Scottish Science Advisory Council

The Environmental Impacts of the Scottish Manufacturing Industry

This report summarises the opportunities and challenges for decreasing greenhouse gas (GHG) emissions associated with the Scottish manufacturing industry.

Contents

SUMMARY

This Scottish Science Advisory Council (SSAC) report summarises the opportunities and challenges for decreasing greenhouse gas (GHG) emissions associated with the Scottish manufacturing industry, providing practical recommendations in support of Scotland's target of Net-Zero emissions by 2045 and generation of opportunities for the sector to thrive in a sustainable way. The report will help to inform the Scottish Government Making Scotland's Future programme and the National Manufacturing Institute Scotland (NMIS) programme.

The primary recommendations are provided below with **recommendations PR9 to PR11 considered immediate priorities in response to COVID-19**. The recommendations are strongly linked, and integrated with the Scottish Government Just Transition; Making Scotland's Future; and COVID-19 Green Recovery Response programmes, and the Scottish Government / Skills Development Scotland Climate Emergency Skills Action Plan programme.

1. Establish strategic pan-Scottish **coordination** of sustainable and circular manufacturing to drive the transition to Net-Zero.
2. Develop a suite of manufacturing sector **roadmaps** to Net-Zero, including resilience and supply chain, at both the general manufacturing and key sectoral levels.
3. Develop an integrated environmental impacts **training programme** for SMEs and industry targeted at supply chain opportunities and linked to Scottish Government Just Transition.
4. Identify **opportunities in supply chains** where Scotland is in a potentially strong position to lead in manufacturing in the context of domestic and global Net-Zero.
5. Integrate **circularity into the design of products**, with second life, reuse and reassembly addressed at the product design stage.
6. Review incentives and tax-based approaches holistically, and provide **support for investment in new technology** using targeted fiscal measures and incentives with loans or grants.
7. Develop an enhanced national **knowledge exchange coordination framework**, based on the existing network of support organisations, to act as a 'one-stop shop' for decision-makers in manufacturing to seek advice and to act as a central portal for signposting of funding.
8. Benchmark global best practice for **certification and standards** on environmental impacts and circularity for products and processes underpinning the future development or adoption of a recommended toolkit and Life Cycle Assessment (LCA) standard for Scotland.
9. Launch a dual initiative to tackle **resilience and environmental** aspects for responsible local production and supply.
10. Collate and develop a suite of **case studies** across selected manufacturing sectors as part of a nationwide initiative.
11. Develop an integrated **digital lean production system** integrating technologies to reduce waste and to address sustainability and supply chain resilience.

1. Introduction and Scope

The Scottish Government has a strong range of commitments towards ending Scotland's contribution to climate change and creating a fair, successful and green economy (Protecting Scotland's Future: the Government's Programme for Scotland 2019-2020[1]). In response to the COVID-19 pandemic, the Scottish Government has established the Advisory Group on Economic Recovery[2]. Reducing greenhouse gas (GHG)[3] emissions and adapting to climate change are integral to any recovery package. Climate policy can play a core part in rebuilding the economy post-pandemic (Green Recovery for Scotland)[4]. The UK Committee on Climate Change (UKCCC) has recently made recommendations to the Cabinet Secretary for Environment, Climate Change and Land Reform (Building a Resilient Recovery from the COVID-19 Crisis)[5]. Reframing of Scotland's Climate Change Plan is underway in the context of this 'green pathway' to aid in economic recovery in line with Scotland's statutory Net-Zero[6] targets. This report aims to complement these initiatives with recommendations specifically targeted at Scotland's manufacturing industry.

Negative impacts on the environment (air, land and water) are associated with most human activities, not least for manufacturing. Many solutions are already in place within the various manufacturing sectors with regulations specifically designed to ensure compliance with good practice. Our awareness of the urgency and criticality of identifying key solutions to decrease emission of GHGs associated with the manufacturing industry is more recent and the priority set by the Scottish Government is high with targets for reductions set by law.

Innovations within the manufacturing industry exist and continue to be developed but it is critical that decreases in GHGs should not be at the expense of progress made in dealing with other environmental issues. Furthermore, we know that to address the climate, and other environmental crises we face, all sectors of the economy must undergo transformational change, rather than incremental change.

The Scottish Science Advisory Council (SSAC)[7] provides independent science advice and recommendations, through the Chief Scientific Adviser (CSA) for Scotland, to the Scottish Government and to Scottish Ministers, including the First Minister. The main aim of this SSAC report is to **summarise opportunities and challenges for decreasing greenhouse gas (GHG) emissions associated with the Scottish manufacturing industry and to provide practical recommendations in support of Scotland's mission towards Net-Zero emissions and that generate opportunities for the sector to thrive in a sustainable way**. As Scotland transitions to a Circular Economy[8], it is vital that a holistic, whole-system, circular approach is central to strategic decision-making. Therefore, the report also tries to take into consideration the effects any policies, actions or technologies designed to minimise GHG emissions in Scotland may have on other environmental impacts within Scotland and beyond.

