ore mining given the sheer scale of ore and earth (overburden) that is moved as part of the process, and the scale of the waste produced.

Figure 3.11 Satellite image of part of the Córrego do Feijão in Brumadinho mine in Minas Gerais State, Brazil[220]

Minas-Rio iron ore mine, Brazil

Minas-Rio is an open pit iron ore mine located in Minas Gerais, Brazil. Owned by the UK multinational, Anglo American, it is among the world's largest iron ore operations. Commencing mining in 2014, it produced 23 million tonnes of ore in 2021 earning the company US$4.15 billion (almost one tenth of group revenue).[221] The mine and its tailings dam are situated in the buffer zone of the Espinhaço Range Biosphere Reserve, one of Brazil's priority conservation areas.

Local communities have raised concerns and protested on the following issues:

- water depletion, particularly from the ore delivery pipeline which consumes about 2.5 million litres of water per hour, as well as water contamination;
- damage to health and crops from wind-blown dust;
- impacts from mine traffic, lights and blasting for those close by the mine;
- potential impacts of a tailings dam breach for those living downstream (given the dam was designed to hold five times more than the volume held by the Brumadinho dam), and controversial plans to significantly expand the tailings storage and dam wall height;
- inadequate public consultations and poor-quality state regulation;
- land title disputes and resettlement issues leading to growing community divisions; and
- threats against, and intimidation of, local residents and critics of the mine.[222]

"The Passa Sete stream has lost all its native fish following two incidents of fish deaths in 2014, and its water is no longer suitable for domestic or agricultural use, for bathing or recreation."

Local community member, from Minas Gerais, Brazil[223]

Iron ore mining in Canada

Canada mined 57.5 million tonnes of iron ore in 2021, making it the ninth-largest producer of iron ore in the world.[224] The mining mainly takes place in the Labrador Trough region of Quebec and Labrador, as well as Nunavut. In that year, Canada also produced almost 13.3 million tonnes of steel, of which approximately 6 million tonnes was exported, mainly to the USA.[225]

Iron ore mining has had significant and long-lasting impacts. The Innu First Nation of Matimekush-Lac John filed legal proceedings against Iron Ore Company of Canada (IOC) in 2013 because of historical damage to their land and livelihoods in Quebec and Labrador.[226] Research conducted at IOC's Wabush mine in Labrador identified areas of concern for community health around water, soil and dust pollution.[227] ArcelorMittal was found guilty of numerous environmental violations at its Mount Wright iron mine near Fermont, Quebec.[228]

Iron ore processing has also had significant effects. The coke ovens at the Sydney tar ponds in Cape Breton, Nova Scotia, have been identified as Canada's largest toxic waste site. The community of more than 25,000 people has experienced elevated rates of cancer, heart and respiratory problems and birth defects.[229] The Algoma Ore iron processing plant in Ontario has left the Wawa Plume, a "24 km trail of environmental destruction".[230]

Canada is promoted as a 'good enforcement jurisdiction', i.e. one where less due diligence may be required. However, environmental contamination from mines is already significant and there are still major gaps in oversight of mine waste sites and water pollution controls across Canada, with slow progress on improvement[231] A federal regulation also allows the destruction of lakes and rivers for mine waste disposal, under certain conditions.[232] There are also numerous conflicts with Indigenous peoples, particularly on whether communities can exercise their right to free, prior and informed consent.[233]

Steel production in Turkey

Turkey produced 40 million tonnes of steel, worth US$22.4 billion in 2021. The country became Europe's largest steel producer in 2020, and the seventh largest in the world.[234] In 2021, it exported 615,000 tonnes to the UK and 922,000 tonnes to the European Union.[235]

The industry has been associated with both pollution and issues on worker rights. There has been a community struggle related to cancer-related deaths in the steel producing Dilovasi Industrial Zone, in Kocaeli Province, which are three times the global average and linked to air pollution.[236] In the Aliaga metal industry district in Izmir Province, ship breaking yards mix with steel works which has led to heavy metal pollution, especially in the local waterways.[237]

In terms of workers' rights there have been a number of recent industrial actions between unions and their employers, over pay and working conditions.[238] There are particular concerns over anti-union activities. According to the ITUC's 2020 Global Rights Index report, Turkey features in the ten worst countries in the world for working people.[239] In late 2022 President Erdogan invoked national security in order to ban strikes at two steel works in Kocaeli Province.[240] Unions have been fighting the steel company POSCO Assan at its plant in Kocaeli, where the company is refusing to reinstate workers dismissed for joining a trade union in 2017, despite a court victory recognising the union.[241]

4 Demand reduction and circular economy opportunities

Chapter key points

- Creating a fair and sustainable energy system for Scotland requires careful consideration, cooperation and regulation of materials, and in particular transition minerals. Minimising the impacts of transition minerals requires reducing demand as much as possible before ensuring more efficient use of materials which enter our economies.

- Demand reduction is essential for reducing the impacts of mining and therefore transition minerals. This is because mining will always have some social and environmental impacts, so these must be minimised by not taking any more than is needed.

- 58% of Scotland's carbon footprint come from imports.[242] Emissions from the production of imports are not included in its existing climate targets, which means policy makers ignore the wider carbon impact of Scotland's material demands. Associated human rights abuses and social and environmental harm are not accounted for either.

- Different decarbonisation paths create distinct material demands, with policies focused on public services over private ones offering the potential for greater savings. Displacing private electric cars with active and public travel options could significantly reduce Scotland's demand for lithium, for example.

- Increasing recycling rates for transition minerals, including lithium, may have significant additional savings. For steel, modernising production, reuse and recycling techniques are important for reducing production emissions.

- Circular economy strategies can be developed alongside domestic just transition plans and policies to implement global supply chain justice. Policies which encourage supply chain justice include expanding public ownership to leverage public procurement while regulating private corporations, and reparative trade policies.

The rapidly rising demand for transition minerals and the environmental and social impacts of their extraction and use, as outlined in this report, show that urgent action is required to understand and minimise our use of transition minerals, on a global level and for individual nations.

It is not possible to create a sustainable and fair future that avoids the worst impacts of climate change and respects planetary limits without careful consideration, co-operation and use of transition minerals.

