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Towards resource efficiency and decarbonisation

of the metal industry in Argentina

MAIN AUTHORS
Elena Brandaleze
Mariana Arrazubieta

CO-AUTHOR
Ezequiel Gaspes

CONCEPT AND COORDINATION
Stefan Landauer

Implemented by:

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IKI INTERNATIONAL CLIMATE INITIATIVE

Authors

Elena Brandaleze, Director, Department of Metallurgy, National Technological University (Universidad Tecnológica Nacional - UTN-FRSN), Argentina.

Mariana Arrazubieta, Coordinator, Department of Occupational Health, Safety and Environment, Argentine Metal Industries Association (Asociación de Industriales Metalúrgicos de la República Argentina - ADIMRA).

Co-author: Ezequiel Gaspes, External Consultant to GIZ.

Concept and coordination: Stefan Landauer, GIZ.

Collaboration and support: Filiz Jaetzold, GIZ

Contributors

Interviewees:

Dr Leila Devia, University of Buenos Aires (Universidad de Buenos Aires - UBA) - National Institute for Industrial Technology (Instituto Nacional de Tecnología Industrial - INTI).

Mr Guillermo Susini, Managing Director, Argentine Foundry Chamber (Cámara de Industria de la Fundición de la República Argentina - CIFRA).

Mr Pablo Gaspari, President, Argentine Foundry Chamber (Cámara de Industria de la Fundición de la República Argentina - CIFRA) and Manager, MEGAFUND S.A.

Mr Ricardo Fragueyro, Managing Director, Argentine Chamber of Farm Machinery Manufacturers (Cámara Argentina de Fabricantes de Maquinaria Agrícola - CAFMA).

Mr Mariano Spinosa, Managing Director, Argentine Chamber of Trailer and Semi-trailer Manufacturers (Cámara Argentina de Fabricantes de Acoplados y Semirremolques - CAFAS).

Mr Pablo Sola, Vice-President, Argentine Chamber of Trailer and Semi-trailer Manufacturers (Cámara Argentina de Fabricantes de Acoplados y Semirremolques - CAFAS), and Manager, SOLA Y BRUSA S.A.

Ms Elisa Coghlan, Directorate for Sustainable Industry, Secretariat for Industry and Productive Development, Ministry of Economy (Dirección de Industria Sostenible, Secretaría de Industria y Desarrollo Productivo, Ministerio de Economía de la Nación), Argentina (former Minister for Productive Development).

Mr Franco Ciaffardini, National Directorate for Climate Change, Secretariat for Climate Change, Sustainable Development and Innovation, Ministry for the Environment and Sustainable Development (Dirección Nacional de Cambio Climático, Secretaría de Cambio Climático, Desarrollo Sostenible e Innovación, Ministerio de Ambiente y Desarrollo Sostenible de la Nación), Argentina.

Ms Natalia Lecca, Consumption and Sustainable Production, Secretariat for Climate Change, Sustainable Development and Innovation, Ministry for the Environment and Sustainable Development (Consumo y Producción Sostenible, Secretaría de Cambio Climático, Desarrollo Sostenible e Innovación, Ministerio de Ambiente y Desarrollo Sostenible de la Nación), Argentina.

Reviewers

Argentine Metal Industries Association (Asociación de Industriales Metalúrgicos de la República Argentina - ADIMRA).

Argentine Foundry Chamber (Cámara de Industria de la Fundición de la República Argentina - CIFRA).

Argentine Chamber of Farm Machinery Manufacturers (Cámara Argentina de Fabricantes de Maquinaria Agrícola - CAFMA).

Argentine Chamber of Trailer and Semi-trailer Manufacturers (Cámara Argentina de Fabricantes de Acoplados y Semirremolques - CAFAS).

Directorate for Sustainable Industry, Ministry of Economy (Dirección de Industria Sostenible, Ministerio de Economía de la Nación), Argentina.

National Directorate for Climate Change, Secretariat for Climate Change, Sustainable Development and Innovation, Ministry for the Environment and Sustainable Development (Dirección Nacional de Cambio Climático, Secretaría de Cambio Climático, Desarrollo Sostenible e Innovación, Ministerio de Ambiente y Desarrollo Sostenible de la Nación), Argentina.

Department of Mechanics, University of Buenos Aires (Universidad de Buenos Aires - UBA).

National Technological University (Universidad Tecnológica Nacional - UTN), Argentina.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

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The project is funded through the International Climate Protection Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

The global IREK II project focuses on cooperation with selected emerging G20 countries where most of the resource efficiency challenges and opportunities are found.

It aims to contribute to the development and implementation of integrated concepts to improve resource efficiency and climate protection, with a focus on strengthening the skills of key players in the public and private sector.

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Foreword

"The metal industry presents profound challenges to effective decarbonization because of its need for reliable and high intensity energy. Developing countries which rely on metal extraction and processing are particularly sensitive to any interventions which might jeopardize their economic competitiveness in the sector. This study presents nine practical policy options for improving resource efficiency for a major extractive economy – Argentina. Lessons gleaned from this study have broad applicability and is a welcome addition to the program of work on resource efficiency and climate change conducted by the United Nations International Resource Panel. The recommendations also echo some of the findings of the Panel's earlier work on mineral resource governance with further sharpened policy advice.

The report can serve as a model for developing climate instruments in a participatory manner and integrating them into national climate plans. Because the lessons can be applied to other industrial sectors in other countries, the study is a blueprint for policymakers around the world. Each of the options is engagingly written and framed around the imperatives of impact, action, urgency, climate relevance and integration into national climate plans, making the study a must-read for climate decision-makers and consultants alike. The report is also important for developing countries with large metal industries in charting out their Nationally Determined Contributions (NDCs) under the Paris Agreement on Climate Change. The IRP looks forward to working with UN member states in furthering these goals through such science-based products to expedite policy action on climate mitigation."

Professor Saleem H. Ali
International Resource Panel, United Nations Environment Programme.

Blue and Gold Distinguished Professor of Geography and Spatial Science, University of Delaware.

https://twitter.com/saleem_ali

Reviews

"From the subsector of trailer and semi-trailer manufacture, we promote a number of initiatives and improvements, both technological and regulatory, in line with global developments in the areas of environment protection and road safety. Therefore, we believe that this paper meets and reinforces the sector's outlook, with the very important and needed implementation of financial measures that will allow the gradual replacement of these units with others that are safer and have a more efficient design under environmental considerations." **Argentine Chamber of Trailer and Semi-trailer Manufacturers (CAFAS).**

"At the Chamber we have carried out research to find an environmentally sustainable and economically viable solution to manage the foundry sand, given that there are already examples around the world of its use in other processes. This paper offers an option for this, allowing for more scope for interchange and debate on the subject." **Argentine Foundry Chamber (CIFRA).**

"This paper proposes an option to the farm machinery subsector, supporting research and development towards the manufacture of products with a better environmental performance, the use of materials that will allow reductions in the consumption of resources, and the reduction of greenhouse gas emissions. It promotes also the implementation of financial instruments for the purchase of equipment with new technologies in the Argentine agricultural sector, promoting in this way domestic production." **Argentine Chamber of Farm Machinery Manufacturers (Cámara Argentina de Fabricantes de Maquinaria Agrícola - CAFMA).**

"From an academic and scientific perspective, the National Technological University (UTN) endorses this paper, considering its subjects and scope. We think that these general and specific objectives meet the metal industry's development needs for the decarbonisation process, a commitment that we accept as a country, bringing specific measures for the global management of the environment. In addition, the analysis of the proposals exposes the situation in the metal sector and proposes measures to reduce emissions, considering also alternatives that will allow future commitments to be met gradually, integrating regulatory changes and economic measures." **National Technological University (UTN).**

"At the Department of Mechanics of the University of Buenos Aires, we value the proposals for the decarbonisation of the metal industry, given that they are focussed on different industrial process innovations, the design and application of alternative materials in domestic production, as well as the development of new products with use in the production of plant and equipment. In addition, powder metallurgy is included as an industrial alternative for reusing metal waste, which is a further contribution towards this sector's decarbonisation and recycling rate increase." **Department of Mechanics, University of Buenos Aires (UBA).**

Contents

Figures and tables

Abbreviations and acronyms

ADIMRA Argentine Metal Industries Association (Asociación de Industriales Metalúrgicos de la República Argentina)

AFIP Argentine Federal Administration of Public Revenue (Administración Federal de Ingresos Públicos)

GHG Greenhouse gases

GIZ Deutsche Gesellschaft für Internationale Zusammenarbeit[1]

INTI National Institute for Industrial Technology (Instituto Nacional de Tecnología Industrial), Argentina

IRAM Argentine Standardization and Certification Institute (Instituto Argentino de Normalización y Certificación)

VAT Value added tax

MAyDS Ministry for the Environment and Sustainable Development (Ministerio de Ambiente y Desarrollo Sostenible de la República Argentina), Argentina

ME Ministry of Economy (Ministerio de Economía), Argentina

PANIyCC National Action Plan for Industry and Climate Change (Plan de Acción Nacional para la Industria y el Cambio Climático), Argentina

PNAyMCC National Plan for Climate Change Adaptation and Mitigation (Plan Nacional de Adaptación y Mitigación al Cambio Climático), Argentina

SMEs Small and medium-sized enterprises

UBA University of Buenos Aires (Universidad de Buenos Aires)

UTN National Technological University (Universidad Tecnológica Nacional), Argentina

Abbreviations and units

CO_2-eq Carbon dioxide equivalent

Mt Megatonne

t tonne

kg Kilogramme

km Kilometre

1 As a federal enterprise, GIZ supports the Government of the Federal Republic of Germany to achieve its aims in international cooperation for sustainable development.

Glossary

Scrap dealers/processors: any person that is engaged in purchasing recyclable materials, sorting and processing them for the purpose of resale.

Circular economy: a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products for as long as possible in order to create value added. This way, the life cycle of products is extended. In practice, it involves reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy whenever possible. These can be used productively time and again, thus creating value added. This is in contrast with the traditional linear economy, mainly based on the concept of "use and throw away", which requires large quantities of cheap and readily available materials and energy[2].

Resource efficiency: in general terms, resource efficiency refers to the general objectives for decoupling: increasing human well-being and economic growth, whilst reducing the requirement of resources and the negative impacts on the environment associated with the use of the resources[3].

Secondary raw materials: these are recycled materials that can be used in production processes instead of or together with virgin raw materials.

Recycling industry: industrial businesses that carry out the physical, chemical or physico-chemical transformation of the form or essence of recyclable materials through an industrial process, using machinery and equipment, and obtaining from this process a raw material or a new product.

Trade-in plan: a programme to encourage the removal of obsolete vehicles from circulation, with grants for the purchase of a new unit with the handover of the obsolete vehicle.

Sustainable production: a model of production of goods and services that minimises the use of natural resources and the generation of toxic materials, waste and polluting emissions, by promoting a production management strategy that integrates environmental considerations through the prevention of pollution and an efficient management of resources[4].

Industrial symbiosis: a tool in the model of the circular economy that promotes sustainable growth and an increase of resource efficiency. This is achieved by setting synergies for interchanges and uses between industries that will produce a beneficial relationship for the industries involved[5].

2 European Parliament, https://www.europarl.europa.eu/news/es/headlines/economy/20151201STO05603/economia-circular-definicion-importancia-y-beneficios
3 International Resource Panel, https://www.resourcepanel.org/es/glosario
4 MAyDS https://www.argentina.gob.ar/ambiente/desarrollo-sostenible/produccion-sostenible
5 Hurtado Ruiz A., Jordá Ferrando L., http://www.conama.org/conama/download/files/conama2018/CT%202018/222224264.pdf

Summary

The main focus of this paper is analysing the Argentine metal industry and proposing measures to contribute to resource efficiency and decarbonisation in this sector.

Its development is part of the global Initiative for Resource Efficiency and Climate Action project (IREK II), that the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is leading as part of the intergovernmental cooperation between Argentina and Germany. The objective is to contribute to the discussion on public policies, leading to a more decarbonised industry by the application of strategies for the efficient use of resources.

It is important to make clear that, given the breadth and diversity of the value chain in the metal industry, this paper is focussed on three subsectors. Regarding the production of ferrous and non-ferrous metals, only foundries are considered, and in the production of plant and equipment, only the industries producing trailers, semi-trailers and farm machinery are considered.

The paper presents a description and an analysis of the evolution of the metal industry over time. In addition, it shows the current situation in the selected subsectors, based on the information obtained. It considers the factor of sustainability in some production processes and identifies barriers and opportunities in the sector.

This work has led to making a proposal that considers nine measures, identifying theirs players in the public sector, the private sector, and the academic and research sector, amongst others. In a collaborative approach, each measure has been validated considering its feasibility.

These measures deal with legal, technological and economic aspects, intending to advance towards public policies that will drive the development of a metal industry that is efficient in the use of resources and decarbonised.

Introduction

TOWARDS RESOURCE EFFICIENCY AND DECARBONISATION OF THE METAL INDUSTRY IN ARGENTINA

1. Introduction

This paper is part of the Initiative for Resource Efficiency and Climate Action project (IREK II) by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, which focusses on proposing measures for an efficient use of resources considering strategies such as: recycling, technological development for design and selection of alternative materials, increase in the use of secondary raw materials, with emphasis on greenhouse gas reduction.

The metal sector in Argentina is huge and is made up of different industries producing ferrous and non-ferrous metals with different production volumes, industries that process semi-finished and finished products in different alloys, manufacturers of plant and equipment: machinery, tools, equipment, trailers, semi-trailers, farm machinery, automotive components, amongst many other metal products. It is an essential element of the productive fabric of the country, not only for its technology and value added, but also for its interlinking with other industrial sectors.

As previously stated, this paper covers mainly the subsectors of foundry, trailers and semi-trailers, and farm machinery. This selection considers the foundry industry to be an industrial link for the use of waste materials in its processes, a practical example of circular economy. Moreover, it is considered to be a strategic subsector supplying semi-finished and finished parts to sectors such as automotive, rail, oil and gas, shipbuilding, mining, water and wastewater treatment, household appliances, and capital plant, etc. This explains its large production volumes and the importance this sector has for industrial development.

Concerning the industry involved in the manufacture of trailers and semi-trailers, it is experiencing a growing demand for its equipment, which is the reason why it is identified as a growing sector. In particular, this subsector is highly relevant because of the high percentage of loads that are distributed throughout the country by road.

The farm machinery subsector is distinguished by its high willingness to drive innovation that will meet the farming sector's diverse demands in terms of types of cultivation and regional needs. This sector is holding a sustained growth and has also a presence in the international market through equipment exports.

The selection of these subsectors is based on these fundamental considerations, taking into account that they present an opportunity to make contributions that will translate into greater resource efficiency and lower greenhouse gas emissions.

The reduction of emissions proposed for the metal industry could contribute indirectly to the reduction of emissions in the transport and agricultural sectors

The proposed measures take into account the National Action Plan for Industry and Climate Change[6] (PANIyCC), with the expectation that they will contribute to its update and implementation.

Furthermore, it is estimated that the reduction of emissions proposed for the metal industry could contribute indirectly to the reduction of emissions in the transport and agricultural sectors, given that they are significant sources of emissions in the country.

Finally, it must be noted that energy consumption by the industries in the selected subsectors, although relevant to greenhouse gas emissions, is not part of this paper's scope.

6 This paper includes the mitigation measures for the industrial sector and the roadmaps that describe the possible way for implementation by 2030 to meet the National Contribution.