1 https://www.gov.scot/publications/protecting-scotlands-future-governments-programme-scotland-2019-20/
2 https://www.gov.scot/news/advisory-group-on-economic-recovery/
3 Greenhouse Gas (GHG) is a gas that absorbs and emits radiant energy within the thermal infrared range. GHGs cause heating of the atmosphere. Earth's primary GHGs in the atmosphere are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), chlorofluorocarbons (CFCs), and hydrofluorocarbons (HFCs).
4 https://www.gov.scot/news/climate-change-plan-update/
5 https://www.theccc.org.uk/publication/letter-building-a-resilient-recovery-from-the-covid-19-crisis-to-roseanna-cunningham-msp/
6 Net-Zero refers to achieving an overall balance between emissions produced and emissions taken out of the atmosphere.
7 https://www.scottishscience.org.uk/.
8 Circular Economy is an economic system aimed at eliminating waste and the continual use of resources. Circularity keeps resources in use for as long as possible, extracts the maximum value from them while in use, and recovers and regenerates materials at the end of life.

The report will help inform the Scottish Government Making Scotland's Future[9] programme and the National Manufacturing Institute Scotland (NMIS)[10] programme.

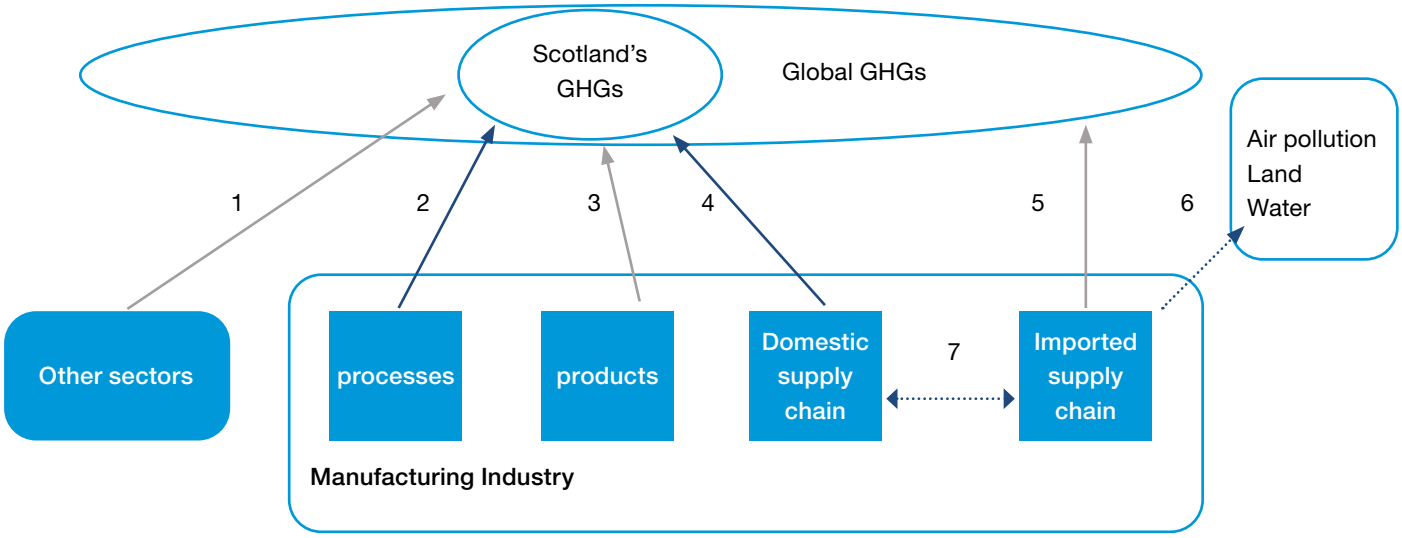
Making Scotland's Future is an integrated pan-Scottish programme to drive the sustainable growth of the manufacturing industry in Scotland and support delivery of Net-Zero emissions by 2045. The Scottish Government is working in close collaboration with key partners across business, academia and the enterprise and skills agencies. The specific aims of the programme are to lead the transformational change in the manufacturing sector, boost productivity, drive innovation and develop workforce skills to sustainably grow Scottish manufacturing capabilities and future-proof Scotland's position as a world-renowned manufacturing nation. The establishment of the NMIS in 2018 was a central initiative by the Scottish Government and its key partners towards delivery of this shared national mission.

A Working Group of experts from across academia and the public sector was formed to conduct this project (Annex A). To establish an overview of existing activities and plans towards GHG emissions and environmental impacts reduction, a literature review was conducted (Annex B). A workshop comprising key stakeholders from across a range of manufacturing industry sectors, academia and public sector agencies was also held to develop deeper insights to the challenges and opportunities ahead (Annex C). Delivery of the workshop was made more complicated by restrictions associated with the COVID-19 pandemic with the majority of the workshop attendees having to attend by videoconference. Post-workshop inputs from some sectors unable to participate on the day are also included. The SSAC discussed a draft of the recommendations in a virtual meeting and are very grateful to all those who took the time to input to the process under these challenging circumstances.

Section 4 of the report provides an overview of the practical recommendations to support the reduction of GHG emissions in Scotland with more details on each recommendation provided in Annex D (separate document - can be found at https://www.scottishscience.org.uk/publications).