Creating a circular economy is often suggested as a solution to reducing the impacts of material consumption, including transition mineral consumption. The term 'circular economy' refers to a set of policies and actions designed to minimise the amount of resources entering an economy and ensuring any resources which are extracted are cycled round the economy as many times as possible. As it has become popularised, the meaning of a circular economy has broadened. For some, it means having plans to deal with waste effectively; and for others it is about creating a sustainable future without compromising economic opportunities. If the goal of a circular economy is to create sustainable and fair use of materials, then principles of demand reduction and just transition must be central to it and presented together, as they are in this report.

4.1 Reducing the impacts of mining must focus on demand reduction

As shown throughout this report, mining companies the world over are not meeting their minimum responsibilities to protect human life and the environment. The result is widespread human rights abuses, social harm and environmental damage which is pushing planetary boundaries to breaking point.

There are due diligence standards and practices that, if immediately adopted and embedded into mining practices, would reduce these social and environmental impacts. There are new practices and technologies being developed and explored to reduce mining impacts as much as possible.[243]

However, mining will always carry the risk of significant social and environmental impact. That is because it must take place in a fixed location, which is often already occupied by people or nature. This means reducing demand, by taking no more than is needed, will always be essential to reducing the impacts of mining.

4.2 Proposed consumption reduction targets for Scotland

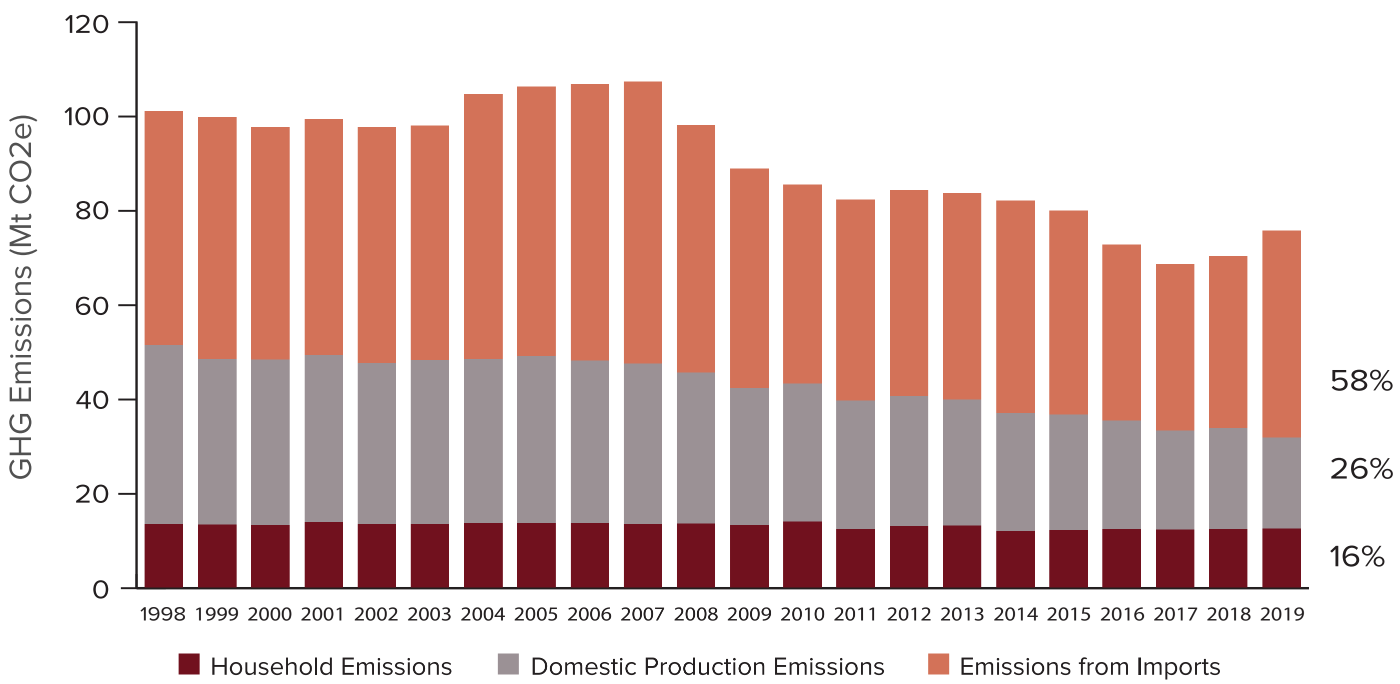
Consumption reduction targets are goals set at a national level to reduce the amount of materials and associated environmental impacts down to sustainable levels without compromising standards of living.[244] They can be measured in terms of any environmental impact but most commonly, they are based on reducing either the carbon or the mass of materials associated with consumption.

They can be used to set the scale and pace of change required to reach sustainable consumption goals. Because their boundaries include the impacts of imports, they are more likely to result in policies and actions which reduce demand for materials, rather than moving this demand outside of the boundaries of the targets (this is sometimes known as "offshoring").

In 2009, the Scottish Government set climate targets aimed at reducing domestic (or territorial) carbon emissions.[245] These targets cover essential cuts to emissions within Scotland. They do not account for the emissions embedded in the supply chain of goods and services imported to Scotland. So, for example, the emissions associated with the production of an electric car imported to Scotland (including raw material extraction, battery and car manufacturing and transport to Scotland), will not be included in Scotland's existing climate targets. This means Scotland's current legally binding emissions targets only cover part of Scotland's carbon footprint.

In 2019, 58% of Scotland's carbon footprint comes from imports (**Figure 4.1**). The emissions associated with the production of imports, and, therefore, a large part of Scotland's material consumption, are not covered by Scotland's domestic climate targets and policies. Whilst domestic emissions are reducing, the emissions from imports are increasing.

Figure 4.1 Scotland's carbon footprint showing the contribution of imports, domestic production and emissions directly from households, 1998–2019, in Mt CO2e[246]



Perversely, the fact that our existing climate targets focus only on emissions created in Scotland can lead to higher global emissions and negative economic impacts for Scotland. This happens when high carbon activities are offshored – sending both emissions and jobs overseas. For example, when Ravenscraig steel mill closed in 1992, the Scottish Government reported 3.5 Mt CO_2e had been removed from Scotland's carbon balance sheets.[247] But Scotland's demand for steel did not decline, leading to imports of goods which may be more carbon intensive to produce than the original Scottish products. Factoring in the global carbon impacts of such policy decisions would allow decision makers to promote solutions with genuine global reduction capabilities, such as low carbon domestic alternatives to high carbon activities, rather than offshoring impacts.