2. Objectives

Overall objective

Contribute to the discussion about public policies in Argentina for the development of a metal industry that is more efficient in the use of resources as it transitions towards decarbonisation.

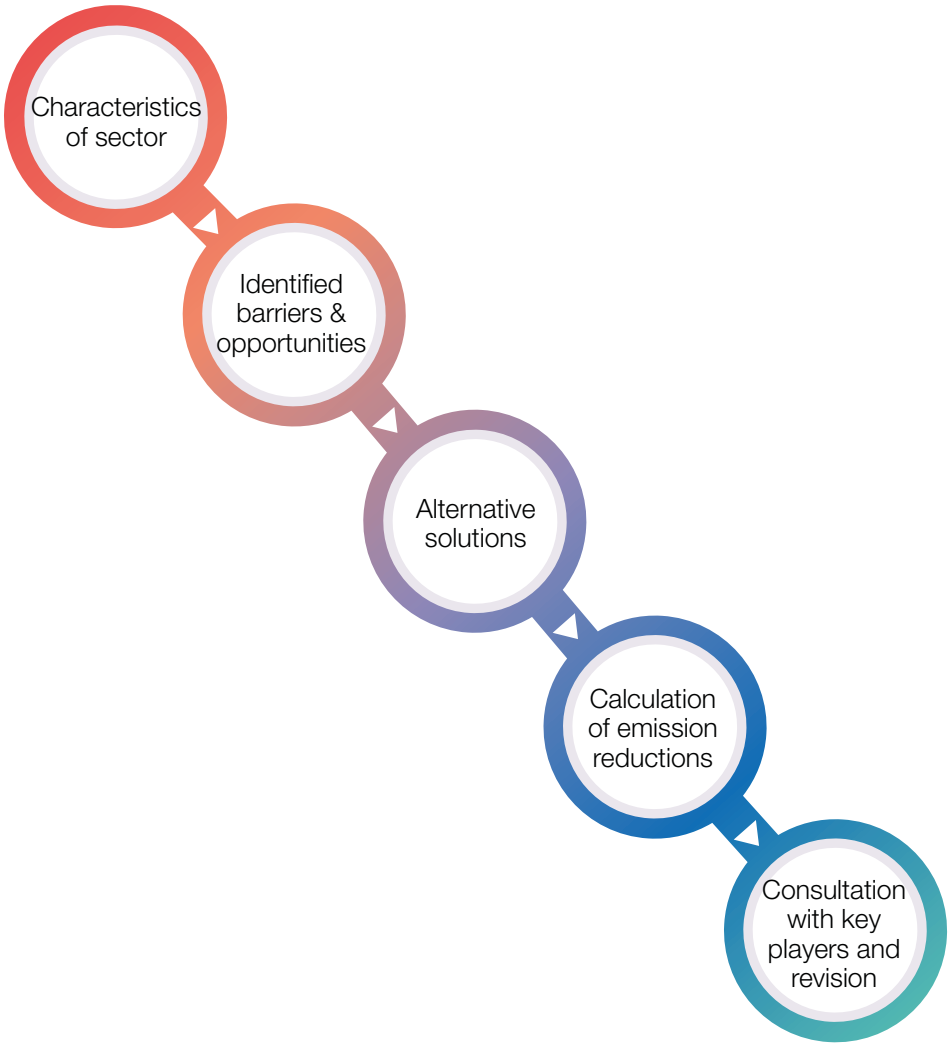
Specific objectives

- Describe the state of the metal industry in Argentina.
- Identify and validate with key players feasible measures that will contribute to the reduction of emissions and the increase of efficiency in the use of resources in the metal industry. This would be achieved with improvements in the design of equipment using alternative alloys, as well as with reductions in the use of non-renewable resources through the introduction of secondary raw materials.
- Propose the foundations for a strategy that will improve resource efficiency and reduce greenhouse gas emissions in the metal industry.

3.
Working methodology

Following the plan, the work was structured in five stages (see figure 1), starting with defining the characteristics of the metal industry and the subsectors under consideration (trailers and semi-trailers, farm machinery, and foundry). Next was identifying the problems related to greenhouse gas emissions in each subsector, making a list of possible solutions. Then, the emission reduction achievable with some of the measures was calculated, and, finally, key players were interviewed to check the feasibility.

Figure 1. ▶ **Methodology applied to carry out the work.**



Source: authors' compilation.

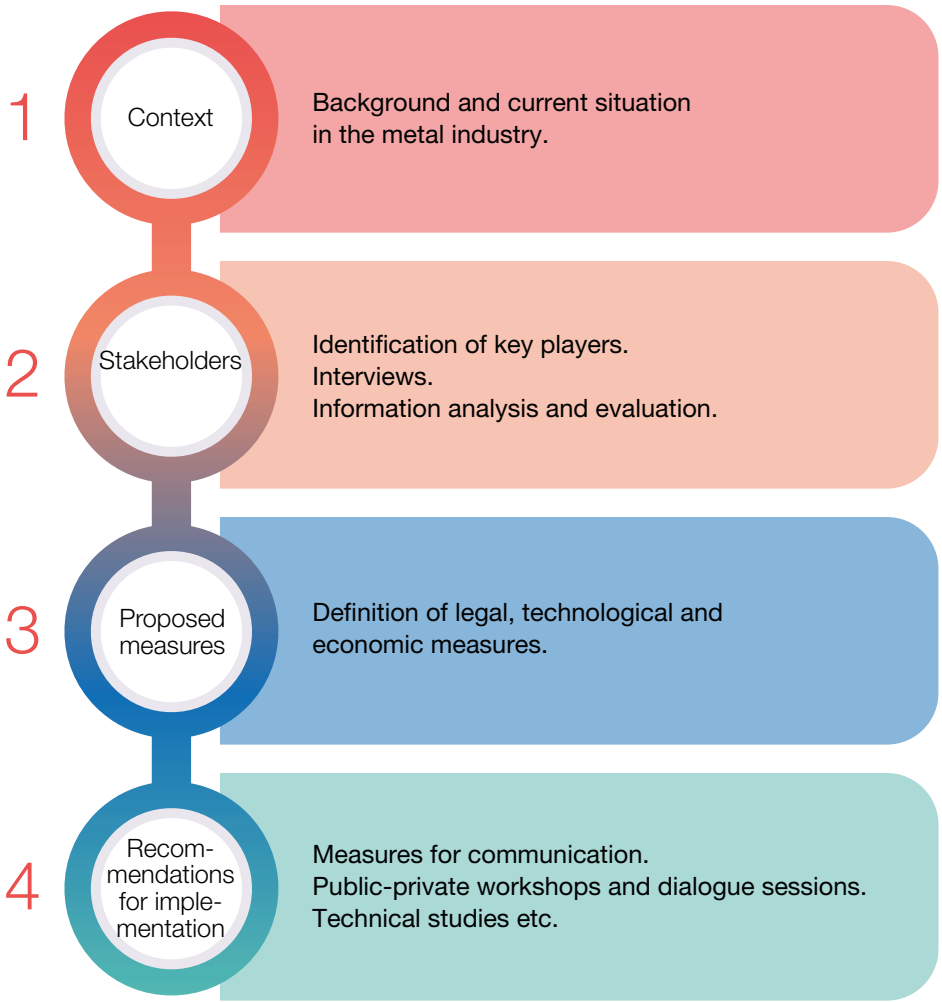
This process was carried out between February and August 2022, during which time a number of activities took place:

- Compilation of reports, publications, research, as well as national and international technical standards and regulations.
- Brainstorming about the problems and the possible areas of improvement in the sector, in relation to greenhouse emissions and the efficient use of resources.
- Compilation of a wide-ranging list of proposals for solutions to the problems identified, as well as opportunities identified.
- Selection of nine proposed measures, in which technological, regulatory and other types of alternatives were identified.
- Calculations of the potential reductions of greenhouse gas emissions with the implementation of the proposed measures.
- Meetings and interviews with the key players (INTI, Ministry of Economy -former Ministry for Productive Development-, Ministry for the Environment and Sustainable Development, CAFAS, CIFRA and CAFMA) to discuss the work, consult on the proposed measures and obtain relevant data.
- Preparation of the draft paper.
- Process of draft paper review by the aforementioned players, as well as by key experts from academia (UTN, UBA).
- Gathering of responses and comments, followed by a review of the measures and editing of the overall paper.

4. Work structure

The structure of the proposed work for the metal industry is described in figure 2.

Figure 2. ▶ **Work structure.**



Source: authors' compilation.

1. Context. This section presents a brief description of the country, the background information about the metal industry, and an analysis of this industry. In addition, it describes the current situation in the subsectors, including information about emissions, amongst other data considered relevant to this work.

2. Stakeholders. This section identifies a number of key players relevant to this work (MAyDS, ME, CAFAS, CAFMA, CIFRA, INTI). These key players participated in interviews and in the paper's review process.

It also identifies other social players and stakeholders who are relevant to the implementation of the proposed measures, or as direct beneficiaries.

3. Proposed measures. This section includes the proposed legal, technological and economic measures to improve efficiency in the use of resources, and to contribute to the reduction of greenhouse gas emissions of this industry, describing the opportunities and the problems that the measures will tackle, the background, the beneficiaries, etc.

1. Promoting technological research and development to replace structural components in chassis of trailers and semi-trailers with lighter components made of materials that have high strength, toughness and good weldability.

2. Promoting technological research and development to replace structural components in agricultural machinery with lighter components made of materials that have high strength, toughness and good weldability.

3. Promoting economic, financial and tax incentives so that trailers and semi-trailers are gradually replaced by lighter designs and/or 3-axle units are replaced by 4-axle units.

4. Promoting economic, financial and tax incentives allowing the farming sector to replace obsolete tractors and towed equipment such as seeders with others made in the country, equipped with new technologies, lighter, and suited to the requirements of the ground.

5. Producing a technical standard to class spent foundry sands as a secondary raw material.

6. Producing a statutory regulation allowing the use of foundry sand as a secondary raw material for other production processes.

7. Producing a technical standard to class metal swarf as a secondary raw material.

8. Extending federal statutory regulations to provincial and local levels to make it easier to free up impounded vehicles for processing and use as scrap.

9. Modifying tax law to include VAT exemption for the sale of materials intended for recycling, thus promoting the recovery and recycling of ferrous and non-ferrous scrap, as well as other recyclable materials.

4. Recommendations for implementation. In this section, a number of actions such as raising awareness, communication, workshops, public-private dialogue, technical studies, etc. are suggested to promote the implementation of the proposed measures.

5.
General context

Argentina is a large country situated in South America, covering an area of 3.8 million square kilometres, and with a population of 44.5 million inhabitants, which gives an average population density of 11 inhabitants/km^2[7]. This ranks the country 32 in a total of 196 countries. 91% of the population is urban, of which 32% of the total is concentrated in the Metropolitan Area of Buenos Aires (AMBA). The country is made up of 24 jurisdictions: 23 provinces and a federal district (Autonomous City of Buenos Aires).

Farming and agro-industrial production make one of the most significant contributions to the country's GDP, as a source of employment and a generator of foreign currencies, with an important presence of exporting sectors in regional and global value chains.

With the large extension of its territory, Argentina has a wide variety of climates. It has arid and cold regions in the west and the south, whilst the centre and the north has temperate and warm regions. Within this geographical setting, climate change produces different effects: droughts in localised regions or fires that devastate large areas and alter the soil mineralisation, with the resulting decrease of permeability. In addition, variations in rain patterns cause flooding and muddy floods. This causes severe damage to regional economies. In coastal areas, the risk of sea level rise increases the risks of flooding. It is known that the main forces that drive climate change are the increases of greenhouse gas emissions such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc. The impact these gases have on the environment is linked to multiple factors: latitude, seasonal variations, soil properties, global temperature variations that affect atmospheric air currents, all having an effect on the climate change dynamics over time[8]. Based on this, there is the need for a greater knowledge of the causes of this problem and for measures that will allow the transition to a decarbonised future for the country. To this end, it is important to have the data on the current situation regarding greenhouse gas emissions in Argentina.

7 Ministry of the Environment and Sustainable Development, Argentina, Cuarto informe bienal de actualización de la República Argentina a la Convención Marco de las Naciones Unidas sobre el Cambio Climático, 2022 (Spanish), https://www.argentina.gob.ar/ambiente/cambio-climatico/cuarto-informe-bienal

8 M. Médice Firme Sá, C.E.G.R. Schaefer, D. C. Loureiro, F.N.B. Simas, B.J.R. Alves, E. de Sá Mendonça, E. Barretto de Figueiredo, N. La Scala Jr, A.R. Panosso, Fluxes of CO_2, CH_4, and N_2O in tundra-covered and Nothofagus forest soils in the Argentinian Patagonia, Science of the Total Environment, 2019, 659, 401-409, doi:10.1016/j.scitotenv.2018.12.328

The metal industry

TOWARDS RESOURCE EFFICIENCY AND DECARBONISATION OF THE METAL INDUSTRY IN ARGENTINA

6. Background information about the sector

The metal industry comprises a diverse range of manufacturing activities which, to a greater or lesser degree, use steel products and/or its by-products as raw materials throughout the production chain. Equally, the electro-mechanical and electronic sectors are part of this industry.

Its origins in Argentine date back to the early part of the 20th century, but the greater development took place between the 1930s and the mid 1970s, a period that saw the country's major industrialisation. During this period, its share of the industrial gross product rose by 167% to reach almost 40%. This led to a level of production 15 times greater and the creation of over half a million jobs[9].

Between the 1980s and the 2000s, the sector suffered an important contraction, with a significant loss of capacity for engineering and technological development. This was caused by the start of a number of structural reforms that moved the State away from production activities, the setting of strong price controls, and the limitations introduced on the external protection mechanisms which opened the doors to imports of capital plant and equipment (both equipment and technology). This was compounded by a lack of promotion of the national industry. All these changes reshaped Argentina's productive profile, where the metal industry, hegemonic before, starts to loose prominence to primary production and services. This process has a negative effect on the Argentine metal industry's share of the gross product, causing in turn negative consequences for employment, industrial development and domestic technology creation. However, a group of SMEs, especially producers of automotive and other metal components, forgings and castings, manage to overcome the various and recurring national crises, producing experienced business managers who are capable of facing up to these critical situations.

Most of these companies managed to sell part of their production to international markets before the 2001-2002 crisis. In any case, export will become a regular activity for only a small group of companies. The producers of capital equipment for the farming sector achieved the most steady exports during those years. From 2003, the industry underwent a strong recovery, reaching a maximum gross value of production in 2008. This recovery allowed this sector to increase its share of the overall manufacturing industry, despite still being below historical levels[10].

9 Argentine Metal Industries Association ADIMRA, Industria Metalúrgica Argentina, Plan Estratégico 2010-2020, 2010 (Spanish).
10 National Institute for Technological Education INET, Estudio del sector metalmecánico, 2009, (Spanish), http://catalogo.inet.edu.ar/files/pdfs/info_sectorial/metalmecanico-informe-sectorial.pdf

From 2012, the metal industry began to undergo fluctuations, with signs of stagnation. With the difficulties in the international environment, the competition for market access intensified, especially in the sectors with high value added such as capital equipment.

In 2014, the performance of the metal industry was affected by the structural difficulties facing the Argentine economy at macroeconomic level and in the sector, which demanded a strengthening of industrial policies. Between 2015 and 2019, against the backdrop of trade liberalisation and financial deregulation, industrial firms had to make great efforts to remain competitive in a very demanding market[11].