9 Making Scotland's Future programme is currently under development by the Scottish Government and key partners.
10 The National Manufacturing Institute Scotland https://www.nmis.scot/

Figure 1: Project Scope



IN SCOPE

- **GHG emissions from manufacturing processes [2]**
- **GHG emissions from the domestic supply chain [4]**
- **Consideration of environmental impacts of the manufacturing industry and supply chains when reducing GHG emissions [6]**
- **Consideration that the balance between using domestic supply chain and imports influences Scotland's GHGs but it is the global total emissions that impacts the climate [7]**

OUT OF SCOPE

- **Emissions from other related sectors [1]**
- **The use of the manufactured products [3]**
- **Direct emissions from imported parts of the supply chain [5]**

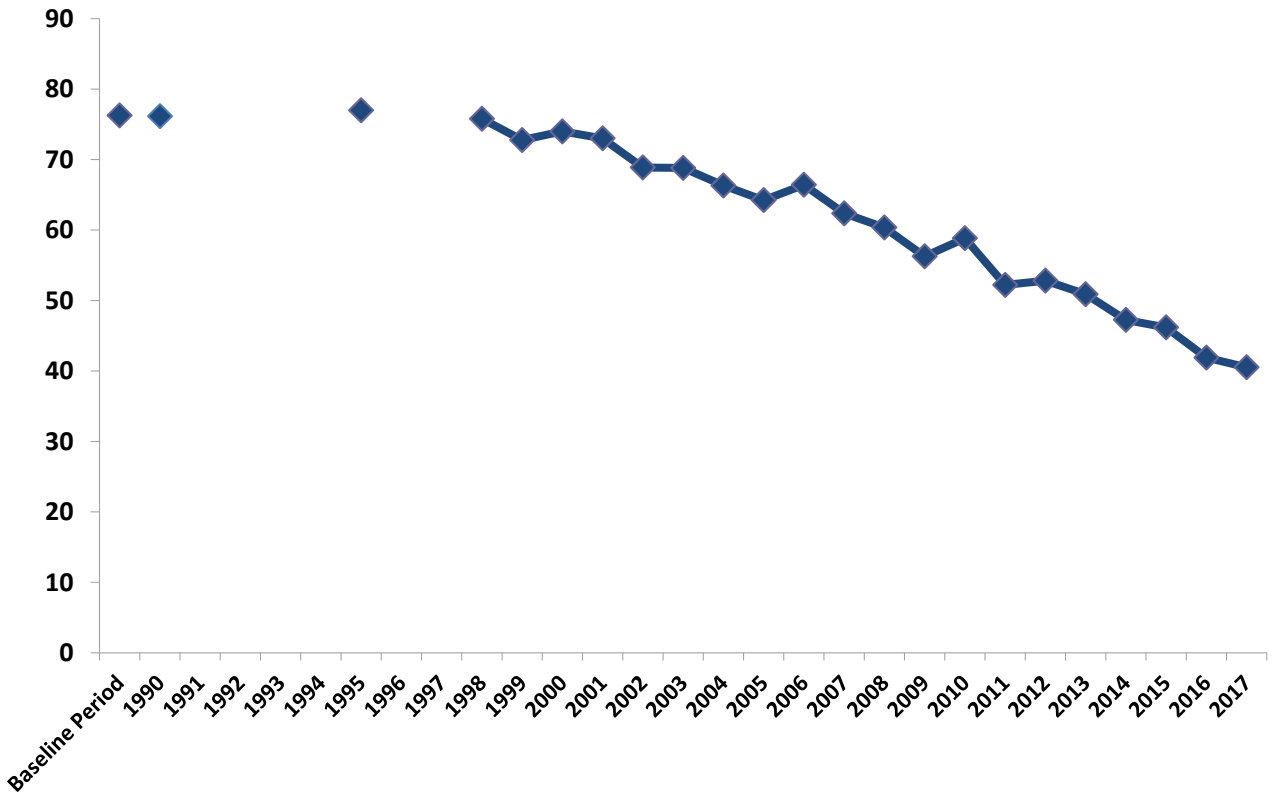
Figure 1 illustrates the project scope. Within the project scope are the manufacturing industry GHG emissions including energy and non-energy-related GHG emissions and the potential consequences of ways of decreasing those on the environment (air, land and water). The effects of increased energy efficiency, and the balance between using domestic manufacturing supply chain versus imports are also within scope. The potential for Scottish manufactured products to decrease emissions from other sectors was also considered. The emissions from the use or operation of manufactured products and the impacts of moving to renewables as an energy source for manufacturing or product operation are not within the scope of the project.

2. Scotland's Contribution to Climate Change Targets

The Scottish Government target is to reduce Scotland's GHG emissions to Net-Zero by 2045 at the latest (five years ahead of the UK), with interim targets for reductions of at least 56% by 2020, 75% by 2030, and 90% by 2040[11]. At the heart of this transition to Net-Zero are the principles of a Just Transition[12] i.e. reducing emissions in such a way as to tackle inequality and promote Fair Work.

In 2017, the source emissions[13] in Scotland stood at 40.5 $MtCO_2e$[14], a reduction of 46.8% from 1990, and 3.3% from 2016 as shown in Figure 2.

Figure 2: Scottish GHG Emissions, 1990 to 2017. Values in $MtCO_2e$. (Source - Scottish greenhouse gas emissions 2017: Estimates of greenhouse gas emissions in Scotland for the years 1990 to 2017[15])



11 The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 https://www.gov.scot/policies/climate-change/reducing-emissions/

12 Just Transition Commission https://www.gov.scot/groups/just-transition-commission/

13 Source emissions are a combination of emissions minus removals from the atmosphere by carbon sinks.

14 $MtCO_2e$ refers to million tonnes of carbon dioxide equivalent and is a consistent measure of assessing the contribution of GHGs to global warming. Equivalent means not just CO_2 emissions but includes other GHGs.