Without legally binding targets to strengthen accountability, regular reporting of Scotland's carbon-based consumption emissions, as required since 2009 Climate Change Act, has not resulted in reductions. In its latest report to the Scottish Parliament,[248] which was critical of the lack of progress made, the Climate Change Committee highlighted that Scotland's consumption emissions are growing. Simply reporting these figures is clearly not enough to stimulate the required action.

This gap could be addressed by introducing additional targets to reduce Scotland's carbon and material consumption, including the impacts from our imports. Such targets should be science based and statutory to improve accountability. They would complement existing domestic climate targets, ensuring that actions taken to reduce Scotland's emissions were impactful on a global level. Friends of the Earth Scotland has recommended the following consumption reduction targets to be adopted by the Scottish Government:

Carbon-based consumption targets

Scotland should reduce its global carbon footprint to zero by 2045, with an interim target of 75% by 2030, based on 1998 levels.

Material-based consumption targets

Scotland should reduce its material consumption to eight tonnes per person per year by 2045 (57% reduction), with an interim target of 13 tonnes per person per year (30% reduction) by 2030, based on 2017 levels.

Research shows that it is possible to live a high quality, sustainable life on eight tonnes of materials per person per year,[249] and that globally carbon emissions must be net zero by 2050 to meet the 1.5℃ goal of the Paris Agreement. For a global just transition, under the equity principles of the UN climate regime, Global North countries who have taken a disproportionate share of carbon budgets and the Earth's resources must move first and fastest.

The targets would include an estimate of all material consumption, including transition minerals. Some materials, particularly some transition minerals including lithium, may not appear to be significant in either carbon or material impacts. This does not mean they do not have high social and environmental impacts – there are many scientifically accepted indicators of social and environmental impact, from human toxicity and water use to biodiversity loss. Therefore, it may be necessary to monitor consumption of some individual materials, the use of which are considered important to the fair and sustainable goals, but which are not well represented by carbon and material targets alone.

Introducing consumption reduction targets would allow Scotland to keep pace with developments across Europe and in the EU. In 2021, the European Parliament voted to create binding, science-based targets for material use and consumption footprint[250] and in 2022, Sweden voted to introduce carbon consumption reduction targets.[251] Austria is the latest country to set consumption reduction targets, pledging to cut its material footprint by 80% by 2050 to seven tonnes per capita.[252]

Consumption reduction targets would set the scale and pace of change required for Scotland to reduce its carbon and material consumption to a sustainable level.

Targets should be based on the science of what is required to meet sustainable goals and bound by social responsibilities without compromising quality of life, to be effective.

4.3 Demand reduction and circular opportunities for lithium

Promoting better mining practices

Where mining does occur, impacts can be minimised by promoting, investing and supporting the development of more sustainable extraction techniques to reduce global consumption impacts further. For example, at the site of extraction, technological alternatives to direct lithium extraction, where brine is pumped to a processing unit where a resin or adsorption material is used to extract only the lithium, before the rest of the brine is reinjected into the salar, could also play a role in reducing environmental impacts. It is crucial, however, that such technologies are made available to resource rich states rather than patented for the sake of profit.[253]

As the possibility of lithium mining continues to be explored in Scotland, the impacts must be minimised by early and meaningful engagement with communities on the sharing of benefits and careful siting, and thorough assessment of potential environmental impacts and how to minimise them. A recent BGS report exploring transition mineral mining potential in the UK, identifies Glen Gairn, which is situated within Cairngorms National Park, as one of the best sites for lithium exploration.[254] Such resource extraction should not be considered in areas designated for protection such as National Parks and Sites of Special Scientific Interest.

To create a globally equitable society, any safeguards adopted in Scotland should set the minimum requirements for minerals mined elsewhere which are then consumed in Scotland. Expecting people and communities in the Global South to tolerate mining practices which are deemed unsafe and harmful in Scotland is unfair and unjust.

Reducing lithium extraction

In Scotland, demand for lithium is aligned to electric vehicle use. While Scotland must decarbonise its transport sector as fast as possible to meet its domestic climate targets, it must also ensure this does not result in unnecessary material demand. Modal shift to active and public transport will decarbonise transport, while achieving a range of other public policy benefits from increasing physical activity to enhancing community cohesion. In addition, public transport is a more efficient use of materials than private transport, so electrifying public transport and replacing private transport options at the same time will minimise harmful domestic and global environmental impacts.

A recent report by the Climate and Community project modelled different scenarios for decarbonising transport in the USA.[255] It found that a scenario using smaller lithium-ion batteries (which are lighter but provide less energy and have a shorter life, resulting in a reduced range) and radically reducing car ownership by investing in public transport would require 74% less lithium than a scenario where car ownership levels and large batteries are maintained. This is because buses are a more efficient way of using lithium – each bus only needs to displace 5.5 cars for there to be a saving in the amount of lithium required. A recent study of French road transportation found similar results, and concluded that “total electrification of French road transportation is not sustainable without sufficiency measures to contain the increase in demand”.[256]

The principle that an electrified public transport system would have less lithium demand is also true for Scotland. Replacing Scotland’s 2.5 million fossil fuel cars and 4,400 buses, like for like, would require 20,200 tonnes of lithium in total. If the proportion of journeys in Scotland taken by bus increased to 30% (which would bring the proportion of journeys made by public transport in Scotland up to the levels we see in London today) lithium requirements would be 13,800 tonnes (32% less).[257]

These figures are only an initial estimate but provide a high level overview of the dramatic differences in lithium demand between a transport system geared around high quality public transport and one with high car ownership levels. Investing heavily in public transport and reducing car ownership will not only help deliver mobility justice and reduce pollution but will greatly decrease demand for lithium-ion batteries, the dominant end use of lithium.

Lithium reuse and recycling

As well as reducing demand, better use of lithium once it enters the economy can also limit its impacts by replacing requirements for new resources. The reuse and recycling of lithium batteries is still rare, despite potential for both. For lithium-ion batteries used in electric vehicles, when they reach their end of life they still often retain around 80% of their original capacity.[258] They can be reused for less demanding applications for an additional 7 to 12 years, such as in energy storage, as spare electric vehicle battery back-ups, and in less intensive vehicles such as forklifts and warehouse tuggers.[259] Processing centres would need to be built with the capacity to reclaim, test and reassemble battery packs before sending them on to their second use. This would require significant investment, further research and development, and there are some technological hurdles to be overcome, but the process is completely feasible.