The activity in July 2022 in the metal industry registered an 8.1% increase from the previous July. With this, production has accumulated a 7.4% growth and remains above 2019 levels

During 2020, the pandemic had a great impact on production, and in line with other economic activities, the metal industry suffered an important contraction of its activity with a 10.3% drop[12].

The activity in July 2022 in the metal industry registered an 8.1% increase from the previous July. With this, production has accumulated a 7.4% growth and remains above 2019 levels. All sectors in general registered annual growth. In this respect, the sectors of coachbuilding and trailer production, capital plant and foundry work led the way to growth. However, all other sectors kept a positive trend, albeit with annual growth below the general average[13].

11 Busquet Y., Arno F., Metalurgia: el desafío de la articulación público-privada, Impresiones, Revista de la Editorial de la Imprenta del Congreso de la Nación, 2022, vol. 9, no. 5 (Spanish).
12 ADIMRA, Boletín de actividad. Actualidad de la industria metalúrgica, segundo semestre de 2020, 2021, (Spanish) https://www.adimra.org.ar/informes-y-comunicados?pager.offset=96&titulo=&area=0
13 ADIMRA, Boletín de actividad metalúrgica, julio de 2022, 2022, (Spanish), https://www.adimra.org.ar/informes-y-comunicados?pager.offset=0&titulo=&area=0

7.
Analysis of the metal industry

As part of this report, there is a need to make an exploratory analysis of the industrial sector involved in metal processing. To this end, data on economic performance, employment, value chain, etc. is presented. Equally, consideration is also given to the characteristics of the main industrial processes, products, waste and emissions that this sector's production generates.

In Argentina, the metal industry (see figure 6), excluding producers of steel in large volumes which are not included within the scope of this report, comprises approximately 24,000 production firms distributed mainly across the provinces of Buenos Aires, Cordoba, Santa Fe, Mendoza and Entre Rios, where over 92% of the firms in this sector are concentrated, according to data provided by the Argentine Metal Industries Association (ADIMRA). Of these firms, 95% are SMEs with domestic ownership. These firms represent 21% of industrial employment, with almost 243,000 direct jobs in 2019, and close to 259,000 in 2022[14].

This shows that the metal industry's direct employment amounts to 20% of the national total, which makes this industry the second largest employer after the food and drink sector. A large part of its labour force is highly qualified (engineers, technicians and skilled operators).

Currently, the sector represents 18% of GDP and is represented mainly by ADIMRA, an association that groups over 60 trade and regional chambers.

According to ADIMRA's report, international production in this sector in 2020 exceeded 11 trillion dollars annually, representing over 30 % of the world's total. The following countries are some of the most important exporting economies: China, the EU countries (of which over 50% of exports are from Germany, France, Italy and the Netherlands), the NAFTA countries (with USA leading the block), Korea and Japan. And the two most important Latin American countries in the global metal industry are Mexico and Brazil[15]. Throughout history, this industry's production has sustained the country's production growth, driving the development of the farming sector, as well as goods production and services. It is an industrial sector that produces a wide range of goods that are key to the development of economic activities. It provides industrial alloys, components, equipment and machinery, as well as tools to a variety of industries. It is a sector that is closely linked to the automotive industry, supplying it with components. It also includes producers of trailers and semi-trailers (used in transporting goods by road), farm machinery, heavy machinery (used in construction, mining, etc.), general

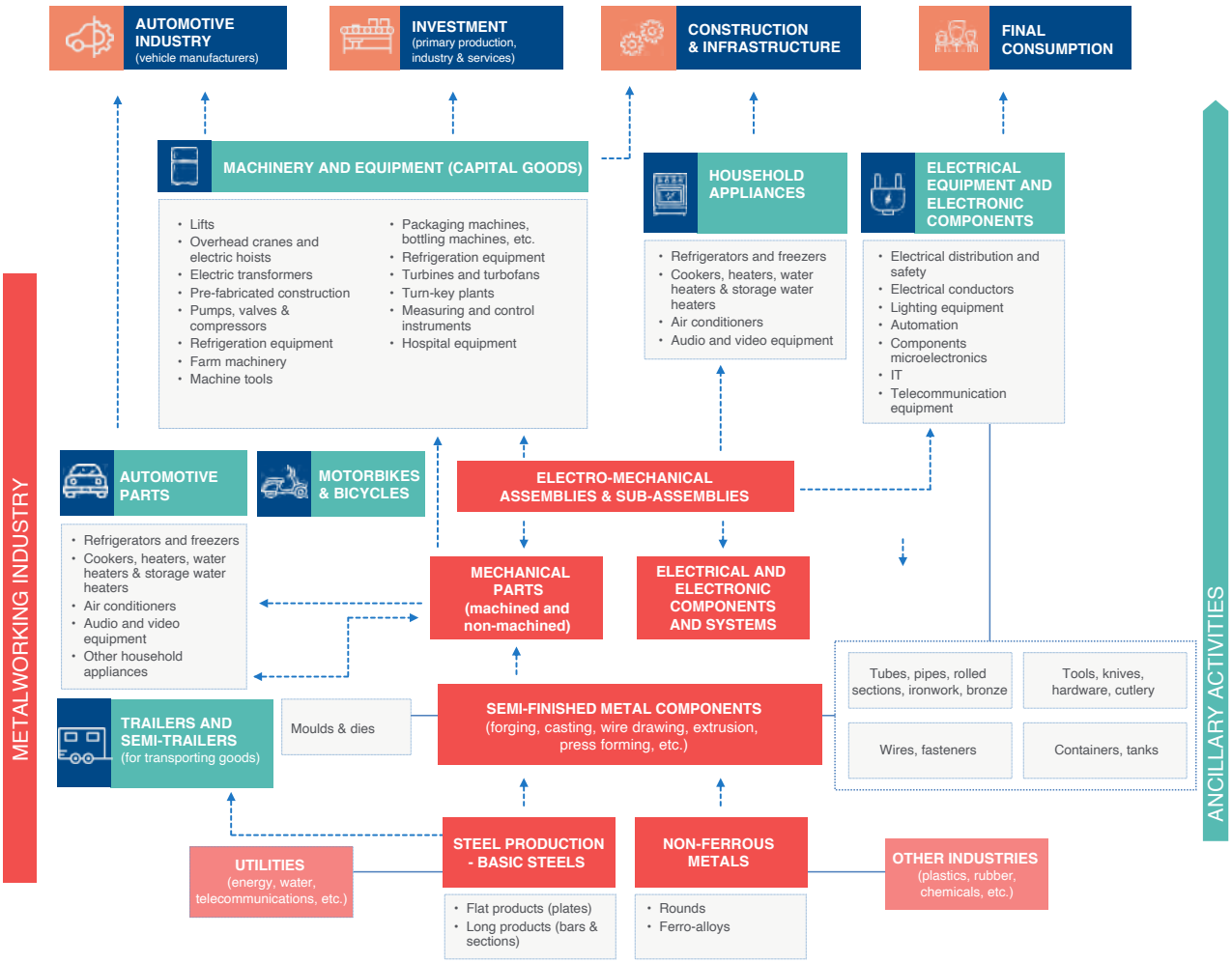
14 ADIMRA, based on data from the Observatory for Employment and Business Activity OEDE, 2019, 2022, https://www.trabajo.gob.ar/estadisticas/oede/index.asp

15 Secretariat for the Environment and Sustainable Development, Argentina, Guía para la producción sustentable en el sector metalmecánico, 2019, (Spanish), https://www.oneplanetnetwork.org/knowledge-centre/resources/guia-para-produccion-sustentable-en-el-sector-metalmecanico

mechanical equipment, components for electrical equipment, etc. Also part of this sector are the foundries producing ferrous and non-ferrous castings.

Different links can be seen in the metal industry's value chain, from steel making and foundry, through to the manufacture of products and equipment parts (see figure 3).

Figure 3. ▶ **Value chain in the metal industry.**

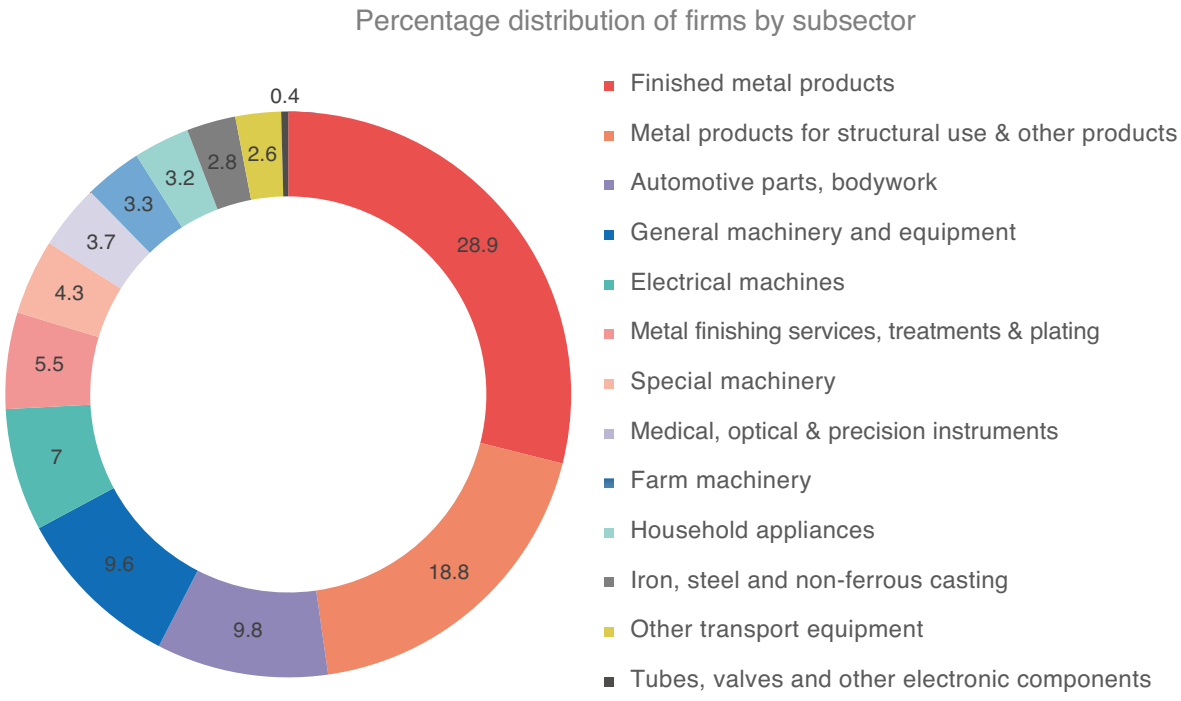


Source: Guide to Sustainable Production: Metal Processing Industry. Secretariat for the Environment and Sustainable Development - Argentina, 2019.

Considering the classification of enterprises by subsector, 67% of the manufacturing firms are concentrated in the production of metal products (28.9%), metal products for structural use (18.8%), automotive components (9.8%), machinery and general equipment (9.6%), with the rest involving production of electrical equipment, metal processing, treatment and

plating, special machinery, medical, optical and precision equipment, farm machinery, household appliances, castings, passenger and goods transport, tubes (including for uses such as deep drilling, distribution of water, gas, etc.), valves and electronic components. Figure 4 shows the percentage distribution of firms by subsector as provided by ADIMRA. Through the use of key raw materials, the activity is linked to other industrial sectors that are drivers of the economy: automotive industry, construction, transport, mining and farming.

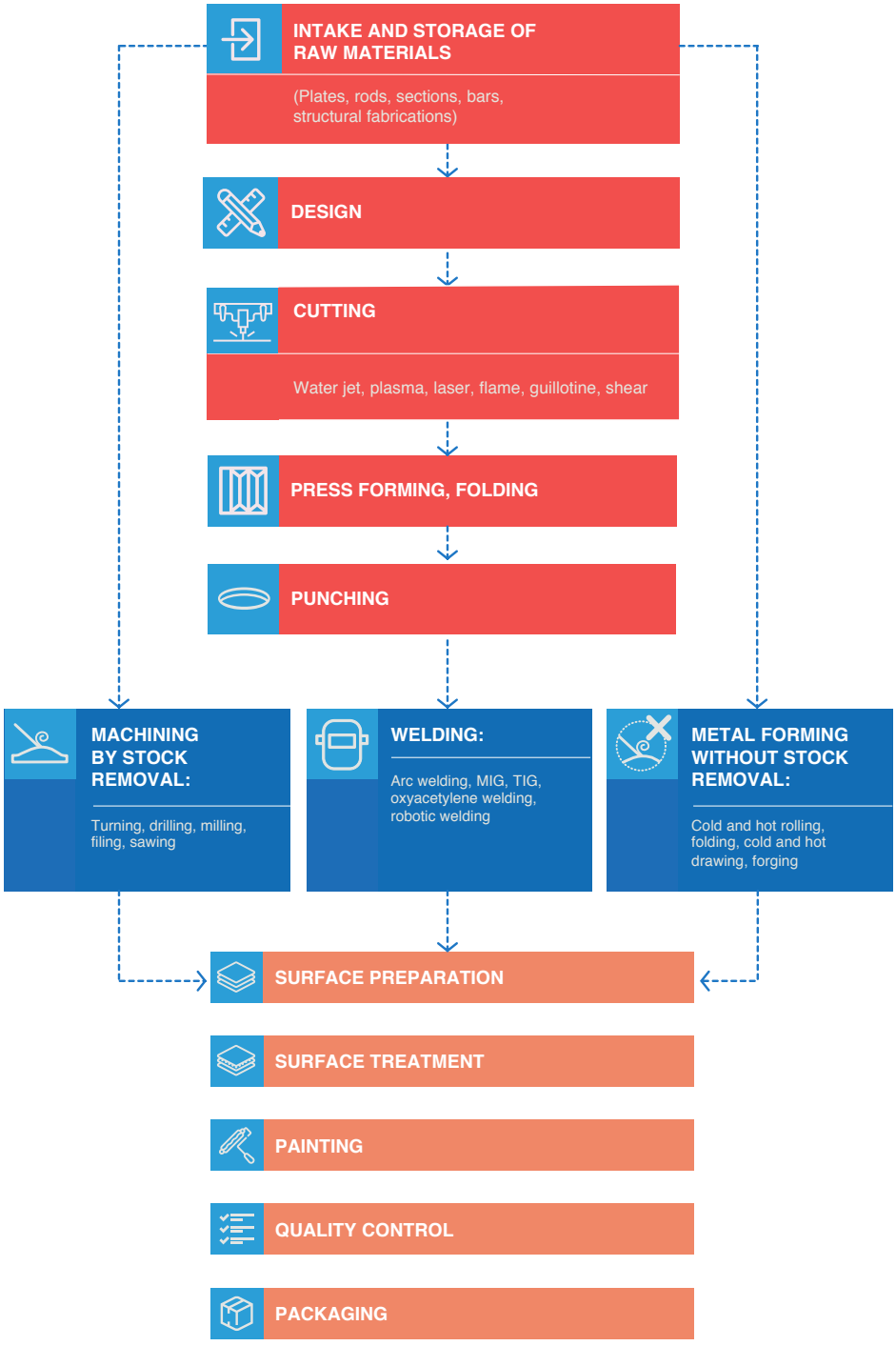
Figure 4. ▶ **Percentage distribution of companies per subsector in Argentina.**



Source: Observatory for Employment and Business Activities (OEDE), 2019.

The diversity of products and capital equipment that make up the whole spectrum of this sector involve a wide range of processes that are difficult to cover in their entirely. These processes vary and change depending on the production stages of each product, the type of raw material, and the machines and tools used. Figure 5 shows some of the basic processes that are used.