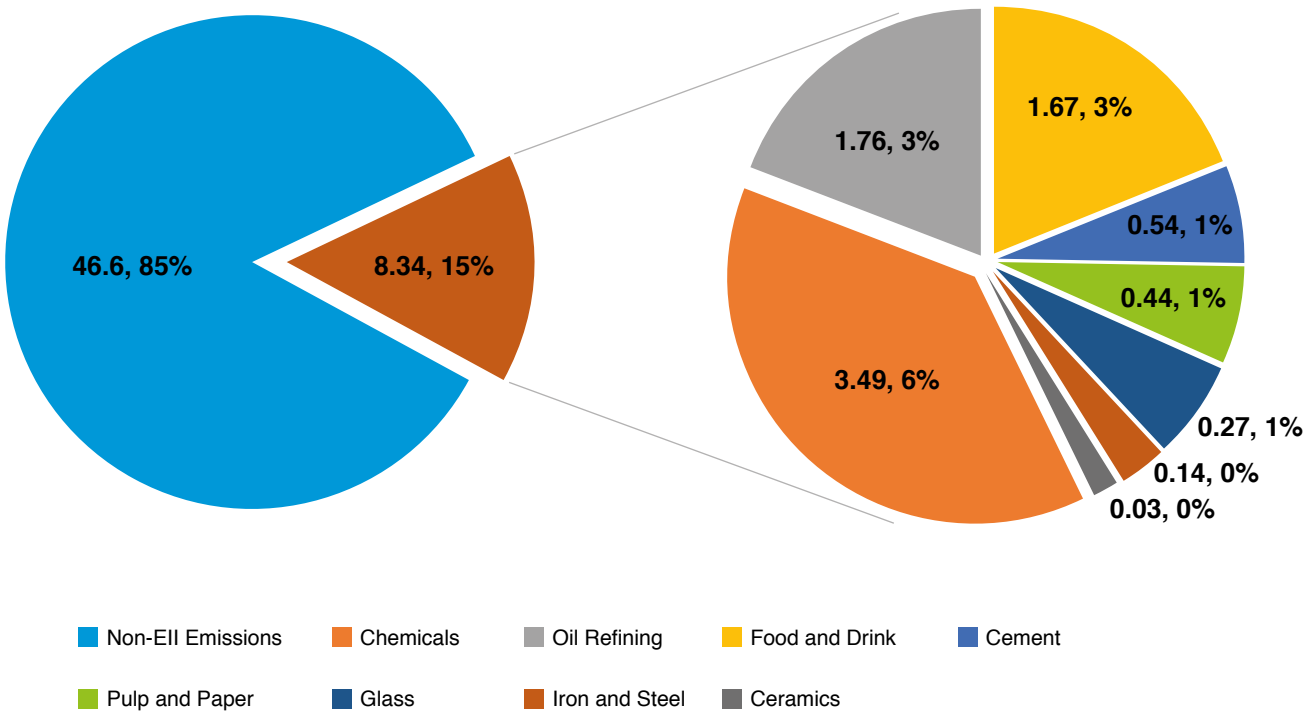
15 Scottish greenhouse gas emissions 2017: Estimates of greenhouse gas emissions in Scotland for the years 1990 to 2017 https://www.gov.scot/publications/scottish-greenhouse-gas-emissions-2017/pages/6/

The 46.8% reduction between 1990 and 2017 was mainly due to a 73.5% reduction in energy supply emissions (e.g. power stations); a 39.7% reduction in business and industrial process emissions (e.g. manufacturing); a 72% reduction in waste management emissions (e.g. landfill); and a 29.4% reduction in agriculture and related land use emissions[15].

It should be noted that European Union Greenhouse Gas Emissions Trading System (EU ETS) Adjusted emissions[16], the indicator on which the Scottish Government's statutory targets are based, increased in 2017 even though actual source emissions fell[15,17].

Some manufacturing sectors are energy intensive. The Energy Intensive Industries (EII) contributed 8.3 $MtCO_2$ (15%) of all GHG emissions (54.9 $MtCO_2$) generated in Scotland in 2012[18], as shown in Figure 3. The largest single contributor to these industry emissions was the Scottish chemical industry (42%), followed by oil refining (21%), and the food and drink industries (20%). It should be noted that the manufacturing sectors covered within this report fall into both the non-EII and EII categories within Figure 3[18].

Figure 3: Scotland's 2012 Carbon Emissions ($MtCO_2e$) (Source - Zero Waste Scotland: Industrial Decarbonisation and Energy Efficiency Roadmaps: Scottish Assessment: Summary Report[18]).