A significant obstacle, however, relates to battery ownership. The decision on whether to reuse, recycle or dispose of a battery has environmental consequences. Original equipment manufacturers (OEMs) are considering models where they sell vehicles to consumers but lease the batteries, meaning they will retain ownership at the end of a batteries' life. There are no clear market or policy drivers about what factors OEMs are likely to consider in this choice.[260] In order for processing centres to be effective, OEMs would need to either sell batteries to the processing centres at end-of-life, or licence them to collect and reassemble on their behalf. Leaving this decision to market forces provides no certainty that reuse facilities can be effectively scaled up and made use of. Regulation is therefore needed to ensure that OEMs are either required to reuse or recycle their batteries in house, or sell them at low costs to processing facilities.

Regulation of the end of life of lithium batteries could be implemented as a form of Extended Producer Responsibility (EPR). EPR schemes are where the producers of goods and services are required to pay for the clean-up of their products. This encourages waste reduction and recycling as producers seek ways to reduce their costs. There are thousands of established and successful examples of EPRs all around the world.[261]

Lithium-ion battery recycling is even further off being implemented than reuse. Less than 1% of lithium-ion batteries are recycled globally compared to over 99% of lead batteries in the EU and USA.[262] Recycling rates in Europe are at 5% and at present there are no recycling facilities in the UK.[263] Recycling is technologically possible, and there are a range of facilities in Europe using different recycling techniques where lithium, cobalt, nickel and other minerals can be recovered. A report by Earthworks estimated that a 95% recycling rate for all metals is possible, noting that 100% recovery has been reported in labs.[264] Once again, the lack of state ownership or control at all stages of the supply chain is the major barrier to scaling up recycling. The key reason recycling facilities have not been scaled up is to do with cost: the cost of recycling lithium-ion batteries is around three times the value of the reclaimed materials.[265] Extended Producer Responsibility schemes are designed to reduce costs by bringing them back to producers.

End of life solutions for lithium batteries are needed urgently as unsafe disposal has both environmental and economic impacts. In 2022, an incorrectly disposed lithium battery was the suspected cause of a large fire in a recycling plant in Aberdeen.[266]

Investment in research and development could bring the cost of recycling lithium down. Facilities have been established by a range of states including the ReCell Center in the USA, Faraday Institution ReLiB project in the UK, Commonwealth Scientific and Industrial Research Organisation in Australia, and the ReLieVe, Lithorec and Amplifll projects in the EU.[267] It is important that investment of this kind continues, not just to bring down the cost of recycling, but to improve its efficiency.

More robust regulation is needed to ensure effective recycling is implemented in the near future. China is the world leader in lithium-ion battery recycling (see **Figure 4.2**). This was achieved through state regulation; China first started regulating End of Life treatment of lithium-ion batteries in 2012 and has since implemented several laws, including requiring manufacturers to work with recycling companies to improve the recycling process and implementing a Battery Traceability Management Platform to better track electric vehicle batteries through their life cycle.[268]

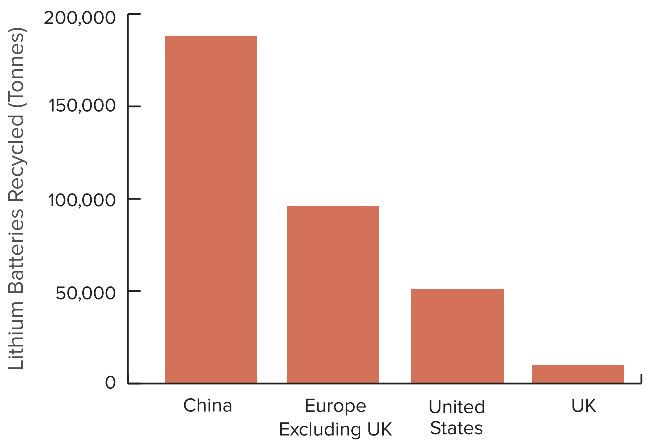


Figure 4.2 Global examples of lithium ion-battery recycling activity in 2021[269]

4.4 Demand reduction and circular opportunities for steel

Reducing iron ore extraction

With nearly 2 billion tonnes of steel produced every year, the sheer quantities of steel produced and used means that it is a serious and significant contributor to social and environmental harm and to climate emissions. Minimising demand is the most effective way of reducing the social and environmental impacts of iron ore extraction because it directly limits the need for this activity.

In Scotland, reducing funding for socially harmful end uses, such as unnecessary or unsustainable construction applications, could cut steel demand.

At the UK level, military applications are a major steel consumer. **Table 3.1**, in Section 3 above, shows that a significant proportion of Scotland's steel use is associated with ship building, which is almost completely for military use.

Material demand reduction for Scotland's Energy Strategy means not building more wind turbines (and other renewable infrastructure) than necessary. The Energy Strategy and Just Transition Plan states its aim is to produce enough energy for Scotland and additional energy production for export. Policy makers need an understanding of the material requirements that this huge expansion of wind capacity creates. Cooperation at the UK level and with European governments, to coordinate the most efficient way to create required capacity is also essential.

Improving scrap steel recycling

Globally, recycling of steel represents some of the most comprehensive and efficient recycling systems for any material. Over 60% of scrap steel is recycled and scrap steel makes up 40% of total new steel production.[270]

However, recycling is not the most sustainable use of scrap steel. Recycling requires steel to be remelted, which is energy intensive. If steel can be reused without remelting, this will save more carbon emissions than recycling. After maximising reductions of steel use in construction by, for example, retrofitting rather than demolishing and using alternative materials such as timber, new buildings that do require steel can be designed to be modular and taken apart again after their initial use is complete to be used again.[271]

When scrap steel cannot be reused and must be recycled, this should be done as efficiently as possible. A global effort is needed to electrolyse steel production as rapidly as possible. Traditional steel production and recycling, which still makes up 75% of steel production, uses Blast Furnace – Basic Oxygen Furnace (BF-BOF). This method requires coal to melt the steel and is limited to a maximum of 20% scrap steel inputs.[272] More modern Electric Arc Furnaces use electricity to melt the steel and can take 100% scrap. To decarbonise new steel production completely, the EAF electricity must come directly from renewables and the iron reduced with green hydrogen.[273] Such a process was used in 2021 in Sweden to produce the world's first steel without coal.[274]

The steel recycling rate of 60% is relatively high compared to other materials but there is no technological reason why this could not be much higher. A 2015 study found that the most important reasons for unrecoverable steel discards was "end-use products are discarded in a manner or place that does not allow for recovery of their ferrous material".[275] Many metals are often described as "infinitely recyclable" or "100% recyclable".[276] Given the huge amount of steel produced, failing to recycle even a small proportion of this means millions of tonnes of steel are being disposed of, and yet more iron ore extracted, unnecessarily.