Figure 5. ▶ **Basic processes in the metal industry.**



Source: Guide to Sustainable Production: Metal Processing Industry. Secretariat for the Environment and Sustainable Development - Argentina, 2019.

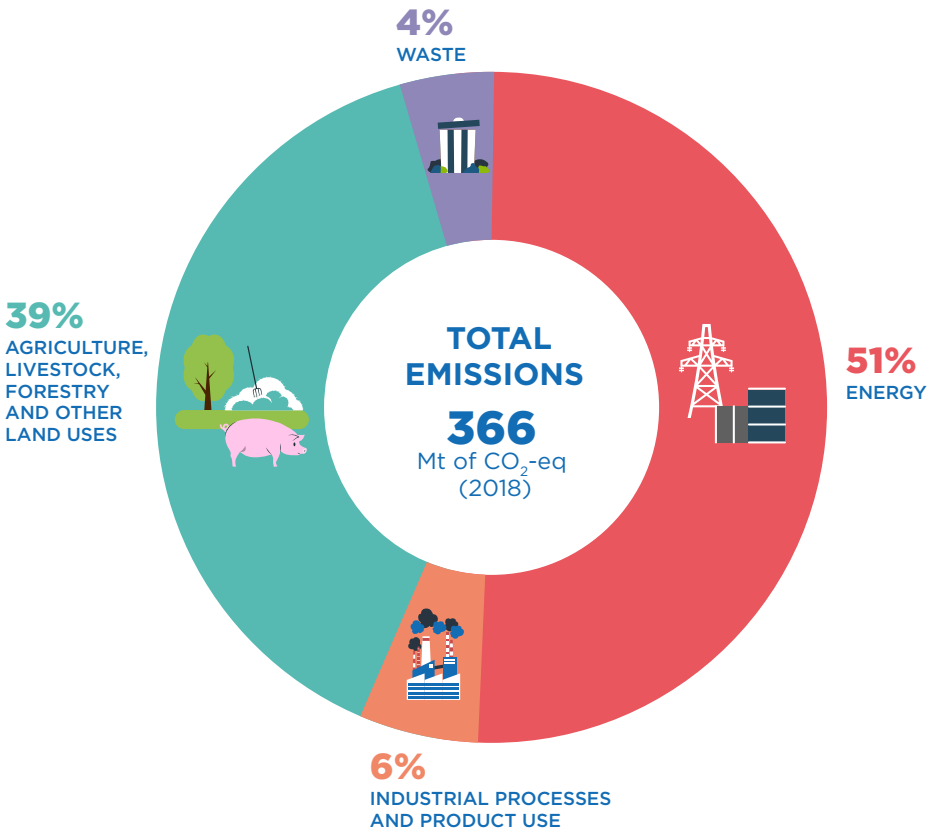
These processes generate scrap metal, waste material and swarf that can be used as secondary raw material by the same company or by other industries. Generally, companies have concerns about adapting gradually to the technological, economic and social evolution in their region, and about integrating new technologies gradually that provide production increases, keeping their products competitive in the market.

8. Measurement of greenhouse gas emissions

According to Argentina's Fourth Biennial Update Report to the United Nation Framework Convention on Climate Change published this year by the Ministry of the Environment and Sustainable Development, the country's total net emissions in 2018 have been estimated to be 366 Mt of CO_2-eq[16].

Figure 6 shows the share of greenhouse gas emissions by sector in 2018.

Figure 6. ▶ Distribution of GHG emissions per sector in 2018.



Source: Argentina's Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change, Ministry of the Environment and Sustainable Development (MAyDS), Argentina, 2022.

16 Ministry of the Environment and Sustainable Development, Argentina, Cuarto informe bienal de actualización de la República Argentina a la Convención Marco de las Naciones Unidas sobre el Cambio Climático, 2022 (Spanish), https://www.argentina.gob.ar/ambiente/cambio-climatico/cuarto-informe-bienal

As shown, *industrial processes and use of products* represented 6% of total emissions in 2018. This includes GHG emissions caused by chemical reactions during the use of GHG as a raw material in different industrial processes, as well as by non-energy use of the carbon contained in fossil fuels.

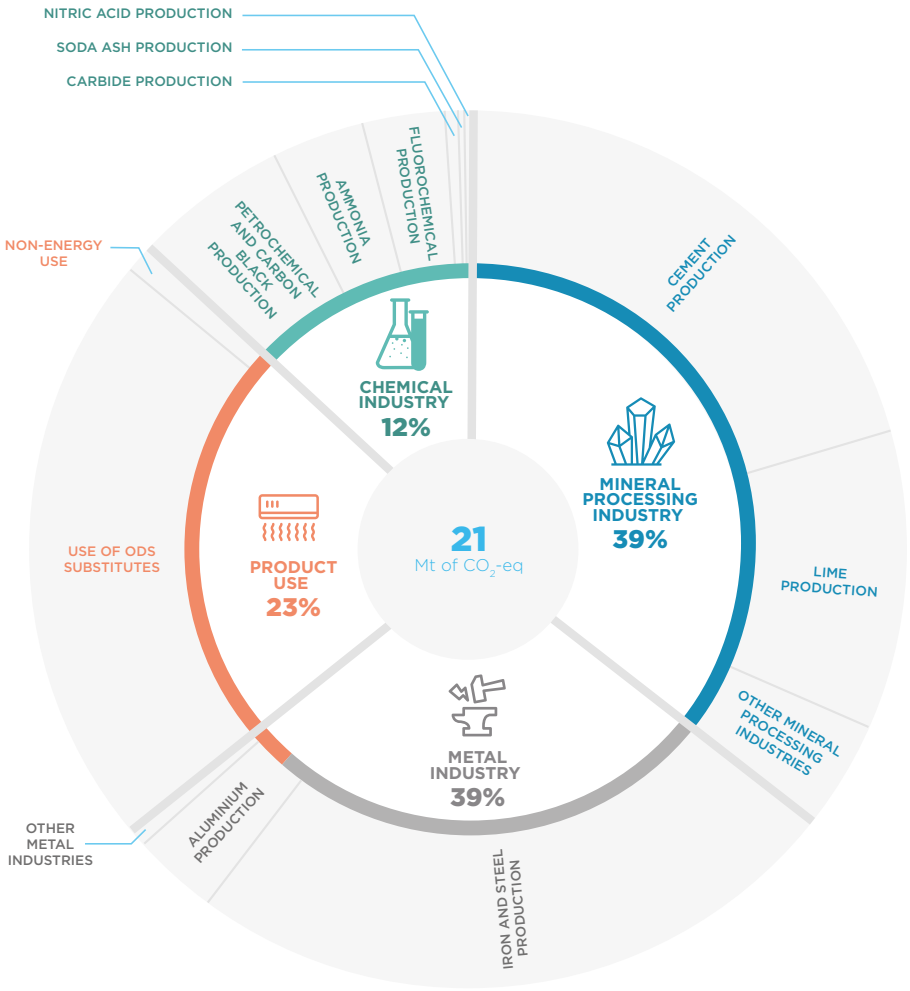
87% of emissions by the metal industry come from iron and steel production

Figure 7 illustrates the share of emissions between the main categories under *industrial processes and use of products*. One of them is the *metal industry*, which includes the production of iron and steel, aluminium and other metals, and contributes a 29% of CO_2 emissions (6 Mt of CO_2-eq from a total of 21 Mt of CO_2-eq)[17].

87% of emissions by the metal industry come from iron and steel production, whereas the emissions from the sector involved in metal processing would come under the category of *other metal industries*.

17 Ibid

Figure 7. ▶ **Emissions from industrial processes and use of product in 2018.**



Source: Argentina's Fourth Biennial Update Report to the United Nations Framework Convention on Climate Change, Ministry of the Environment and Sustainable Development, Argentina, 2022.

Although the calculation of the metal industry's total emissions has not been possible at national level, it has been possible, as part of this work, to estimate that any emission reductions in the sector would contribute positively towards achieving the mitigation target to which the country committed in November 2021, namely not exceeding net emissions of 349 million tonnes of carbon dioxide equivalent by 2030.

It is expected that the absolute target will be achieved through a number of adaptation and mitigation measures applied to the economy. These measures would be defined by working committees from the National Office for Climate Change and be integrated in the National Plan for Climate Change Adaptation and Mitigation (PNAyMCC), in accordance with the Minimum Budgets for Global Climate Change Adaptation and Mitigation Law

No. 27520/2019.

This is why it is so important to establish and apply different measures which, through the management of resources, the circular economy, and legal and regulatory frameworks, will allow the work that will contribute to achieving the objective stated in this paper.

9.
Current situation in the subsectors

Following the analysis carried out, three metal industry subsectors are selected for this paper. These three subsectors offer opportunities for improvement in the efficient use of resources that can contribute to the reduction of GHG emissions, given that, as has been mentioned previously, these subsectors have been identified as having growth potential in the industry. In this respect, in the group of metal and alloy producing industries, foundries are considered as promoters of metal recycling. This allows a reduction in the use of non-renewable resources, with the resulting reduction of these emissions. Equally, the production of castings in ferrous alloys (mainly grey cast iron, nodular cast iron and steel) and in non-ferrous alloys (ingots and components in aluminium, copper and other alloys) supplies a variety of industrials sectors.

Concerning the trailer and semi-trailer subsector, it must be pointed out that, given the large area of the country, a high percentage of goods are transported by road in Argentina, using a network that includes: 40,000 km of national roads (primary national network), 189,000 km of provincial roads, and approximately 285,000 km of municipal road (tertiary network)[18].

Transport as well as farming, produce a high proportion of the country's greenhouse gas emissions

Concerning the farm machinery subsector, it also offers an interesting potential for mitigating emissions, given that Argentina has large areas dedicated to cultivation.

As can be seen, transport as well as farming, produce a high proportion of the country's greenhouse gas emissions.

Taking into account that the target for 2030 is for emissions below 349 Mt of CO_2, these three sectors offer a significant opportunity to mitigate emissions by using different strategies, amongst them, resource efficiency.

Within the improved proposals considered for the metal industry, some measures have a direct impact, whereas others could make indirect contributions. In the first instance, the proposed contributions involve replacing parts with lighter parts made of stronger materials with the purpose of reducing the weight of trailers, semi-trailers and farm machinery. This will result in a lower use of resources, and therefore in lower CO_2 emissions. Other proposals consider promoting different measures for the replacement of parts, the renewal of obsolete equipment, the use of disused or impounded vehicles that could enter the recycling circuit as scrap, amongst other measures that will be detailed later in this paper.

Concerning indirect contributions, one such example is the lower fuel consumption in road transport, as well as in the use of farm machinery.

18 Ministry of the Environment and Sustainable Development, Argentina, Cuarto informe bienal de actualización de la República Argentina a la Convención Marco de las Naciones Unidas sobre el Cambio Climático, 2022, (Spanish).

In addition, in the latter case, there is also a lower soil degradation. It is important to note that the analysis and quantification of these emission reductions are not within the scope of this work.

Data about the trailer and semi-trailer subsector

The number of rigid and articulated goods vehicles in Argentina is 300,000 units, and they transport between 85% and 90% of the loads by road[19]. 50 % of the units, with an age over 20 years, can be considered obsolete according to the Law no. 24449/1995. A fleet of motor vehicles with this profile involves not only higher greenhouse gas emissions, but also higher risks for road safety. According to the Argentine Chamber of Trailer and Semi-trailer Manufacturers (CAFAS), 2008 reached a peak of 14,000 trailer registrations.

Since that year, the sector's national production has been keeping at around 10,000 units per year, which represents approximately 40,000 t of steel per year. An increase over time is possible, given that there is production capacity for 16,000 units[20].

Amongst the recent advances in goods transport that have made a significant impact is the Decree no. 32/2018 that has broken through the ceiling that had the maximum total gross weight per unit set at 45 t. The decree allows new types of trailers such as 4-axle trailers with a capacity of 52.5t, the semi-trailer 1+1+1 of 55.5 t, and the B-doubles of 60 t and 75 t, increasing the load capacity by between 20 and 30% with practically the same fuel consumption, which translates into an important reduction of emissions per transported tonne. These larger units must also comply with the power-to-weight ratio of 6 hp per transported tonne. This has generated a greater demand on trailer and semi-trailer manufacturers, which has produced a rise in sales.

Concerning design requirements, trailers and semi-trailers must comply with specific standards covering active and passive safety in order to be allowed on the road, and they must also be built in compliance with ISO 9001, all of which contribute to road safety. The different types of vehicles that are manufactured include: 2, 3 and 4-axle trailers, 1, 2 and 3-axle semi-trailers, low loaders, B-doubles and bodies on chassis, each in a variety of configurations and built using different materials.

Food, sand and other aggregates, fuel and farm produce and livestock make up most of the goods that are transported. However, there are currently some restrictions in place that limit the use of the larger units, particularly in some provinces and affecting mainly B-doubles. Another difficulty for hauliers is the need for access to credit to be able to replace units.

19 CAFAS, Se normaliza la industria del remolque, 2021, (Spanish), http://www.cafas.org.ar/noticias/noticia-new-14.php
20 Ibid.

Within the improved proposals considered for the metal industry, some measures have a direct impact, whereas others could make indirect contributions.

page 30

It is important to point out that the introduction of these larger units has helped sales recovery for trailer manufacturers, in some cases with 40% increases[21]. In this sector, the main suppliers make up a group of 49 firms, all of them members of the Argentine Chamber of Trailer and Semi-trailer Manufacturers (CAFAS).

Data about the farm machinery subsector

Farming has a long history in our country and is one of the main sectors linked to the production of capital equipment, exporting consistently to five continents[22]. It represents 1.6% of the gross value added generated by the manufacturing sector and 1% of the private employment in the industrial sector[23].

From the national production, the main products are seeders, tractors, harvester headers, sprayers and implements for different applications. The industrial sector is operating at around 66% of its capacity. In addition to exporting a large volume of products, it also works on developing products to replace imports. The geographical distribution of this industry is: province of Santa Fe 44%, province of Cordoba 33%, province of Buenos Aires 14%, rest of the country 9 %.

According to the Argentine Chamber of Farm Machinery Manufacturers (CAFMA), which has most of the main firms of the sector as its members, there are multinational companies with subsidiaries in Argentina that import farm machinery with different origins. However, it can be pointed out that there are approximately 30 national manufacturers of a diverse range of equipment: seeders, harvester headers, grain trailers with extractors, sprayers, ploughs, harrows, etc. Some of these manufactures are Vassalli, Apache, Ascanelli, Agrometal, Crucianelli, etc. In addition, around 8,000 tractors per year are produced in the country, for a range of uses in farming. Pauny is one of the main tractor producers, with all their production located in the country[24].