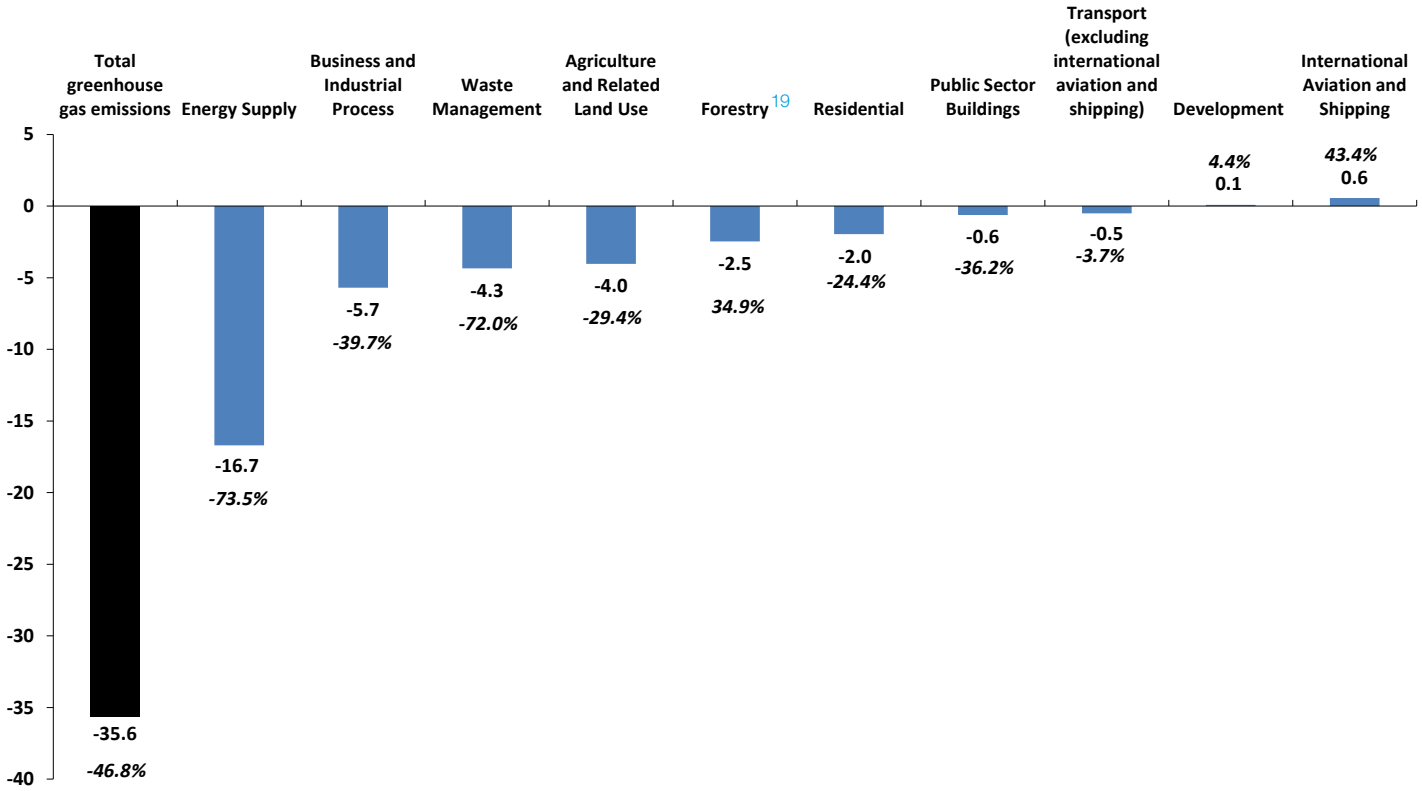
16 European Union Greenhouse Gas Emissions Trading System (EU ETS) is the largest multi-national emissions trading system in the world. Launched in 2005, the EU ETS is an EU policy aimed at mitigating climate change by limiting GHG emissions from industry sectors and aviation.

17 When emissions are adjusted to take account of trading in the EU Emissions Trading System (EU ETS), emissions increased by 3.7% between 2016 and 2017 (from 44.8 $MtCO_2e$ to 46.4 $MtCO_2e$). This is the basis against which progress towards the targets outlined within the Climate Change (Scotland) Act 2009 are measured.

18 Zero Waste Scotland: Industrial Decarbonisation and Energy Efficiency Roadmaps: Scottish Assessment: Summary Report https://energy.zerowastescotland.org.uk/sites/default/files/downloadable-files/Industrial%20Decarbonisation%20and%20Energy%20Efficiency%20Roadmaps%20Scottish%20Assessment.pdf

Figure 4 shows the change in net emissions between 1990 and 2017 broken down by sectors.

Figure 4: Change in Net Emissions by Scottish Government Sector between 1990 and 2017 - in $MtCO_2e$ and percentage changes. (Source - Scottish greenhouse gas emissions 2017: Estimates of greenhouse gas emissions in Scotland for the years 1990 to 2017[15, 19])



Business and Industrial Process (which includes manufacturing) accounts for 21% of the 2017 inventory[20], and has seen a 5.7 $MtCO_2e$ (39.7%) fall in emissions between 1990 and 2017 with much of this decrease occurring between 1990 and 1995 linked to a decline in emissions from the manufacturing and iron and steel industry over this time period[15].

19 Positive changes to net emissions from forestry are a negative percentage change because forestry causes a net removal of emissions.

20 Inventory contains GHG emissions estimates for Scotland and the UK based on five sectors: energy, industrial processes, agriculture, land-use, land-use change and forestry, and waste.

3. Scotland's Manufacturing Sector

In 2018, the Scottish manufacturing sector contributed £12.5 billion in Gross Value Added (GVA)[21] to Scotland's economy. The three largest contributions came from the beverages industry at £2.5 billion (20.0% of total manufacturing GVA), food products industry at £1.4 billion (11.5%) and repair and installation of machinery and equipment at £1.2 billion (9.8%). Together these three industry divisions accounted for around 41% of total manufacturing GVA[22].