This suggests better economic incentives to recycle steel, such as Extended Producer Responsibility schemes, could increase recycling rates. Improving collection and processing systems for recycling scrap steel will increase the proportion of scrap steel sent to recycling rather than landfill or incineration. Products which contain steel can be redesigned to ensure reuse and recycling can be maximised.

Recycling steel in Scotland

Scotland has significant amounts of scrap steel from sources such as decommissioned oil and gas rigs and older generation wind turbines which are already reaching end of life. As oil and gas production is wound down in the coming years there will be a huge amount of scrap steel which could be melted and reshaped directly into the renewable energy technologies needed for the energy transition.[277]

In 2021, all 595,000 tonnes of scrap steel were exported from Scotland.[278] The Scottish Government does not have a plan for improving its management of scrap steel and the Steel Sector Round Table of stakeholders and experts set up in 2016 is no longer active.[279] There are no facilities to recycle steel domestically in Scotland, but the existence of CELSA Steel Electric Arc Furnace in Wales,[280] which produces 1.2 million tonnes of steel a year, demonstrates how real this possibility is for Scotland. Taking advantage of Scotland's low carbon electricity grid would mean Scotland could be producing some of the greenest steel in the world.

If Scotland were to produce its own steel from domestic scrap in an electric arc furnace, this would cut carbon emissions by 60% compared to current estimates of the emissions associated with recycling Scotland's scrap steel, which must be exported.[281] Crucially, this would reduce Scottish demand for iron ore and so reduce the global impacts from its supply chain.

Ownership of Scottish offshore wind

UK public entities own just 0.03% of offshore wind generation, lower than the proportion owned by the Malaysian Government (0.1%) and the city of Munich (0.85%). However, if foreign state ownership and controlled entities is included, then 44.2% of the UK's offshore wind generation could be classed as publicly owned.[282] Ørsted, for example, is one the biggest companies operating offshore wind plants in Scotland and while it is publicly listed the Danish state has a 50.1% controlling stake. This lack of UK public control over offshore wind makes it much harder to implement circular economy and supply chain justice strategies.[283]

At present, all scrap steel and, therefore, all decommissioned wind turbines, ends up being exported from Scotland. Expanding public ownership of offshore wind would create a steady stream of decommissioned steel to be recycled domestically, once sustainable recycling capacity is created through the development of electric arc furnaces.

Supply Chain Justice

A publicly owned energy company operating projects including offshore wind in Scotland would also have complete control of supply, meaning stringent public procurement standards could be enforced. As part of this strategy, the Scottish Government could take ownership stakes in privately owned ports to ensure that the infrastructural upgrades necessary to facilitate increasingly large scale offshore wind projects are being implemented.[284]

Where private corporations, rather than governments, own renewable energy generation the implementation of strong regulations is required to ensure social and environmental standards are met.

A reparative trade policy would begin to address the colonial legacy of countries in the Global South being forced to sell raw materials at artificially low prices, with little value from extraction benefiting local communities but instead being captured by multinational corporations largely based in the Global North. This is a process extensively documented, for example in a report by War on Want which found that 'Africa's wealth in natural resources is being handed over to foreign, private interests'.[285]

Decommissioning of wind turbines

As the wind sector grows, so too will the need for decommissioning of turbines as they come to the end of life. Around 5,500 turbines will be decommissioned in Scotland by 2050, representing nearly 1.5 million tonnes of materials, mostly steel. As described in Zero Waste Scotland's report on onshore wind turbine decommissioning,[286] this can be done in a circular way, if planned for properly.

The possibility of old wind turbines being exported whole to countries in the Global South as they reach the end of their life is not a fair or equitable waste management solution. Instead, an Extended Producer Responsibility (EPR) scheme for wind turbines could ensure developers take on the responsibility and financial costs of decommissioning.

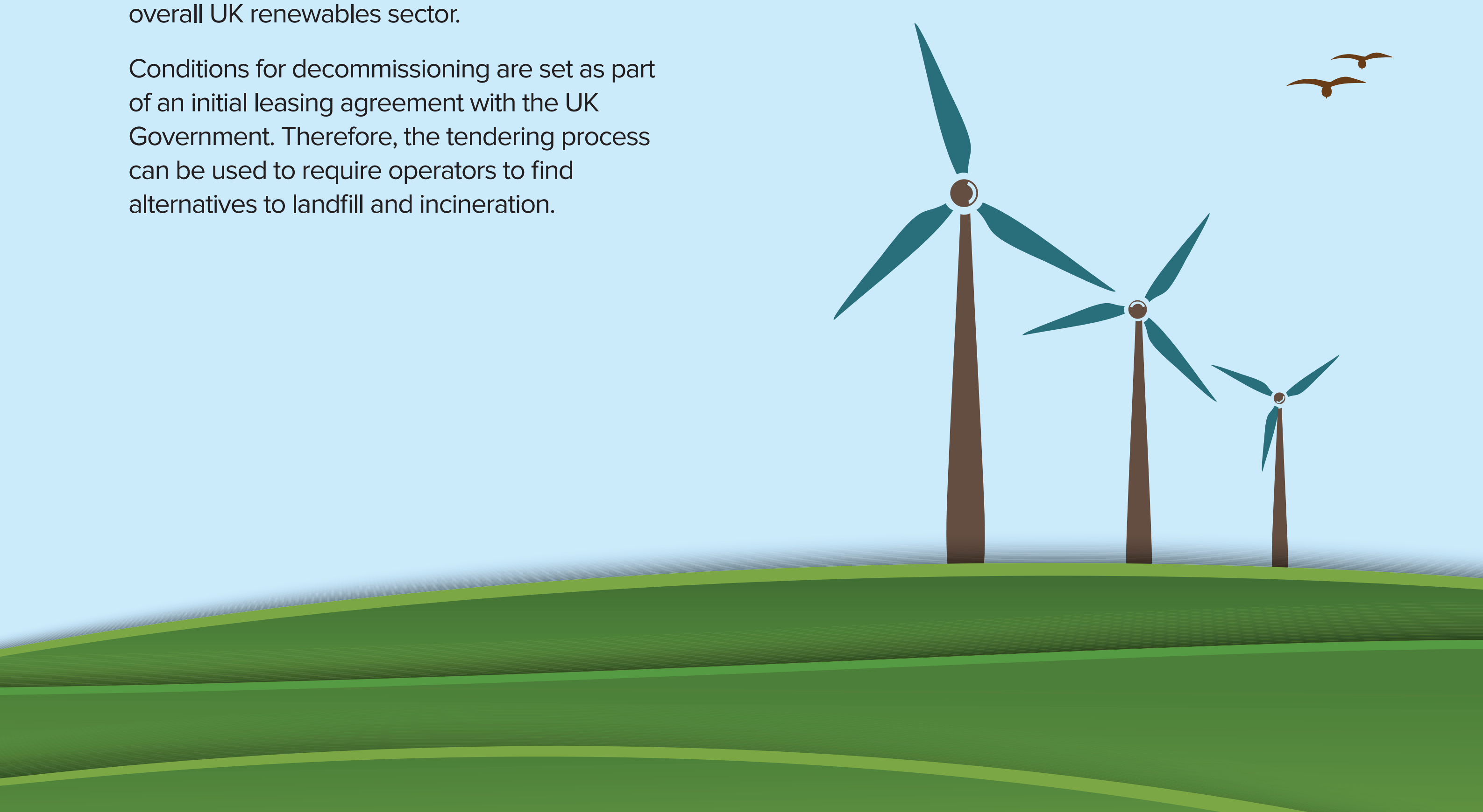
The UK Government's main mechanism for supporting low-carbon electricity generation, known as the Contracts for Difference (CfD) scheme, currently only considers the cost of projects. The scheme, which is to be reviewed in 2023, could be amended so that it (or its successor) also includes an assessment of whole life carbon impacts as well. This is a reserved matter but the Scottish Government is well placed to influence the design of CfD, given the importance of Scottish projects to the overall UK renewables sector.