CAFMA also reports that farming machinery production includes attachments and towed equipment such as seeders, headers, baggers, etc. which is sold mainly in the country. Regarding seeders, they vary in size and are used for different grains. They can also be used in different tandem configurations to increase the seeding capacity. The weight of traditional models vary, with weights ranging between 15,700 and 17,300 kg. Due to the characteristics of the soil in Argentina, seeders must have a certain weight, but it is possible to consider the possibility of replacing some components with other lighter

21 CAFAS, Revista El Remolque, vol. 108, 2022, (Spanish), http://www.elremolque.com.ar/noticias/noticia-new-58.php
22 CAFMA, La industria de maquinaria agrícola Argentina, evolución 2002-19 y perspectivas, 2019, (Spanish),https://cafma.org.ar/web/uploads/statistics-files/4/Maquinaria%20Agr%C3%ADcola%20Nacional%202002-2019,%20Informe%20CAFMA.pdf?1594650963
23 Ministry of Treasury, Argentina, Informes de cadenas de valor; maquinaria agrícola, 2019, (Spanish), https://www.argentina.gob.ar/sites/default/files/sspmicro_cadenas_de_valor_maquinaria_agricola.pdf
24 CAFMA, Informe de coyuntura CAFMA; II trimestre de 2019, 2019, (Spanish), https://cafma.org.ar/web/uploads/statistics-files/4/Maquinaria%20Agr%C3%ADcola%20Nacional%202002-2019,%20Informe%20CAFMA.pdf?1594650963

Due to the characteristics of the soil in Argentina, seeders must have a certain weight, but it is possible to consider the possibility of replacing some components with other lighter components but with the same or better mechanical performance, reducing the weight to the minimum admissible

components but with the same or better mechanical performance, reducing the weight to the minimum admissible.

In this sector, there is an important market for farm machinery which is generally offered by different producers.

Regarding the tractor market, an average of 6,520 units have been sold annually, most of them with power ranging between 80 hp and 200 hp. Almost all the tractors produced in the country are sold in the country. The current number of tractors is estimated at 60,000, and although there is some renewal in the fleet, a large number of these units in use are obsolete. This is why a trade-in programme could be considered to prioritise the replacement of obsolete equipment with equipment incorporating lighter components. This would allow an improvement in the weight of the units, reducing fuel consumption and, therefore, reducing also greenhouse gas emissions. In the case of exports of tractors, a change in the destinations can be observed. In 2015, most of the sales were to Chile, but in 2018 destinations were more diverse and Paraguay became the main destination for these exports.

Concerning the production of farm machinery components, in general there is a group of diverse suppliers involved: those that produce components to order in accordance to specific drawings or specifications, and those that produce assemblies or sub-assemblies that are then fitted to equipment, such as headers, transmissions, seeders and harvesters, etc. together with other more standard components (tyres, rims, pumps, valves, belts and batteries). Farm machinery manufacturers in Argentina have some incentives to production such as the VAT rebate scheme, which allows the recovery of part of the VAT from the difference between the VAT on domestic sales and the VAT on the purchase of materials, parts and components used in the manufacture of these farm equipment[25]. Farm machinery manufacturers can also benefit from the capital plant investment relief scheme that gives them access to benefits such as a 90% rebate on company investments, availability of tax relief for exports, on corporation tax and on research and development up to a certain percentage[26].

Data about the foundry subsector

This subsector comprises producers of cast components, mainly of ferrous alloys (grey and nodular cast iron, cast steel), but also non-ferrous castings (aluminium, copper, bronze, etc.). It is made up of around 200 firms, most of them SMEs and members of the Argentine Foundry Chamber (CIFRA)[27].

According to the data provided by the chamber, 98% of the raw material used in the production of castings is scrap metal, most of it from the waste processing industry and from components replaced due to wear and tear.

25 Ministry of Industry and Productive Development, Régimen de devolución de saldo técnico (STI), (Spanish), https://www.argentina.gob.ar/servicio/acceder-al-regimen-de-devolucion-de-saldo-tecnico-sti
26 Decree no. 209/2022 https://www.boletinoficial.gob.ar/detalleAviso/primera/261461/20220427
27 Argentine Foundry Chamber CIFRA, http://www.fundidores.org.ar/actividades-de-la-entidad/

Concerning the production of ferrous castings, the production in grey and nodular cast iron in 2022 was approximately 80,000 t, an output at 95% of capacity. Next in size is the production of steel castings (ordinary and special steels), with a production of 6,000 t/year. In the case of non-ferrous alloys, the production is approximately 20,000 t/year for aluminium, and 3,000 t/year for copper alloys. The estimate is that this production consumes over 100,000 t/year of recycled material[28].

As part of their processes, foundries generate an amount of waste sand (spent foundry sand) that is currently managed and disposed of as hazardous waste in accordance with the National Law no. 24051/1991. However, according to some studies[29], this sand could be treated as secondary raw material for use in other processes.

28 Data provided by CIFRA, August 2022.
29 Argentine Foundry Chamber CIFRA, Utilización de arena descartada de fundición (ADF) como insumo de otro proceso, 2008, (Spanish).

10. Sustainability

Sustainability involves social, economic and environmental factors that can be integrated into an industry's strategy.

Faced with an excessive consumption of resources (raw materials and goods) and the accelerated generation of waste, sustainable production emerges as a model intended to improve products and production processes, and to reduce the consumption of non-renewable resources, the use of dangerous materials and the generation of waste[30].

Assessing the sustainability of the processes in the metal industry requires a review of the stages that generate metal waste which, for instance, could be recirculated industrially as secondary raw material. The main processes where waste is generated include:

A. **Cutting:** the different cutting operations done to semi-finished flat products (plate) and long products (sections, bars, rods, etc.) generate offcuts of a range of alloys, but mostly steel, in different shapes and sizes. In many industries, these offcuts are recovered, reaching large volumes depending on the production levels. However, the possibility of recycling them as scrap in steelworks or foundries offers an important opportunity for improving the environment, not only because recycling allows a reduction of use of non-renewable resources, but also because it reduces CO_2 emissions.

B. **Machining by stock removal:** this type of operations are carried out on semi-finished and finished products made of ferrous and non-ferrous alloys, in both the capital equipment sector and the foundry sector. Machining is done to achieve the geometry of a metal part with the required dimensions, removing stock material using machining centres, lathes, drills, milling machines, etc. The resulting swarf (ferrous and non-ferrous) can be integrated into other industries as secondary raw material, producing briquettes and recycling them in foundries, thus increasing the efficiency in the use of resources and reducing greenhouse gas emissions. Uses for other applications include powder metallurgy and metal plating, having previously degreased and pre-finished the part to the required dimensions.

C. **Melting of metal parts:** the foundries produce parts by melting metals and alloys. The main variables in this production process are the type of metal, the moulding or casting, and the melting.

   The production stages can be summarised as job planning, moulding, melting, casting, removal from the mould, and finishing.

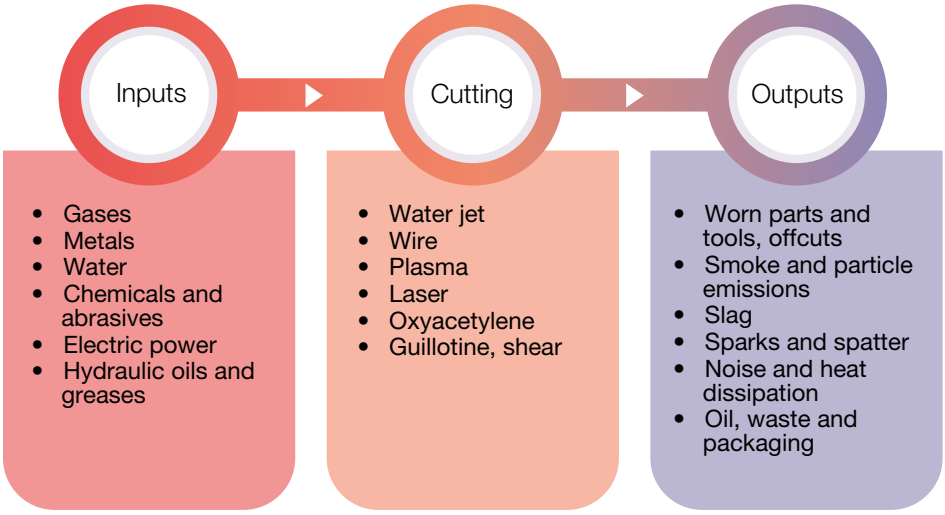
30 Secretariat for the Environment and Sustainable Development, Argentina, Guía para la producción sustentable en el sector metalmecánico, 2019, (Spanish).

Spent foundry sand comes from the moulds in which the parts are cast in ferrous and non-ferrous alloys.

Both nationally and internationally, spent foundry sand has a high potential for reuse, as is shown by the research carried out in sectors and applications such as construction and asphaltic concrete[31] [32].

A way of making a quick assessment of the possible environmental impacts of these processes is by looking at their inputs and outputs in each instance (see figures 8 to 10).

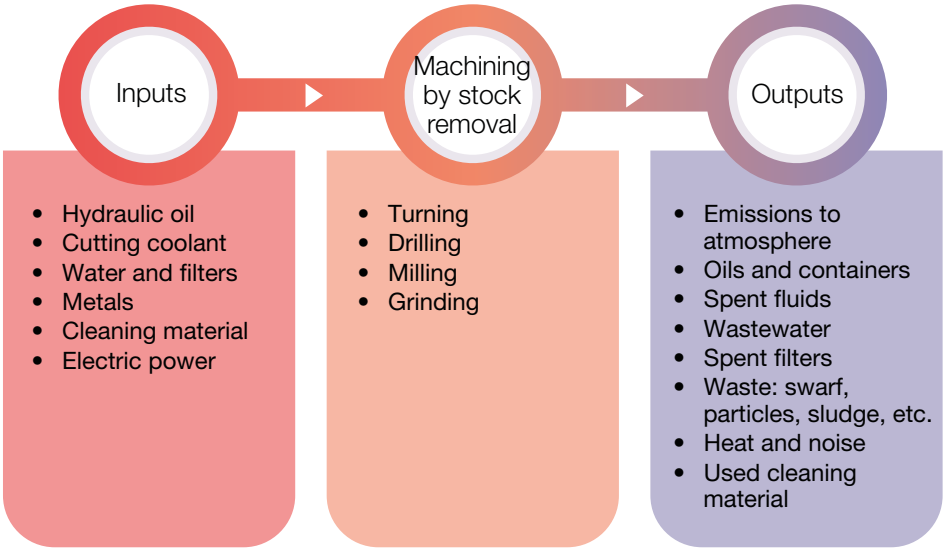
Figure 8. ▶ **Breakdown of cutting processes.**



Source: Authors' compilation based on information from Guide to Sustainable Production: Metal Processing Industry. Secretariat for the Environment and Sustainable Development - Argentina (2019).

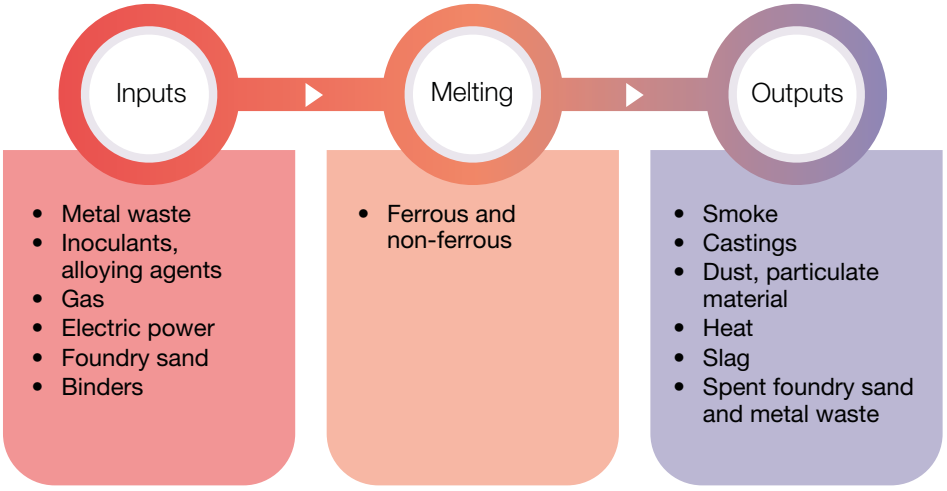
31 R. Miguel, R. Banda Noriega, A. Porta, R. Marozzi and J. Sota, Valorización de arena descartada de fundición en hormigones de cemento portland y concreto asfáltico en caliente, 2011, (Spanish).
32 U.S. Environmental Protection Agency, Beneficial Uses of Spent Foundry Sands, https://www.epa.gov/smm/beneficial-uses-spent-foundry-sands#BU

Figure 9. ▶ **Breakdown of processes of machining by stock removal.**



Source: As in figure 8.

Figure 10. ▶ **Breakdown of foundry processes.**



Source: As in figure 8.

Reviewing these assessments, it is clear that cutting and machining by stock removal produce ferrous and non-ferrous metal waste.

It is important to point out that cutting processes are performed in the manufacture of trailers and semi-trailers, as well as farm machinery, and that, consequently, they all generate offcuts of different shapes, sizes and metal alloys. This calls for the need to classify these according to their chemical composition and size for eventual use as secondary raw material in other industrial processes.

The foundry industry uses in its process metal offcuts from other industrial plants, scrap metal, as well as defective castings from its own process. Most foundries use a large proportion of scrap metal made up of low, medium and high-carbon steel, stainless steel, high-strength steel and non-ferrous metals.

Another possible reuse of steel scrap is in the steelworks (through the five integrated steelworks in the country) that use ferrous scrap metal for their production in large quantities, although, as stated before, this sector is not analysed in this paper.

Non-ferrous scrap metal is recycled differently depending on the metal or alloy (aluminium, bronze, copper, nickel, tin, lead, zinc, etc.) in the foundry sector, or by producers of secondary metals. However, another possible use that could be considered is as additives to alloys to improve mechanical properties and/or corrosion resistance.

It is important to point out that the recovery and valorisation of industrial metal waste, as well as of scrap metal from disused products, is a valuable source of resources

Metal swarf can be used for briquettes. Another possible use is to obtain metallic powder for the production of parts by powder metallurgy, and hard metal plating of parts used in heavy machinery and farm machinery (it extends the service life).

It is important to point out that the recovery and valorisation of industrial metal waste, as well as of scrap metal from disused products, is a valuable source of resources. This is so because obtaining metal ore from mining not only involves the depletion of non-renewable resources, but also generates an important amount of greenhouse emissions.

We can also mention that steel can be recycled an indefinite number of times, and, according to the World Steel Association, 1.5 tonnes of CO_2 emissions are avoided for every tonne of recycled scrap metal[33].

The recovery of disused vehicles, which, when abandoned on the land, can affect the environment, is another significant source of scrap metal. Its use as raw material in steel making favours the circular economy of steel, avoiding the use of virgin ore.

Concerning the generation of foundry sand, as mentioned before, after casting, part of the sand used in making the moulds is discarded. Approximately 90% of the green sand used in moulding is recycled by the foundries themselves, whereas only 40% of the sand with phenolic or furan resin is recycled. Coming from this source, it is estimated that between 60,000 and 90,000 tonnes of spent foundry sand are discarded annually in the country[34].

According to a report published by the GRID-Geneva team of the UN Environment Programme (UNEP), sand must be recognised as a strategic resource, not only as a construction material, but also for its multiple roles in

33 World Steel Association, Raw Materials; Maximising scrap use helps reduce CO_2 emissions, https://worldsteel.org/steel-topics/raw-materials/

34 Ministry of Production and Work, Sustainable Development Unit, Argentina, Informe Técnico Arenas de Fundición, 2019, (Spanish).

the environment[35]. Sand is a finite, non-renewable resource which, contrary to many other mineral raw materials, can be recycled many times over for other applications without loss of quality.

One such example is the reuse of spent foundry sand that can minimise the environmental impact produced by the extraction, processing and transport of virgin sand. A pilot project in Spain has used spent foundry sand in construction applications[36], promoting resource efficiency and circularity and reducing the use of virgin sand.

35 UN Environment Programme, Sand and Sustainability: 10 Strategic Recommendations to Avert a Crisis, 2022, https://www.unep.org/resources/report/sand-and-sustainability-10-strategic-recommendations-avert-crisis
36 Ibid.