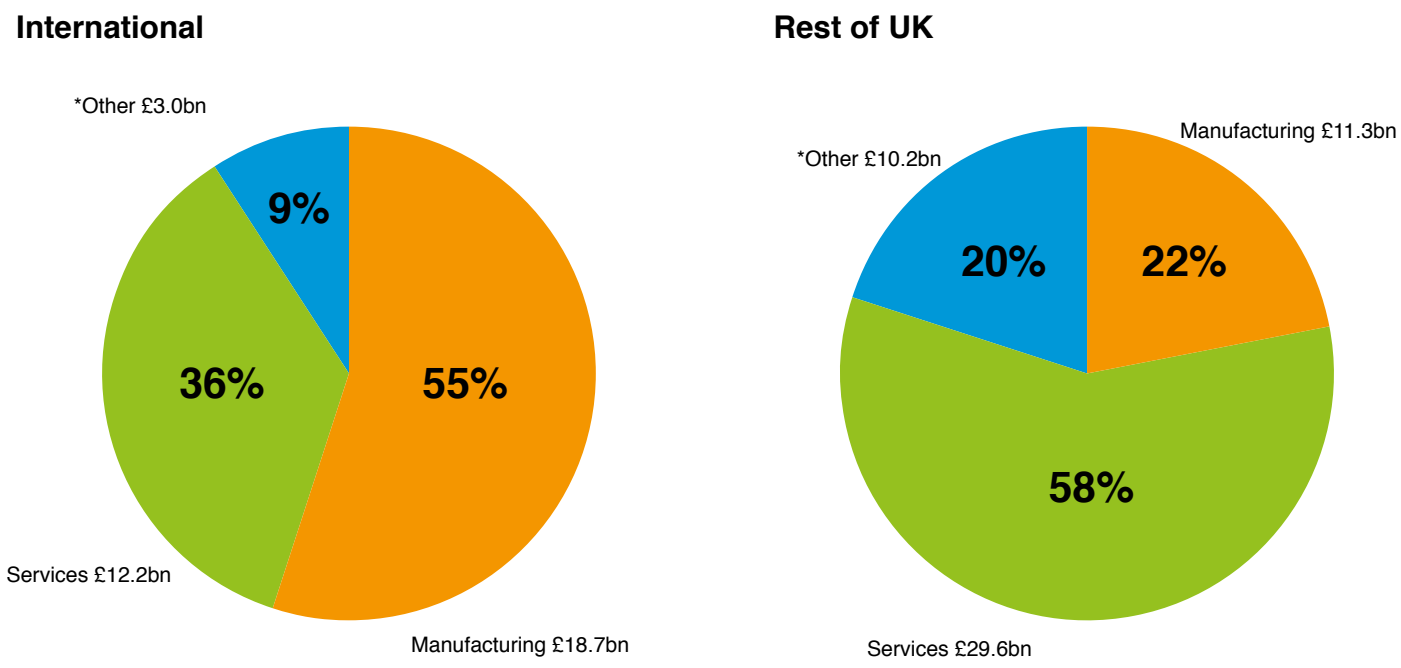
In 2018, the Scottish manufacturing industry had a total employment of 181,000 people, accounting for 6.9% of total employment in Scotland[23].

As of 2019, there were 9,645 registered enterprises operating in the manufacturing sector in Scotland. Small enterprises (< 49 employees) accounted for 91% of all enterprises, 26% of employment and 13% of turnover. Large enterprises (> 250 employees) accounted for 3% of enterprises, 48% of employment and 63% of turnover in the sector[24].

In 2017, Food and Drink was Scotland's biggest export sector accounting for a 19.6% share of exports, with Engineering and Advanced Manufacturing[25] second largest accounting for 17.6%[26].

In 2018, the manufacturing sectors accounted for 55% of all international exports compared with 22% of exports to the rest of the UK[27] (see Figure 5).

Figure 5: Scotland's Exports by Industry Type, 2018 (Source - Export statistics Scotland: 2018[27])



*Other includes Agriculture, Forestry and Fishing, Mining and Quarrying, Utilities and Construction

21 Gross Value Added (GVA) is measured as earnings before interest, taxes, depreciation and amortisation and staff costs including employers' pension and national insurance contributions.
22 'Scottish Annual Business Statistics 2018' https://www.gov.scot/publications/scottish-annual-business-statistics-2018/.
23 Business Register Employment Survey 2018 (accessed through NOMIS statistical platform)
24 Businesses in Scotland 2019 https://www.gov.scot/publications/businesses-in-scotland-2019.
25 Engineering and Advanced Manufacturing is defined here as metal manufacturing; advanced manufacturing; transport equipment; engineering services; other manufacturing.
26 Scotland: A Trading Nation Scotland: A plan for growing Scotland's exports (April 2019). https://www.gov.scot/publications/scotland-a-trading-nation/about/
27 Export statistics Scotland: 2018 https://www.gov.scot/publications/export-stats-scotland-2018/

Manufacturing in Scotland is diverse with a large proportion of SMEs and this brings challenges in raising awareness and provision of support towards Net-Zero.

For the purposes of this project, the manufacturing sector in Scotland was broken down into seven sub-sectors:

- Precision Manufacturing (e.g. photonics; quantum; medical devices; satellites)
- Medium-Scale / In-Factory Manufacturing (e.g. automotive; aerospace)
- Large-Scale Fabrication (e.g. shipbuilding; wind turbines)
- Food and Drink (including Scotch whisky)
- Chemical / Pharmaceutical
- Materials Production (e.g. metals; glass; paper; pulp; cement; ceramics)
- Textiles (including leather)

It should be noted that there are other sectors that were not included within this report. For example, oil refining and agriculture include aspects of manufacturing, but these are not considered as core manufacturing sectors and the emissions associated with these sectors have been covered in depth elsewhere[28] [29].