Conditions for decommissioning are set as part of an initial leasing agreement with the UK Government. Therefore, the tendering process can be used to require operators to find alternatives to landfill and incineration.

Whilst voluntary standards have a history of over-promising and under-delivering, Vattenfall has set a target to achieve a 50% recycling rate of wind turbine blades by 2025, and 100% by 2030, by self-enforcing a landfill ban on end of life blades from their wind farms.[287]

Public sector procurement

The Scottish public sector currently spends over £13.3 billion a year[288] and the Scottish Government has stated their commitment to a 'sustainable procurement duty' and to ensuring public spending helps 'reduce inequalities' and 'protect[s] those who work in our supply chains'.[289] While there is currently no mention of transition minerals in procurement outcomes of the sustainable procurement duty, this is a policy area where public authorities could have a significant impact.



5 Conclusions and recommendations

Chapter key points

- Transition minerals are vital to replacing fossil fuel based energy systems but the social and environmental impacts of their extraction are significant and extensive. This is likely to increase if demand rises rapidly, as expected with current policies.

- There is evidence that lithium supplied to Scotland is being mined in harmful ways. Scotland could reduce the impacts of its lithium consumption by prioritising active and public transport over private transport decarbonisation strategies and by encouraging higher rates of lithium recycling.

- Steel comes from complex global supply chains which are socially and environmentally harmful. Demand for steel in Scotland will increase to build the wind turbines required to meet the policies set out in the Scottish Government's Energy Strategy and Just Transition Plan. Scotland can reduce the impacts of its steel consumption through demand reduction, more circular use of scrap steel and applying principles of a just transition and due diligence.

- The Scottish Government should create a resource justice strategy, which includes a just and sustainable approach to transition minerals that would be based on demand reduction, cooperation and supply chain justice. It would place the utmost importance on the lives of communities impacted by transition minerals and seek to limit as much as possible the social and environmental harm caused by their extraction.

- The resource justice strategy should also promote clear and transparent data use and establish a fair and collaborative policy process.

Transition minerals are vital to replacing fossil fuel based energy systems. While Scotland must transform its energy systems to meet its climate goals, to do so without minimising demand for transition minerals will compromise the social and environmental aims of a just transition and risk failing to deliver a renewable energy system.

There is a rising global demand for transition minerals. Critical mineral strategies, which aim to stockpile as many minerals as possible, exacerbate supply chain injustices. This approach is avoidable. Instead, countries like Scotland should aim to create transition mineral strategies based on principles of a just transition and demand reduction. Beyond issues of security of supply, a transition towards renewable energy technologies must deliver justice for impacted workers and communities across the world and minimise the environmental destruction associated with the mining and processing of minerals.

The social and environmental impacts of mining transition minerals are extensive, from human rights abuses and unsafe labour conditions to carbon intensive extraction techniques, water pollution and biodiversity loss. This report has focused on injustices in the lithium and steel supply chains but there is overwhelming evidence that many transition minerals have similar issues. From the dispossession and rights abuses of Indigenous land owners in Indonesia, to the toxic impacts associated with rare earth mining in China, the renewable energy technologies critical to the energy transition carry heavy social and environmental costs. Despite having a responsibility to respect human and environmental rights, mining companies are not doing enough to minimise these impacts.

Lithium supplied to Scotland can be traced back to the main global producers of lithium: Australia and Chile. Processing often takes place in China and lithium-ion batteries used in Scotland are manufactured in China and Germany. Chilean lithium extraction is associated with violations of the rights of Indigenous communities, labour exploitation and high levels of water depletion.

Hard rock lithium mining in Australia is also highly environmentally damaging and disruptive to local communities.

Projections of increased lithium demand are closely tied to the expected expansions in electric car ownership rather than energy storage and public transport vehicles. Reducing car ownership rates could therefore greatly limit any potential increase in lithium demand. Increasing reuse and recycling rates of lithium can also offer significant savings.

Global steel supply chains are vast and complex. Steel supplied to Scotland is extracted, as iron ore, from many countries, including Brazil where issues of Indigenous consent and environmental destruction are widespread and significant. Steel will be needed in increasingly large quantities in Scotland for scaling up wind turbine capacity as part of the energy transformation.

Reducing steel impacts will require material demand reduction strategies, such as ending socially harmful steel applications and unnecessary energy expansion. Reuse and recycling strategies could also reduce impacts. The development of a Scottish wind turbine manufacturing chain, centred around a Scottish electric arc furnace and supported by a publicly owned energy company, would reduce Scottish emissions globally and should be developed in a collaborative way which promotes a just transition for Scottish workers and communities.