11.
Identified barriers and opportunities

During the analysis carried for this paper and concerning particularly the sector under consideration, a number of barriers and opportunities in the transition towards resource efficiency and decarbonisation in the metal industry were identified.

In relation to barriers, some are specific to this sector, whereas others affect industry in general. On this matter, the Argentine Industry Association (UIA) state that Argentina needs a profound updating of the environmental legislation at national, federal and local levels in order to achieve a sustainable development based on resource efficiency. In particular, there is a need for new regulation on waste management that will make possible an integrated use of resources and materials, removing "waste generation" from the productive structure. In addition, they also state that a circular economy approach is needed to "harmonise industrial development with sustainability and care for the environment without affecting the sector's competitiveness"[37].

The following is a list of some of the barriers that have been identified:

- There are instances of legislation without regulations, delaying implementation.
- The current legislation on waste management is over 20 years old and has a cradle-to-grave approach, which limits material circularity.
- Lack of technical standards and regulations that promote the use of secondary raw materials.
- Little availability of suitable finance for SMEs (length and cost of finance) and difficulties for qualifying for credit.
- Business managers pay little attention to environmental matters.
- Business managers with resistance to change and to new technological advances.
- Limited access to reliable technical information suitable to the needs of businesses and their capacity to understand and process.
- Manufacturers and users with little confidence to innovate with some lighter components in traditional products.

37 Argentine Industrial Association UIA, Plan productivo 2020-2023; Una plataforma para generar y exportar valor al mundo, 2019, (Spanish), https://www.uia.org.ar/publicaciones/3517/plan-productivo-2023-una-plataforma-para-generar-y-exportar-valor-al-mundo/

- Limited research and development in national science and academia for the replacement of components with other lighter components.
- Limited finance for research projects on design and development of new materials for the industrial sector.
- Lack of economic, financial and tax incentives for replacing trailers and semi-trailers with lighter or 4-axle units, and for replacing older farm machinery with machinery of lighter weight.
- Casual nature of the collection of recyclable materials, with false paperwork in the scrap metal trade.

The analysis of processes in the sector shows the opportunities to recirculate large volumes of secondary raw material such as scrap metal

Regarding the opportunities identified in the metal industry, particularly in the subsectors analysed here, we can approach different aspects related to sustainability, especially social, economic and environmental aspects that could help towards an industry that is more efficient in the use of resources and decarbonised. Measures could be adopted in the foundry, farm machinery, and trailer and semi-trailer subsectors intended to minimise the use of resources (raw materials and service supplies) and the generation of waste, increasing at the same time the recycling of materials.

The analysis of processes in the sector shows the opportunities to recirculate large volumes of secondary raw material such as scrap metal.

Other opportunities for improvements in the sector, with favourable impact concerning the objectives set out in this paper, can be achieved through the design and development of new materials allowing component and equipment weight reductions in accordance with standard and certification requirements, with also a reduction in the use of materials, all contributing to a more efficient fuel consumption and a reduction of greenhouse gas emissions. These measures require the intervention of different social players and financial support, but they can produce significant benefits to metal industry subsectors such as the manufacture of trailers and semi-trailers and of farm machinery, both of which have high levels of production in the country. Equally, these benefits generate other indirect benefits that are not covered by this paper but have a high impact on goods transport by road and on farm work. The former is justified by the high percentage of goods that are transported by road, and the latter by the large areas of land used for cultivation.

Proposals for resource efficiency

TOWARDS RESOURCE EFFICIENCY AND DECARBONISATION OF THE METAL INDUSTRY IN ARGENTINA

12.
Key players and stakeholders

As mentioned before, this work has been carried out as part of the cooperation agreement between the German Government and the Argentine Government. The recipients are the Argentine Ministry of the Environment and Sustainable Development, the Argentine Ministry of Economy, and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

In the course of the work, we have sought to have contributions from players linked to the scope of the work, the proposed measures and their implementation (see figure 11).

Key players in the process

We have consulted a number of public bodies and business associations concerned with the metal industry's value chain to obtain and validate information for the work.

To this end, we interviewed a number of people to present the proposal, receive contributions, comments on outlook, difficulties and possible opportunities, in order to analyse and propose measures for resource efficiency resulting in the reduction of emissions.

Business associations:

- Argentine Foundry Chamber - CIFRA.
- Argentine Chamber of Trailer and Semi-trailer Manufacturers - CAFAS.
- Argentine Chamber of Farm Machinery Manufacturers - CAFMA.

Government:

- Directorate for Sustainable Industry, Secretariat for Industry and Productive Development, Argentine Ministry of Economy.
- National Directorate for Climate Change, Secretariat for Climate Change, Sustainable Development and Innovation, Argentine Ministry for the Environment and Sustainable Development.
- National Institute for Industrial Technology - INTI.

Other social players and stakeholders identified as relevant to the implementation of the proposed measures, or as direct recipients:

Public sector:

- **Government:** Ministry of Science, Technology and Innovation, Ministry of Economy, Ministry of Transport, Argentina.
- National and provincial legislative bodies.

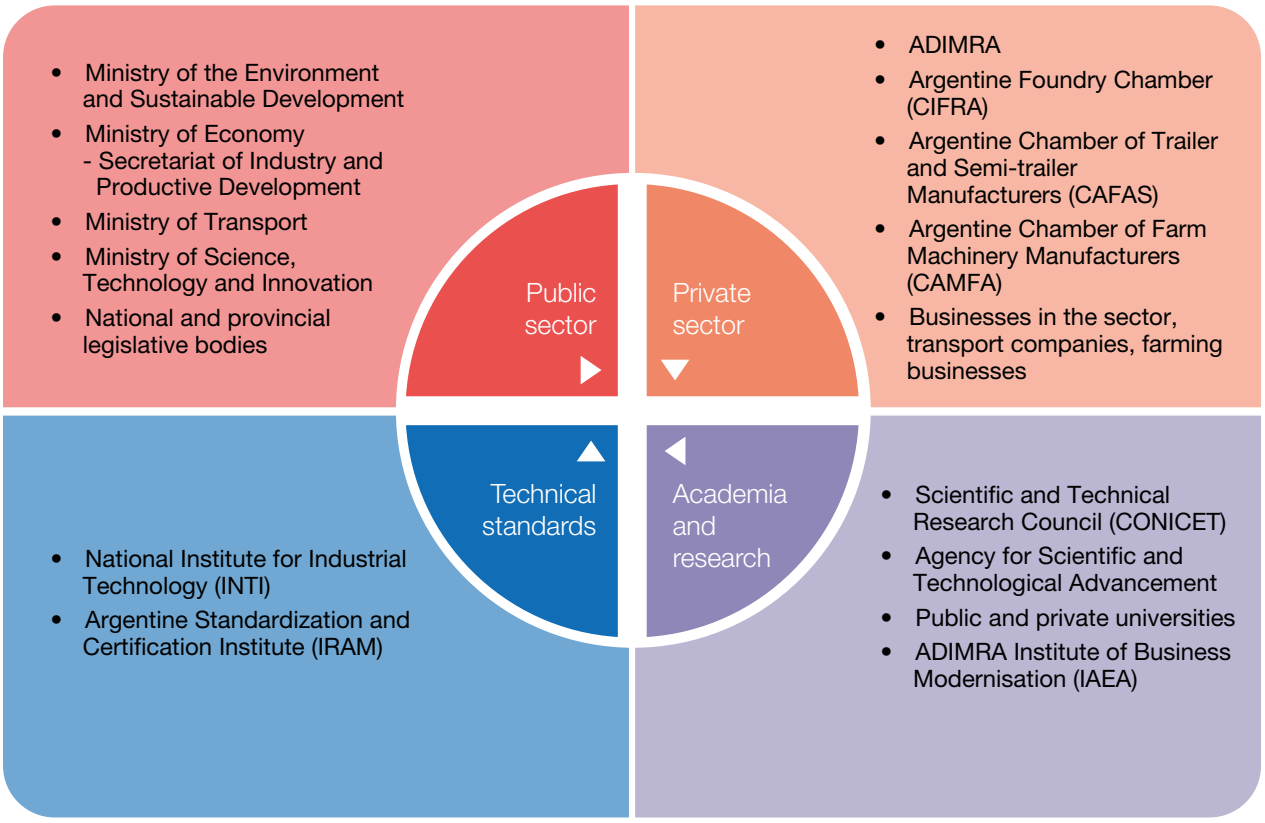
Private sector:

- Argentine Metal Industries Association - ADIMRA.
- Manufacturers of farm machinery, trailers and semi-trailers, and foundries.
- Haulage companies.
- Farmers.

Academia and research:

- **Bodies concerned with education and training:** Public and private universities (University of Buenos Aires, National Technological University, etc.), ADIMRA Institute of Business Modernisation - IAEA.
- **Science and technology:** National Council for Scientific and Technical Research (CONICET), Agency for Scientific and Technological Advancement, ADIMRA Network of Technological Centres.
- **Bodies concerned with developing technical standards**: Argentine Standardization and Certification Institute - IRAM.

Figure 11. ▶ Key players and interested parties involved in the work.



Source: authors' compilation.

13.
Proposed measures

In this section we describe the proposed measures that aim to achieve the objectives stated in the paper.

For each case, the problems that are to be solved, the proposal and the expected benefits are described in detail.

Table 1. ▶ Measures proposed as a contribution to the objective of the work.

Measure	Instruments - Description
1	Promoting technological research and development to replace structural components in chassis of trailers and semi-trailers with lighter components made of materials that have high strength, toughness and good weldability.
2	Promoting technological research and development to replace structural components in agricultural machinery with lighter components made of materials that have high strength, toughness and good weldability.
3	Promoting economic, financial and tax incentives so that trailers and semi-trailers are gradually replaced by lighter designs and/or 3-axle units are replaced by 4-axle units.
4	Promoting economic, financial and tax incentives allowing the farming sector to replace obsolete tractors and towed equipment such as seeders with others made in the country, equipped with new technologies, lighter, and suited to the requirements of the ground.
5	Producing a technical standard to class spent foundry sands as a secondary raw material.
6	Producing a statutory regulation allowing the use of foundry sand as a secondary raw material for other production processes.
7	Developing a technical standard to class metal swarf as a secondary raw material.
8	Extending federal statutory regulations to provincial and local levels to make it easier to free up impounded vehicles for processing and use as scrap.
9	Modifying tax law to include VAT exemption for the sale of materials intended for recycling, thus promoting the recovery and recycling of ferrous and non-ferrous scrap, as well as other recyclable materials.

Measure 1. ▶ Promoting technological research and development to replace structural components in chassis of trailers and semi-trailers with lighter components made of materials that have high strength, toughness and good weldability.

Problems:

The transport of goods by road represents 93% of the total transport of goods in the country[38] [39], with greenhouse gas emissions significantly higher than those of the transport of goods by rail and boat, whilst the transport of goods by air has little significance. The transport by road is done mainly by vehicles using trailers and semi-trailers. According to data provided by the Argentine Chamber of Trailer and Semi-trailer Manufacturers (CAFAS)[40], there are currently around 300,000 rigid and articulated goods vehicles, of which around 150,000 units are over 20 years old, with risks to road safety and greater wear and tear to the road infrastructure.

Rigid and articulated goods vehicles have heavy structures that affect their load capacity and cause a greater fuel consumption per unit of payload carried, an effect that is amplified in older units

Generally, rigid and articulated goods vehicles have heavy structures that affect their load capacity and cause a greater fuel consumption per unit of payload carried, an effect that is amplified in older units, many of them obsolete. Most of the trailers and semi-trailers have 3 axles and a tare weight between 6.6 t and 7.5 t.

Description of the proposal:

Invitations to tender issued by the Argentine Technological Fund (FONTAR) under the National Agency for the Promotion of Research, Technological Development and Innovation, an agency of the Ministry of Science, Technology and Innovation, or by other bodies[41] to finance research, development and innovation projects for the replacement of structural components from trailer and semi-trailer chassis with lighter components made of stronger materials (such as high-strength low-alloy steel grades MLC420, MLC500, dual phase DP 590, ASTM A572, A572M, A575, AISI 8642, etc.) instead of the materials in current use.

Currently, the different types of vehicles are: 2, 3 and 4-axle trailers, 1, 2 and 3-axle semi-trailers, low loaders, B-doubles and rigid vehicles with

38 Ministry of the Environment and Sustainable Development, Argentina, Cuarto informe bienal de actualización de la República Argentina a la Convención Marco de las Naciones Unidas sobre el Cambio Climático, 2022, (Spanish), https://www.argentina.gob.ar/ambiente/cambio-climatico/cuarto-informe-bienal

39 National Office for Climate Change, Ministry of the Environment and Sustainable Development, Plan de Acción Nacional de Transporte y Cambio Climático, 2017, (Spanish), https://www.argentina.gob.ar/sites/default/files/plan_de_accion_nacional_de_transporte_y_cc_1.pdf

40 CAFAS, Se normaliza la industria del remolque, 2021, (Spanish), http://www.cafas.org.ar/noticias/noticia-new-14.php

41 Programa Soluciona Verde https://www.argentina.gob.ar/servicio/acceder-al-programa-soluciona-verde

bodywork, each with its own specific requirements regarding components and materials. According to CAFAS, registration of trailers have reached 10,000 units per year, a number that has kept stable during the last few years. This means approximately 40,000 t of steel per year with the current use. On the choice of steel, the grade ML420 can result in a 20% reduction on the material required, and a 25% reduction in the case of the grade ML520, resulting in both instances in lighter units than with the steel currently in use. A simple calculation gives an estimated reduction of the material used of approximately 8,000 to 10,000 t/year. On this basis, we can propose the replacement of the material of structural components in the chassis with steel of the aforementioned grades or others produced in the country that will allow weight reductions. This should be achieved without altering the mechanical performance in accordance with the relevant standards and the required passive and active safety features.

The grades ML420 and ML500 would allow 20% and 25% reductions respectively of the material used in the manufacture of trailer and semi-trailer components compared with the current use of steel. Next, we present an estimate of the impact that FONTAR's invitations to tender could have, resulting from 20% of the current output being produced using these new materials by 2030 (assumption). For the calculations, the equipment considered are 3-axle units of 6.6 t tare weight with current steel, 4-axle units of 7.58 t tare weight with current steel, using a distribution where 50% are 3-axle units, and the other 50% are 4-axle units.

As the following table shows, for 1,000 units/year where 60% of the current steel is replaced with grade ML420, the reduction achieved amounts to 850.80 t/year of steel. Similarly, when replacing with grade ML500, the reduction achieved is 1,063.50 t/year of steel. In summary, the implementation through FONTAR of this type of projects could generate reductions of over 1,900 t/year of steel.

Table 2. ▶ **Calculations of the reduction of metal in trailers and semi-trailers.**

				2030 1,000 units/year		
ML240 Case	**Current tare weight (t)**	**Steel in current use (60% of tare w.)**	**ML420 grade (t) (-20%)**	**Steel un current use (t)**	**ML420 grade (t)**	**Annual saving 2030 (t)**
3-AXLE EQUIPMENT	6.60	3.96	3.17	1,980.00	1,584.00	396.00
4-AXLE EQUIPMENT	7.58	4.55	3.64	2,274.00	1,819.20	454.80
ANNUAL BENEFIT						**850.80**

				2030 1,000 units/year		
ML500 Case	Current tare weight (t)	Steel in current use (60% of tare w.)	ML500 grade (t) (-25%)	Steel un current use (t)	ML500 grade (t)	Ahorro anual 2030 (t)
3-AXLE EQUIPMENT	6.60	3.96	2.97	1,980.00	1,485.00	495.00
4-AXLE EQUIPMENT	7.58	4.55	3.41	2,274.00	1,705.50	568.50
ANNUAL BENEFIT						1,063.50

Source: authors' compilation.