28 E.g. Global Energy & CO_2 Status Report 2019: The latest trends in energy and emissions in 2018 - Flagship Report (March 2019) https://www.iea.org/reports/global-energy-CO2-status-report-2019/emissions; The Greenhouse Gas Protocol, providing standards, guidance, tools and training for business and government to measure and manage climate-warming emissions https://ghgprotocol.org/about-us; there is also a move to classify oil company emissions under three 'scopes' https://compareyourfootprint.com/difference-scope-1-2-3-emissions/

29 E.g. The Future Farming and Environment Evidence Compendium (February 2018) - DEFRA https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/683972/future-farming-environment-evidence.pdf; Living with Environmental Change: Agriculture and Forestry Climate Change Impacts Report Card 2016 – NERC https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/agriculture/; Agriculture and Forestry Climate Change Impacts Report Card (August 2019) – DEFRA https://www.gov.uk/government/collections/agri-environment-analysis; Land use: Policies for a Net-Zero UK Committee on Climate Change January 2020 https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/

4. Practical Recommendations to Support the Reduction of GHG Emissions

The practical recommendations to support the reduction of GHG emissions are broken down into primary and secondary (refer to Tables 1 and 2) with primary recommendations PR9 to PR11 considered to be of immediate priority in response to COVID-19.

Figure 6 provides a high-level overview of all of the recommendations and their key links.

Annex D provides further details on each recommendation.

Table 1: Summary of Primary Recommendations

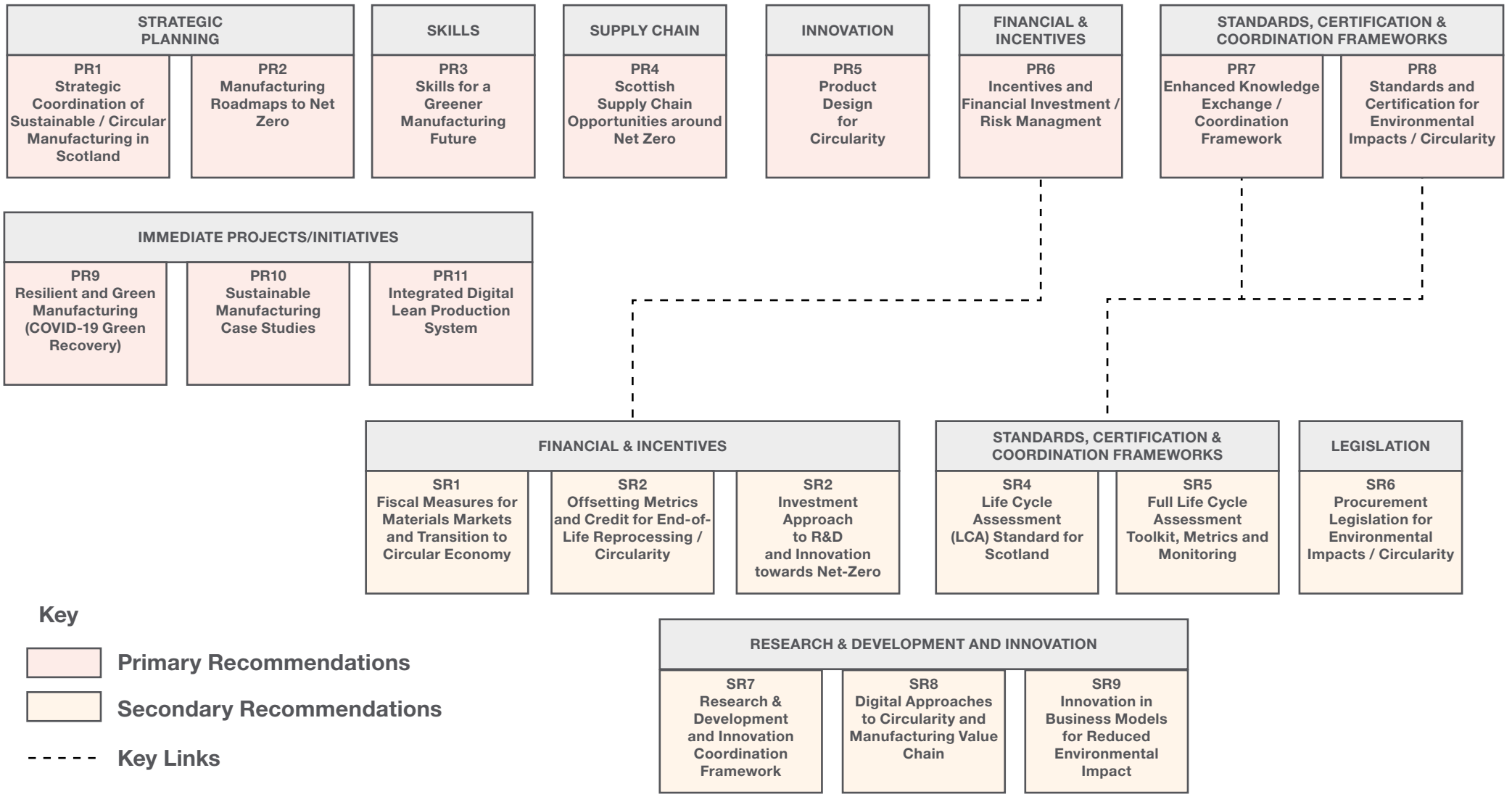
PRIMARY RECOMMENDATIONS		DESCRIPTION
STRATEGIC PLANNING	PR1 Strategic Coordination of Sustainable / Circular Manufacturing in Scotland	Urgent need to establish strategic pan-Scottish **coordination** of sustainable and circular manufacturing to drive the transition to Net-Zero. Reporting to Scottish Government Policy and with financial support required for coordination, administration and potential project delivery.
	PR2 Manufacturing Roadmaps to Net-Zero	Develop a suite of manufacturing sector **roadmaps to Net-Zero**, including resilience and supply chain, at both the general manufacturing level and at the key sectoral levels. Identify priority activities and investments with a dual focus on product and process.
SKILLS	PR3 Skills for a Greener Manufacturing Future	Develop an integrated environmental impacts **training programme** for SMEs and industry targeted at supply chain opportunities and linked to Scottish Government Just Transition. Delivered by the National Manufacturing Institute Scotland (NMIS) and developed around existing courses.
SUPPLY CHAIN	PR4 Scottish Supply Chain Opportunities around Net-Zero	Identify **opportunities in supply chains** where Scotland is in a potentially strong position to lead in manufacturing in the context of domestic and global Net-Zero. Link to Skills and to Scottish Government Just Transition.
R&D AND INNOVATION	PR5 Product Design for Circularity	Integrate **circularity into the design of products**, with second life, reuse and reassembly addressed at product design stage, and approached from both a product and process perspective.
FINANCIAL & INCENTIVES	PR6 Incentives and Financial Investment / Risk Management	Conduct a holistic review of incentives and tax based approaches covering the full product life cycle and manufacturing value chain. **Support for investment in new technology** using targeted fiscal measures and incentives with loans or grants e.g. from Scottish National Investment Bank.
STANDARDS, CERTIFICATION & COORDINATION FRAMEWORKS	PR7 Enhanced Knowledge Exchange / Coordination Framework	Develop an enhanced **knowledge exchange coordination framework**, based on the existing network of support organisations, to act as a 'one-stop shop' for decision-makers in manufacturing to seek advice and as a central portal for signposting of funding.
	PR8 Standards and Certification for Environmental Impacts / Circularity	Benchmark global best practice for **certification and standards** on environmental impacts and circularity for products and processes underpinning the future development or adoption of a recommended toolkit and Life Cycle Assessment (LCA) standard for Scotland.