The Scottish Government should create a resource justice strategy, which includes a just and sustainable approach to transition minerals that would be based instead on demand reduction, cooperation and supply chain justice. It would place the utmost importance on the lives of communities impacted by transition minerals and seek to limit as much as possible the social and environmental harm caused by their extraction.

The Scottish Government should situate Scottish demand for these finite resources in the context of a global just transition, including the UN Sustainable Development Goals which require ensuring electricity supply to the 770 million people worldwide who currently have no access,[290] and the transition of Global South economies as a whole to renewables.

Recommendations

The following recommendations are necessary initial steps towards the sustainable and just use of transition minerals in Scotland as it transforms its energy systems to meet its climate obligations. They are primarily aimed at the Scottish Government, and sometimes at other governments, companies and wider stakeholders, often in collaboration with the Scottish Government.

Create a Resource Justice Strategy for Scotland

The Scottish Government must create a resource justice strategy for Scotland which includes a plan for fair and sustainable consumption of transition minerals. Its aim should be to ensure Scotland's consumption of all materials is sustainable as soon as possible and no later than 2045. It should also include objectives for improving supply chain justice as soon as possible. The aim of the Scottish Government's approach to transition minerals, as part of the wider resource justice strategy, should be to ensure Scotland's consumption of transition minerals is globally sustainable and just as the energy transition progresses.

Other material policies, such as Scotland's Circular Economy Strategy and Waste Route Map, should also be part of the Resource Justice Strategy framework. Existing policies should be adapted to reflect the Resource Justice Strategy and those policies under development should embed the Strategy's overarching principles.

The Resource Justice Strategy should be developed alongside, and lead to the adaptation of, existing Scottish Government policies, including the Climate Change Plan, the National Strategy for Economic Transformation and, most importantly for transition minerals, the Energy Strategy and Just Transition Plan.

The Resource Justice Strategy should be based on five key pillars:

1. Commitment to a globally just material transition
2. Consumption reduction targets
3. Demand reduction policies
4. Clear and transparent data
5. Fair and collaborative policy process

1 Commitment to a globally just material transition

The Scottish Government's resource justice strategy must be embedded with principles of fairness and an overarching goal that Scottish material consumption 'does no harm' internationally, as called for by the Scottish Just Transition Commission.[291] Taking account of our disproportionate historic and ongoing contribution to the multiple environmental and humanitarian crises we are facing today, and plunder of Global South resources, it should apply the principle of reparative justice and support a global just transition. It should recognise the extensive and growing social and environmental damage done by competitive critical mineral strategies and unequal access to energy globally, and seek an alternative path of collaboration and demand reduction.

The Scottish Government must call on the UK Government to develop due diligence legislation which requires, monitors and enforces all businesses operating in Scotland and the rest of the UK that are involved with supply chains for transition minerals to respect human rights and the environment. The new legislation should require businesses to meet due diligence and public disclosure standards throughout the supply chain and provide adequate punitive measures for non-compliance.

The Scottish Government should urgently introduce due diligence guidance, which applies to all executive agencies and Non Departmental Public Bodies and encourage other businesses and services to do the same.

The Scottish Government's due diligence guidance should include:

- Respecting customary and Indigenous land rights, particularly free, prior and informed consent for Indigenous peoples, and ensuring a right to say no for non-indigenous communities;
- Committing to, and putting a framework in place for, holding mining companies responsible for clean-up and rehabilitation of mining sites and incorporate the environmental costs of mining into the price of products;
- Committing to the banning of imports of products made wholly or partially with forced labour, especially where state-sponsored repression prevents companies from conducting on-the-ground assessments of forced labour risks; and
- Committing to harmonisation of international conventions and national laws in order to respect, protect and fulfil the rights of environmental and human rights defenders who are being threatened or killed for their opposition to extractive projects.

The Scottish Government should work with the UK Government to develop legislation on mandatory due diligence measures to protect Scotland's people, communities and the environment from domestic mining exploration and expansion. Expecting people and communities in the Global South to tolerate mining practices which are deemed unsafe and harmful in Scotland is unfair and unjust. Therefore, these standards should be used as the minimum level of due diligence accepted for all minerals consumed in Scotland, whether mined domestically or imported.

Procurement outcomes should be updated to include transition minerals, as soon as possible, as this is an area where public authorities could have a significant impact. The Scottish Government should leverage public procurement by making subsidies and licences conditional on an applicant's respect for human rights and the environment in the supply chain, including an explicit commitment to abide by the OECD guidelines,[292] and give priority to companies that are able to demonstrate they conduct due diligence in line with these requirements.

The Scottish Government should work with others, including the UK Government and EU Commission, to ensure these levels of governance are aligned to the global just transition goals proposed in this report. In particular, the Scottish Government should call for the UK Government to adopt a reparative trade policy which, at a minimum, respects the rights of mineral rich states to introduce export controls, rejects Investor State Dispute Settlements (ISDS) clauses and introduces reparative grant transfers.

The Scottish Government should introduce a publicly owned energy company that can implement circular economy strategies for industries such as offshore wind, as well as driving supply chain justice.

The Scottish Government should urgently establish and enable a just transition skills and jobs pathway, developed with workers and communities, to support people moving from carbon-intensive jobs and fill gaps in skills and knowledge for new critical energy industries and sectors. The Scottish Government's plans for a digital skills passport should align training standards across the energy sector and remove training and skills barriers.[293]

Photo: Matjaz Krivic

2 Consumption reduction targets

The Scottish Government must establish robust consumption reduction targets as an urgent priority to limit the social and environmental impacts of Scottish material use. Targets are required to set the scale and pace of change needed to align with international climate goals. Scotland's proposed Circular Economy Bill is a timely opportunity to embed consumption reduction targets into primary legislation.

These targets should be science based and statutory. They must include both carbon and material targets. They should include interim targets for 2030 to ensure action begins as fast as possible. As such, the following targets must be adopted:

Carbon-based consumption targets

Scotland should reduce its global carbon footprint to zero by 2045, with an interim target of 75% by 2030, based on 1998 levels.

Material-based consumption targets

Scotland should reduce its material consumption to eight tonnes per person per year by 2045 (57% reduction), with an interim target of 13 tonnes per person per year (30% reduction) by 2030, based on 2017 levels.