Benefits:

In the trailer and semi-trailer sector, greenhouse gas emissions are deemed to be 1.45 tonnes of CO_2 per tonne of crude steel. Therefore, applying this value, a reduction of emissions of 2,775.74 tonnes of CO_2-eq by 2030 is estimated.

Table 3. **Calculation of the reduction of CO_2-eq emissions from trailers and semi-trailers.**

	2030 1,000 units/year per alloy	
	Materials reduction	CO_2 emissions reduction (1.45 t of CO^2 per tonne of steel)
ML420	850.80	1,233.66
ML500	1,063.50	1,542.08
REDUCTION/YEAR	1,914.30	2,775.74

Source: authors' compilation

A further estimate should be made about the reduction of emissions that could be achieved with the reduction of fuel consumption per tonne of goods carried, given that a vehicle with a lower tare weight could increase its payload.

If, in addition to this measure, 3-axle trailers were to be replaced with 4-axle trailers, the payload could be increased without significant increases in fuel consumption or the need to increase the power of the tractor units.

Measure 2. ▶ Promoting technological research and development to replace structural components in agricultural machinery with lighter components made of materials that have high strength, toughness and good weldability.

Problems:

According to data from CAFMA, the current size of the tractor market is 6,520 units per year. The current number of existing tractors is estimated at 60,000 units, of which a large proportion are obsolete, with a second-hand market that sustains tractors aged 20 years or more to remain in service. This is related to the higher fuel consumption per farmed hectare and the resulting higher greenhouse gas emissions. Furthermore, their weight produces a higher soil compaction.

In the case of seeders, there is also a high proportion of obsolete units, built with traditional steel, which carries a higher weight and the resulting higher fuel consumption for the driving tractor.

In summary, obsolete equipment, usually heavier, contribute to a higher soil compaction and, at the same time, to a higher fuel consumption per farmed hectare, leading to emissions from the farming sector.

Description of the proposal:

Invitations to tender issued by FONTAR to finance research, development and innovation projects for the replacement of structural components from farm machinery with new lighter components made of stronger materials (such as Strenx 700E/F or Strenx 700MC Plus, and HARDOX 400, HARDOX 500, etc.) instead of the materials in current use.

The manufacture of farm machinery consumes 120,000 t/year of steel, mainly flat products, with a lower proportion of long products

The manufacture of farm machinery consumes 120,000 t/year of steel, mainly flat products, with a lower proportion of long products. Although farm machinery in Argentine needs to be heavier than in other countries due to soil requirements, there is interest in assessing what the minimum weight is for the purpose of avoiding unnecessary fuel consumption and reducing CO_2 emissions. Equally, it would be advisable to propose replacing some materials in current use with other materials that would allow reducing the weight of the equipment within admissible limits considering each application and in compliance with regulatory and certification requirements. This would also contribute to reduce emissions.

Concerning tractors and seeders made in the country, it is estimated that changing to steel grades such as Strenx 700E/F or Strenx 700MC Plus, and HARDOX 400, HARDOX 500, etc., or equivalent grades produced in the country, would lead to a 30% reduction of the unit weight. Next, we present an estimate of the impact that FONTAR's invitations to tender could have, resulting from an annual production of 600 tractors and 100 seeders by 2030 (assumption). For the calculations, the equipment considered are 2 models of tractor made in the country and 2 types of seeder (towed seeders), one a large-grain seeder and the other a small-grain seeder, both with tandem modules, with a share of the work of 50% for each type of equipment.

As the following tables show, for 600 tractors/year with current steel components replaced with lighter components made of stronger steel, the result is equipment that is 70% lighter, achieving a reduction of 1,050 t/year of steel. Similarly, for the seeders, the reduction is 522 t/year of steel. In summary, the implementation through FONTAR of this type of projects could generate reductions of over 1,572 t/year of steel.

Table 4. ▶ **Calculations of the reduction of metal in tractors and seeders.**

			2030 600 units/year		
Tractors	**Current weight without ballast (t)**	**Alloy weight (t)**	**Current weight without ballast (t)**	**Alloy weight (t)**	**Annual saving 2030 (t)**
PAUNY 210 A Regional	3.60	2.52	1,080.00	756.00	324.00
PAUNY 2215ie	8.07	5.65	2,421.00	1,695.00	726.00
ANNUAL BENEFIT					**1,050.00**

			2030 100 units/year		
Sembradoras	**Current weight without ballast (t)**	**Alloy weight (t)**	**Current weight without ballast (t)**	**Alloy weight (t)**	**Annual saving 2030 (t)**
CRUCIANELLI Gringa (con tándem 2 módulos)	17.50	12.25	875.00	612.50	262.50
CRUCIANELLI Pionera (con tándem 2 módulos)	17.30	12.11	865.00	605.50	259.50
ANNUAL BENEFIT					**522.00**

Source: authors' compilation

It must be mentioned that the calculation for weight reductions assume that the structural components are replaced with lighter components with similar mechanical performance, made of steel produced in the country. The assessment carried out for the farm machinery sector indicates that there could be an important contribution to be made for the decarbonisation of this industrial sector through a reduction of the annual consumption of steel. This could even be reinforced by, for instance, integrating new technologies into the equipment.

Concerning the seeders, it must be taken into account that, although the reduction in weight of the equipment can reduce fuel consumption, reducing in turn greenhouse gas emissions, the weight is constrained by requirements derived from the type of soil, its moisture contents (14%) and the type of application. Even with these limitations, the use of home-produced stronger steel in structural components can be considered, while still complying with relevant standards and certification requirements, because it could lead to a reduction of the annual use of steel, in addition to bringing a lower fuel consumption through the integration of new technologies into the equipment, all of which would contribute to a reduction of CO_2 emissions.

Benefits:

In the farm machinery sector, greenhouse gas emissions are deemed to be 1.45 tonnes of CO_2 per tonne of crude steel. Therefore, applying this value, a reduction of emissions of 2,279.40 tonnes of CO_2-eq by 2030 is estimated.

Table 5. **Calculation of the reduction of CO_2-eq emissions from tractors and seeders.**

	Materials reduction	CO_2 emissions reduction (1.45 t of CO_2 per tonne of steel)
Tractors	1,050.00	1,522.50
Seeders	522.00	756.90
REDUCTION/YEAR	**1,572.00**	**2,279.40**

Source: authors' compilation

In addition, an estimate should be made of the reduction of emissions that could obtained from the reduction of fuel consumption per farmed hectare, directly by the tractor, or by towing the seeder, contributing to the farming sector's reduction of emissions, as well as minimising soil degradation.

The assessment carried out for the farm machinery sector indicates that there could be an important contribution to be made for the decarbonisation of this industrial sector through a reduction of the annual consumption of steel.

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Measure 3. ▶ Promoting economic, financial and tax incentives so that trailers and semi-trailers are gradually replaced by lighter designs and/or 3-axle units are replaced by 4-axle units.

Problems: as described for measure 1.

Description of the proposal:

Incentives from the national government can take different forms: tax (VAT) reduction scheme, reduction of registration cost, discount certificates for the purchase of a new vehicle made in the country against the surrender of vehicles that are over 20 years old, finance at preferential rates, etc.

This measure is intended to stimulate demand to drive the renewal of the trailer and semi-trailer fleet with units made in the country that are lighter, with the mechanical strength to meet all the relevant technical and certification standards, producing a lower environmental impact through the reduction of greenhouse gas emissions. This proposal is intended to provide transport businesses with opportunities to stimulate the renewal of obsolete trailers and semi-trailers that are over 20 years old through a *trade-in programme*, as well as the gradual renewal of trailers and semi-trailers under 20 years old or the purchase of new equipment of lower weight through *finance at reduced rates*. This would allow an increase of the load capacity, reducing at the same time the fuel consumption per unit of payload carried, thus contributing to a reduction of the emissions from the goods transport sector.

The implementation of the trade-in programme will require as a condition that the units are taken out of circulation and scrapped, avoiding the sale of those used units back in the internal market

The implementation of the trade-in programme will require as a condition that the units are taken out of circulation and scrapped, avoiding the sale of those used units back in the internal market, and allowing at the same the reintroduction of the scrap metal into the production cycle. It must be noted that this renewal process would generate large volumes of scrap metal which would be fed back into other industrial processes. This would increase the recycling rates, making a contribution to the sector's decarbonisation. The programme implemented by the national government in 1999 can be taken as a reference[42].

On the other hand, the implementation of finance at reduced rates would be aimed at those who need to renew their equipment but do not wish to swap the equipment they already have. This would be because either their current equipment is still serviceable, or they want to increase their fleet. This would concern, for instance, equipment that is under 20 years old and would not qualify for the trade-in programme.

Under this measure, the same alloys are under consideration as under measure 1 above (FONTAR's invitations to tender concerning the sector

42 Decree DNU 35/1999 Parque automotor; Régimen de renovación (Plan Canje), https://www.argentina.gob.ar/normativa/nacional/decreto-35-1999-55729

of trailers and semi-trailers). In this instance, the impact is greater because of the instrument under consideration, which would have a direct effect on the demand for goods. As the following tables show, two time horizons are considered: 2025, with 1,000 units/year where 60% of the current steel is replaced with ML420 and ML500 steel; and 2030, with 2,500 units/year. In each instance, the trade-in programme and the finance at reduced rates are applicable.

Table 6. ▶ **Calculations of the reduction of metal in trailers and semi-trailers (measure 3).**

				2025 1,000 units/year			2030 2,500 units/year		
ML240 Case	Current tare weight (t)	Steel in current use (60% of tare w.)	ML420 grade (t) (-20%)	Steel un current use (t)	ML420 grade (t)	Annual saving 2025 (t)	Steel un current use (t)	ML420 grade (t)	Annual saving 2030 (t)
3-AXLE EQUIPMENT	6.60	3.96	3.17	1,980.00	1,584.00	396.00	4,950.00	3,960.00	990.00
4-AXLE EQUIPMENT	7.58	4.55	3.64	2,274.00	1,819.20	454.80	5,685.00	4,548.00	1,137.00
ANNUAL BENEFIT						850,80			2.127,00

				2025 1,000 units/year			2030 2,500 units/year		
ML500 Case	Current tare weight (t)	Steel in current use (60% of tare w.)	ML500 grade (t) (-25%)	Steel un current use (t)	ML500 grade (t)	Annual saving 2025 (t)	Steel un current use (t)	ML500 grade (t)	Annual saving 2030 (t)
3-AXLE EQUIPMENT	6.60	3.96	2.97	1,980.00	1,485.00	495.00	4,950.00	3,712.50	1,237.50
4-AXLE EQUIPMENT	7.58	4.55	3.41	2,274.00	1,705.50	568.50	5,685.00	4,263.75	1,421.25
ANNUAL BENEFIT						1.063.50			2,658.75

Source: authors' compilation
Note: These tables are valid for either a trade-in programme or finance at reduced rate.

The assumptions made are:

- 50% of the units go through the trade-in programme, and the other 50% through finance at reduced rates.

- The 2025 trade-in programme covers 2,000 units, as does the finance at reduced rates.
- The 2030 trade-in programme covers 5,000 units, as does the finance at reduced rates.

In summary, with either the trade-in programme or the finance at reduced rates, the reductions that can be obtained are 1,914 t/year of steel by 2025, and 4,785 t/year of steel by 2030. Considering a concurrent implementation of both measures, given that they respond to different situations in the transport sector, the reductions in the use of steel would be **3,828 t/year** by 2025, **9,570 t/year** by 2030.

Benefits:

In the trailer and semi-trailer sector, greenhouse gas emissions are deemed to be 1.45 tonnes of CO_2 per tonne of crude steel. Therefore, applying this value, it is estimated that each of the two instruments considered for this measure could achieve emission reductions of 2,775.74 tonnes of CO_2-eq/year by 2025, and 6,939.34 tonnes of CO_2-eq/year by 2030. Applying both instruments concurrently would achieve emission reductions of **5,551 tonnes of CO_2-eq/year** by 2025, and **13,878 tonnes of CO_2-eq/year** by 2030.

Table 7. ▶ Calculations of the reduction of CO_2-eq emissions from trailers and semi-trailers (measure 3)

	2025 1,000 units/year per alloy		2030 2,500 units/year per alloy	
	Materials reduction	**CO_2 emissions reduction (1.45 t of CO_2 per tonne of steel)**	**Materials reduction**	**CO_2 emissions reduction (1.45 t of CO_2 per tonne of steel)**
ML420	850.80	1,233.66	2,127.00	3,084.15
ML500	1,063.50	1,542.08	2,658.75	3,855.19
REDUCTION/YEAR	**1,914.30**	**2,775.74**	**4,785.75**	**6,939.34**

Source: authors' compilation

Measure 4. ▶ Promoting economic, financial and tax incentives allowing the farming sector to replace obsolete tractors and towed equipment such as seeders with others made in the country, equipped with new technologies, lighter, and suited to the requirements of the ground.

Problems: as described for measure 2.

Description of the proposal:

The proposed measure is similar to that for trailers and semi-trailers: a trade-in programme for obsolete equipment, and finance at reduced rates, but, in this case, using the same alloys proposed for measure 2, namely Strenx 700E/F or Strenx 700MC Plus, and HARDOX 400, HARDOX 500, etc., or equivalent grades produced in the country.

In this instance, the impact is greater than in measure (FONTAR) because of the instrument under consideration, which would have a direct effect on the demand for goods. As the following tables shown, 1,200 units/year for tractors and 200 units/year for seeders are considered for both a trade-in programme and finance at reduced rates.

Table 8. ▶ **Calculations of the reduction of metal in tractors and seeders (measure 4).**

			2030 1200 units/year		
Tractors	**Current weight without ballast (t)**	**Alloy weight (t)**	**Current weight without ballast (t)**	**Alloy weight (t)**	**Annual saving 2030 (t)**
PAUNY 210 A Regional	3.60	2.52	2,160.00	1,512.00	648.00
PAUNY 2215ie	8.07	5.65	4,842.00	3,390.00	1,452.00
ANNUAL BENEFIT					**2,100.00**

			2030 200 units/year		
Seeders	Current weight without ballast (t)	Alloy weight (t)	Current weight without ballast (t)	Alloy weight (t)	Annual saving 2030 (t)
CRUCIANELLI Gringa (with tandem 2 modules)	17.50	12.25	1,750.00	1,225.00	525.00
CRUCIANELLI Pionera (with tandem 2 modules)	17.30	12.11	1,730.00	1,211.00	519.00
ANNUAL BENEFIT					1,044.00

Source: authors' compilation
Nota: These tables are valid for either a trade-in programme or finance at reduced rates.

The assumptions made are:

- 50% of the units go through the trade-in programme, and the other 50% through finance at reduced rates.
- By 2030, the trade-in programme covers 1,200 tractors and 200 seeders, as does the finance at reduced rates.

In summary, with either the trade-in programme or the finance at reduced rates, the reduction that can be obtained is 3,144 t/year of steel by 2030. Considering a concurrent implementation of both measures, given that they respond to different situations in the farming sector, the reductions in the use of steel would be **6,288 t/year** by 2030.