PRIMARY RECOMMENDATIONS		DESCRIPTION
PRIORITY PROJECTS	PR9 Resilient and Green Manufacturing (COVID-19 Green Recovery)	Launch a dual initiative to tackle **resilience and environmental** aspects for responsible local production and supply. Form alliances with other nations with synergistic supply chains. Align this with SG COVID-19 Green Recovery Response and capture lessons learned from other sector responses to COVID-19. **PR9 considered as immediate priority in response to COVID-19.**
	PR10 Sustainable Manufacturing Case Studies	Collate and develop a suite of **case studies** across selected manufacturing sectors as part of a nationwide initiative building on the disruption caused by COVID-19. **PR10 considered as immediate priority in response to COVID-19.**
	PR11 Integrated Digital Lean Production System	Develop an integrated **digital lean production system** integrating technologies to reduce waste and address sustainability allowing Scotland and the UK to move the dial simultaneously on sustainability and supply chain resilience. **PR11 considered as immediate priority in response to COVID-19.**

Table 2: Summary of Secondary Recommendations

SECONDARY RECOMMENDATIONS		DESCRIPTION
FINANCIAL & INCENTIVES	SR1 Fiscal Measures for Materials Markets and Transition to Circular Economy	Develop and implement fiscal measures to ensure **stability of material demand** and insulate secondary from primary materials market fluctuations.
	SR2 Offsetting Metrics and Credit for End-of-Life Reprocessing / Circularity	Establish a policy for driving **tax benefits incorporating offsetting** via Key Performance Indicators (KPIs) on low carbon. Credit end-of-life reprocessing, or moving to renewable energy.
	SR3 Investment Approach to R&D and Innovation towards Net-Zero	Stimulate R&D and Innovation investment by **softening the investment boundaries between research and implementation of new technologies** towards Net-Zero whilst adopting more of a 'course-correction' approach to testing / monitoring.
STANDARDS, CERTIFICATION & COORDINATION FRAMEWORKS	SR4 Life Cycle Assessment (LCA) Standard for Scotland	Review existing Life Cycle Assessment (LCA) standards for full lifecycle analysis including end of life and supply chain (nationally and globally). Identify the most appropriate and develop a **portal for standardised LCAs** to increase accessibility for SMEs / industry, and encourage wide adoption.
	SR5 Full Life Cycle Assessment Toolkit, Metrics and Monitoring	Develop a **toolkit and standardized database** for SMEs / industry with holistic systems thinking addressing full lifecycle impacts and circularity enabling reporting and monitoring of sectoral and national trends.
LEGISLATION	SR6 Procurement Legislation for Environmental Impacts / Circularity	Embed **environmental, low carbon and circularity** considerations as key criteria and levers in **procurement** in the private and public sectors through legislation.
RESEARCH & DEVELOPMENT AND INNOVATION	SR7 Research & Development and Innovation Coordination Framework	Launch a **coordinating framework for R&D** and industry support for coordination of existing capabilities and activities across Scotland, and for identification of gaps and opportunities at a pan-Scottish strategic level.
	SR8 Digital Approaches to Circularity and Manufacturing Value Chain	Develop **digital approaches to environmental impacts and circularity** through digital twins at the planning stage. Gather data during product use, develop a framework of digital models for the manufacturing sectors and develop a digitized manufacturing value chain.
	SR9 Innovation in Business Models for Reduced Environmental Impact	Launch a **review of business models and develop a framework and tools** for enhancing optimization and reduction of environmental impacts across business processes.

Figure 6: Overview of Primary and Secondary Recommendations with Key Links



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