The Scottish Government should align the carbon consumption target reporting mechanisms with existing domestic climate targets and reporting and scrutiny mechanisms to ensure the domestic and consumption carbon targets can be used together by policy makers to understand and reduce Scotland's carbon emissions more completely.

The Scottish Government should assess the material demand of all existing and new government policies. New policies must be aligned with the national consumption reduction targets. Existing policies should be altered to reflect the targets, if necessary. A review of energy policies should be prioritised initially e.g. material impacts of hydrogen, low carbon heating options and energy generation technology.

The Scottish Government, working in consultation with key stakeholders including workers, should set sector level reduction targets – prioritising the energy, transport, buildings and waste sectors first. Sector level targets should be designed to meet a fair contribution to the national consumption reduction targets.

The Scottish Government should include an assessment of the amount of lithium and lithium-substitute minerals required in its transport policies. This should be compared to the demands of a global just transition and science-based estimates of fair and sustainable levels of lithium consumption.

3 Demand reduction policies

The Scottish Government should encourage, invest in, and implement alternative ways to obtain raw materials both in Scotland and the rest of the world, including alternative methods of extraction, substitution, extending the life of products, reuse and recycling. In consultation with experts, it should establish an evidence-based approach to prioritising these strategies which accounts for environmental and social harm.

The Scottish Government should reduce demand for lithium-ion batteries by implementing strategies to cut unnecessary consumer consumption of products reliant on transition materials (e.g. by banning disposable vapes), investing heavily in public transport and setting ambitious targets to reduce car ownership levels. It should explore opportunities and consider how to overcome barriers for developing lithium recycling in Scotland, which could meet local demand in a circular and proportional way.

The Scottish Government should develop and invest in the domestic supply chain for wind turbine production, assembly and disassembly based, as much as possible, on locally sourced recycled materials e.g. steel from decommissioned oil and gas rigs. This should include the development of an electric arc furnace, and be taken forward under sectoral and regional just transition planning.

The Scottish Government should fund and support collaborative research and development programmes between industry and academia focussed on the development of innovative ways of improving material efficiency policies revolving around material choice and end-of-life management. Technologies developed should be freely shared with mineral rich nations.

The Scottish Government should direct the Scottish National Investment Bank to support companies which have committed to low impact materials supply chains, just and fair conditions for communities and workers involved in the supply for transition minerals. Companies promoting circular economy solutions should only be supported if they can demonstrate carbon and material savings in line with national consumption reduction target requirements.

Extended Producer Responsibility (EPR) schemes are an important tool in minimising demand by moving the cost of clean up to producers and thereby incentivising them to reduce this. Both batteries and wind turbines are examples of products which EPRs could be developed for. Whether EPRs for specific products or product groups are most usefully done at the Scottish or UK level should be urgently explored.

4 Clear and transparent data

The proposed strategy should include improved data collection and transparency, as well as a pragmatic approach to data which accepts its limitations and allows it to be updated, while allowing sustainable material strategies to be prioritised. For example, the current and expected demand of key transition minerals, including lithium, should be individually tracked and compared to target levels (in tonnage and carbon units). This should be reported annually and publicly.

There is a need to track Scottish specific trade data more comprehensively, e.g. intra-UK trade and for trade data to be reported more specifically in order to track material flows. Improving intra-UK trade data will require better coordination between all UK governments, which the Scottish Government should encourage. On an international level, the Scottish Government should report on the same import categories that the United Nations do and urge the UK Government to do the same. Companies should be required to track and transparently report on their supply chains.

5 Fair and collaborative policy process

The Scottish Government should draw on international expertise to guide Scotland towards its goal. This should include expertise on the social and environmental impacts of transition minerals.

The Scottish Government should create an advisory body in consultation with key stakeholders, prioritising affected communities, workers and their trade unions, as well as consumers and industry. The Scottish Government should prepare and consult on a plan for managing Scottish wind turbines decommissioning as early as possible. There may be synergies between wind turbine and oil and gas decommissioning which could be optimised if the plans are linked by the Scottish Government.

The Scottish Government should be required to measure and report on progress towards the resource justice strategy and transition mineral goals at suitable time intervals, preferably annually. Progress should be measured against implementation, through a robust and publicly reported monitoring and evaluation framework.

These recommendations must be adopted urgently and completely to allow Scotland to work towards a more sustainable and fairer future for all, where material consumption is minimised. Without proper consideration of the social and environmental damage created by the extraction and consumption of transition minerals, and materials more widely, it is impossible to meet international climate goals and the goal of a global just transition on which our collective future depends.

Technical Annex

A1. Lithium requirements for decarbonising Scotland's transport system

2.5 million fossil fuel cars operated in Scotland in 2019

Transport Scotland, Scottish Transport Statistics No. 39 2020 Edition, Chapter 1, 2021
https://www.transport.gov.scot/publication/scottish-transport-statistics-no-39-2020-edition/chapter-1-road-transport-vehicles/

4,400 fossil fuel buses operated in Scotland in 2019

Transport Scotland, Scottish Transport Statistics No. 39 2020 Edition, Chapter 2, 2021
https://www.transport.gov.scot/publication/scottish-transport-statistics-no-39-2020-edition/chapter-2-bus-and-coach-travel/#tb21a

An electric car uses 8 kg of lithium per vehicle and an electric bus uses 44 kg

Climate and Community Project, Achieving Zero Emissions with More Mobility and Less Mining, 2023, p.19
https://www.climateandcommunity.org/more-mobility-less-mining

In Scotland in 2020, the proportion of journeys by bus was 7% and cars 65%, in London public transport journeys are 30% of all journeys

Transport Scotland, Scottish Transport Statistics No. 39 2020 Edition, Table S3, modal share of all journeys by Scottish households, 2021
https://www.transport.gov.scot/publication/scottish-transport-statistics-no-39-2020-edition/summary-transport-statistics/

Hong Kong Transport and Housing Bureau, Public Transport Strategy Study, 2017
https://www.td.gov.hk/filemanager/en/publication/ptss_final_report_eng.pdf

Proportion of journeys by bus (%)	Proportion of journeys by car (%)	Number of buses on the road	Number of cars on the road	Lithium requirement (tonnes)
7%	65%	4,400	2,500,000	20,194
30%	42%	18,857	1,615,385	13,753
50%	22%	31,429	846,154	8,152

End Notes

1 While steel is not a mineral, it is mainly made from iron ore, which is. For clarity and brevity throughout this report we will occasionally refer to steel as a mineral.

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