Benefits:

In the farm machinery sector, greenhouse gas emissions are deemed to be 1.45 tonnes of CO_2 per tonne of crude steel. Therefore, applying this value, it is estimated that each of the two instruments considered for this measure could achieve emission reductions of 4,558.80 tonnes of CO_2-eq/year by 2030. Applying both instruments concurrently would achieve emission reductions of **9,117.60 tonnes of CO_2-eq/year** by 2030.

Table 9. ▶ **Calculations of the reduction of CO_2-eq emissions from tractors and seeders (measure 4).**

	2030 1,400 units/year	
	Materials reduction	**CO_2 emissions reduction (1.45 t of CO_2 per tonne of steel)**
Tractors	2,100.00	3,045.00
Seeders	1,044.00	1,513.80
REDUCTION/YEAR	**3,144.00**	**4,558.80**

Source: authors' compilation

Measure 5. ▶ **Producing a technical standard to class spent foundry sands as a secondary raw material.**

Problems:

Spent foundry sand comes from the moulds in which the parts are cast in ferrous and non-ferrous alloys, as part of the production process in foundries.

Although part of the sand can be recycled, the main problem is that for most of the foundry sand, the only possible outcome is treatment and disposal under national regulations.

According to research by the Argentine Foundry Chamber, there is a ratio of up to 10 kg of sand used per 1 kg of casting produced. However, this ratio can vary depending on the type of casting produced. In addition, the resin-sand ratio is between 1 and 1.5 kg of resin per 100 kg of sand[43].

The consumption of resin (mainly phenol formaldehyde and furan resins) in the country is approximately 1,500 t/year, which, according to calculations, means that approximately 100,000 to 150,000 tonnes of virgin silica sand are processed per year. Setting aside the sand that is recycled and is used again by the foundry for moulding, it is estimated that between 60,000 and 90,000 t/year of sand is available for other applications[44].

43 Ministry of Production and Work, Sustainable Development Unit, Argentina, Informe Técnico Arenas de Fundición, 2019, (Spanish).
44 Ibid.

According to national statutory regulations currently in force concerning hazardous waste (Law 24051/1991), spent foundry sand is classed as hazardous waste, requiring controlled handling and a licensed operator to carry out its safe disposal in industrial landfill. However, there is uncertainty about whether spent foundry sand should be classed as hazardous industrial waste or not[45].

The volumes of spent foundry sand generated annually have an impact on the environment, as well as a significant cost to the foundry industry

The volumes of spent foundry sand generated annually have an impact on the environment, as well as a significant cost to the foundry industry. This cost for the required environmental management must be added to the cost of the product, making it less competitive in the market.

On the other hand, the large volumes of spent foundry sand that go for disposal annually shorten the life of industrial landfill sites, increase the need for more landfill area, and make this land unproductive. In addition, as it is considered a hazardous waste, there are limited possibilities of using it as secondary raw material in other productive processes such as, for instance, construction and civil engineering works, which increases the use of virgin sand in these works.

Description of the proposal:

Development of a new IRAM technical standard to class spent foundry sand as a secondary raw material suitable for other production chains such as, for instance, asphalt and concrete, amongst other possible uses.

It is a proposal with international and regional precedents dating back 10 years, such as standard NBR 15702/2009 published by the Brazilian Technical Standard Association (ABNT) in 2009. This standard sets the criteria for the application of spent foundry sand as raw material for concrete and landfill cover.

According to this standard, foundry sand must meet the following conditions for use in other production processes:

- Classed as class II – non-hazardous, as per ABNT NBR 10004 and ABNT NBR 10007.
- Have a pH between 5 and 10, determined with the aqueous extract obtained as per Annex C of the aforementioned standard.
- Comply with maximum concentrations indicated in Tables 5-6 and 5-7 of the aforementioned standard.
- All analytical tests must be carried out by accredited laboratories with ISO 17025 accreditation.

45 R. Miguel, R. Banda Noriega, A. Porta, R. Marozzi and J. Sota, Valorización de arena descartada de fundición en hormigones de cemento portland y concreto asfáltico en caliente, 2011, (Spanish).

TABLE 5-6 - Maximum concentration in leachate

Substance / element	Maximum concentration in leachate (mg/l)
Arsenic	0.50
Barium	10.00
Cadmium	0.10
Chrome total	0.50
Lead	0.50
Mercury	0.02
Selenium	0.10

Source: ABNT - NBR 15702:2009

Table 5-7 - Maximum concentration in aqueous extract

Substance / element	Maximum concentration in aqueous extract (mg/l)
Chloride	2,500
Copper	2.5
Cyanide	2.0
Fluoride	14.0
Iron	15.0
Manganese	0.5
Nickel	2.0
Phenols (total)	3.0
Sodium	2,500
Sulphate	2,500
Sulphide (total)	5.0
Dissolved solids (total)	5,000
Total Zinc	25,0

Source: ABNT – NBR 15702:2009

Some examples of uses of foundry sand in other countries are given below[46]:

Australia: Mould sand with its resin contents is used in the production of concrete and bricks, in civil construction, asphaltic compounds, etc. For this, the spent foundry sand must comply with the requirements set out by the Australian Environment Protection Authority.

Belgium: Spent foundry sand may be used as a by-product in civil construction, roads, brick manufacture, etc. The composition must be accredited.

France: Spent foundry sand may be used to produce asphaltic compounds. For its use, the maximum concentration of constituents must comply with the limits set out in French regulations for water and soil quality.

46 Dias da Silva K., *Reutilização do resíduo de areia de fundição no Brasil e no mundo o contexto do Estado de Minas Gerais*. Universidade Federal de Minas Gerais, 2010, (Portuguese). https://repositorio.ufmg.br/bitstream/1843/BUOS-9ATFXE/1/monografia_areia_de_fundi__o.pdf

The proposed technical standard could set the characteristics of the spent foundry sand composition, setting the limits for the relevant substances that would make it suitable for use as a material in other production processes.

It is expected that this standard will be the basis for the development of a future legal framework on the matter, using the precedents of standards from other countries[47], and previous national and international scientific studies[48] [49].

Benefits:

Considering that the extraction and processing of virgin sand emit approximately 120 kg of CO_2[50], the use of spent foundry sand, as proposed with this measure, could result in a reduction of 7,200 and 10,800 t/year of CO_2. This amounts to between 0.12% and 0.18% of total emissions by the metal industry, according to Argentina's Fourth Biennial Update Report to the United Nation Framework Convention on Climate Change.

Measure 6. ▶ Producing a statutory regulation allowing the use of foundry sand as a secondary raw material for other production processes.

Problems: as described for measure 5.

Description of the proposal:

Development of a proposal to regulate the classification of spent foundry sand as a secondary raw material for use in other productive chains such as, for instance, asphalt and concrete, giving it an economic value and longer useful life.

This regulation could be based on a relevant technical standard or legal framework in force in other countries, To this end, Brazil could be taken as an example, with its existing national regulatory framework[51] [52].

47 Brazilian standard NBR 15702 of 05/2009, Spent foundry sand - Guidelines for asphalt and landfill application.
48 Banda Noriega R., Miguel R., Sota J., Marcozzi R., Arenas descartadas de fundición como subproducto utilizado en la fabricación de materiales de construcción, 2011, (Spanish).
49 European Union, Life Eco-Sandfill; Valorization of foundry sand, http://www.life-ecosandfill.eu/index.html
50 UN Environment Programme, Sand and Sustainability: 10 Strategic Recommendations to Avert a Crisis, 2022,
51 Brazil, Resolution CONSEMA no. 26 of 6 September 2013. It sets out the guidelines for the use of spent foundry sand, (Portuguese), https://www.legisweb.com.br/legislacao/?id=258568
52 State of São Paolo, Brazil, Decision of Directorate CETESB no. 152/2007 of 08 August 2007. Resolution about the procedures to manage foundry sand, (Portuguese), https://cetesb.sp.gov.br/residuossolidos/wp-content/uploads/sites/26/2013/11/20100621111349_14c906d046b6f3c904a8e859375107c5.pdf

Benefits (measures 5 and 6):

- It favours industrial symbiosis, allowing by-products from an industry or industrial process to be turned into raw materials for another industry.
- It reduces the impact caused by the extraction, transport and use of virgin sand.
- It optimises the use of natural resources, reducing the consumption of virgin raw materials.
- It reduces energy consumption, waste generation, and greenhouse gas emissions.
- It generates new income streams from the sale of resources available for reuse.
- It reduces the costs of waste management and use of land for landfill.

Measure 7. ▶ Producing a technical standard to class metal swarf as a secondary raw material.

Problems:

Given that currently there are no clear limits in the regulations concerning waste, the metal swarf that is impregnated with cutting oil and coolant can be considered hazardous waste (some of these chemical substances are classed as harmful and toxic), therefore generating costs for its management and the loss of use for a resource.

Description of the proposal:

For instance, in the Autonomous Region of the Basque Country in Spain, swarf with an oil content lower than 3% is classed as non-hazardous waste

The proposal is to develop a technical standard to class metal swarf and set the quantities of cutting oil and coolant it can contain, so that it can be used as a secondary raw material in other production circuits such as, for instance, foundries.

It is expected that this standard will be the basis for the development of a future legal framework on the matter, using precedents from other countries. For instance, in the Autonomous Region of the Basque Country in Spain, swarf with an oil content lower than 3% is classed as non-hazardous waste[53].

53 IHOBE, Reducción de costes mediante una gestión eficaz de las virutas, 2002 (Spanish), https://www.ihobe.eus/publicaciones/reducción-costes-mediante-una-gestion-eficaz-virutas-2

Benefits:

- Metal swarf can be used for briquettes, which are later melted in foundries.
- It can also be used to obtain metallic powder for the production of parts by powder metallurgy, and hard metal plating of parts used in heavy machinery and farm machinery.

Measure 8. ▶ Extending federal statutory regulations to provincial and local levels to make it easier to free up impounded vehicles for processing and use as scrap.

Problems:

In Argentina, vehicles at the end of their useful life usually end up in open-air sites. These can become a source of pollution for the soil and the ground water, as well as a cause of other health problems, especially when located close to urban centres. In particular, the accumulation of disused vehicles can have a range of negative impacts such as the release of harmful metals (Cd, Pb, Cu and Zn) and fluids. Therefore, there is a need to find solutions to reduce these storage sites and at the same time monitor the ground water quality regularly, especially in the areas close to vehicle dumps, official pounds, markets and scrap merchants[54].

According to TELAM, citing the Argentine Ministry of Security, in 2018 there were over two million impounded vehicles kept in official pounds in suitable conditions to be crushed.

In this respect, it is important to mention that the Ministry of Security started in late 2021 and early 2022 to crush and decontaminate vehicles held at federal pounds, but that there are many other vehicles held at pounds under provincial or local jurisdictions yet to be processed in this way.

Description of the proposal:

This measure impacts the value chain in the metal industry by allowing the sector to use raw materials with a higher proportion of recycled material, thus reducing the consumption of virgin materials.

The measure is intended to implement effectively the deadlines set out by

54 F. Chizoruo Ibea, A. Iheanyichukwu Opara, B. Onyekachi Ibe, Application of pollution risk evaluation models in groundwater systems in the vicinity of automobile scrap markets in Owerri municipal and environs, southeastern Nigeria, Scientific African, 8, 1-21, 2020, doi.org/10.1016/j.sciaf.2020.e00450

the Law no. 26348 for scrapping abandoned, lost, seized and impounded vehicles.

Equally, this legislation needs to be extended to the provinces, which makes it essential to enact the necessary regulations to harmonise the local legislation to the relevant national law.

Benefits

- Increase of the availability of ferrous scrap, which is the main raw material of steelworks that in turn supply the raw materials to the metal industry.
- Reductions of greenhouse gas emissions as a result of the greater use of recycled material in the process.
- Reduction of the possible pollution sources that the official pounds where vehicles are held represent.

Measure 9. ▶ Modifying tax law to include VAT exemption for the sale of materials intended for recycling, thus promoting the recovery and recycling of ferrous and non-ferrous scrap, as well as other recyclable materials.

Problems:

Foundries, as other metal recycling industries, source their raw materials from the industrial waste produced by industries or from metal scrap dealers and processors.

Although foundries comply with all their legal and tax requirements, paying the relevant tax for the purchase of metal, it happens with some frequency that several years later the Argentine Federal Tax Office (AFIP) will require a foundry to pay the tax that the seller failed to pay, following AFIP's determination that the seller's invoice (scrap dealer or processor) is false or irregular (added to APOC database due to lack of financial standing). This situation causes enormous damage to the recycling businesses, especially the cost increase of these raw material purchases, the possibility of the same problem recurring after having purchased from the same supplier over time, and the resulting difficulties with banks and finance firms for appearing to be in tax arrears or default[55].

55 Bill - Financial regime to promote sustainable development through the promotion of the recycling industry (file 4238-D-2019) of 06/09/2019. https://www.hcdn.gob.ar/proyectos/textoCompleto.jsp?exp=4238-D-2019&tipo=LEY

Description of the proposal:

Amendment of the tax law concerning recycling materials originating from post-consumer and/or post-industrial waste (ferrous and non-ferrous metals, etc.) which are destined for transformation through industrial processing with the purpose of obtaining a raw material or a new product. The proposed amendment would exempt these recycling materials from VAT in any of the transactions prior to the purchase by the businesses that carry out this processing[56].

The purpose of the measure is to exempt initial sales of recycling materials from VAT, proposing to start invoicing with VAT from the stage when the industrial processing of these materials begins.

Benefits:

The recycling industry is presented as a solution for the model of the circular economy, and it also offers an alternative to the growing problems of waste materials. Equally, it is essential to ensure the supply of strategic materials such as ferrous and non-ferrous waste in the context of national shortage, and to give the foundry industry the safety of a legal framework that will guarantee their profitability and existence.

The measure aims to correct the problems that have been described, allowing these businesses not just to remain active, but also grow, with the subsequent generation of green employment. It is also expected that this tax policy will encourage the recovery of materials.

Recycling ferrous and non-ferrous scrap valorises these materials, introducing them as secondary raw material into production cycles. This brings a number of related environmental benefits such as lower consumption of virgin minerals, lower consumption of electricity and gas and less need for imported materials, all of which contribute to a reduction of greenhouse gas emissions.

Other benefits that can be identified[57]:

- **Administrative and legal aspects:** Elimination of submission and processing fees to businesses until the applications have been resolved.
- **Tax benefits:** It would increase tax revenue from the last link in the recycling chain, and, at the same time, would discourage intermediaries whose benefits are generated by tax evasion, creating the space to encourage all operators in the chain to operate in compliance with regulations.
- **Improving competitiveness:** Through a regulated supply of raw materials coming for the valorisation of metal waste and, at the same time, the possibility of replacing imports, resulting in a positive effect on the balance of trade.

56 Ibid
57 Ministry of Production and Work, Sustainable Development Unit, Technical report on VAT exemption for the sale of recycling materials, 2019.

14. Recommendations for implementation

To facilitate the implementation of the proposed measures, the first requirement is to inform all involved industrial sectors about the concept of resource efficiency and the importance of its application to contribute to emission reductions and achieve more sustainable and competitive production.

The next requirement is to put in place a communication plan directed at, on the one hand, the relevant trade and industry associations, and on the other hand, government bodies, to inform about all the proposed measures so that they can participate in their implementation.

As a third step, to set up workshops creating space for dialogue and consensus between official bodies (in the governmental and legislative spheres) involved with each measure, academics, technology experts, industrial sectors and all interested parties who might be able to provide information on technical and economic aspects of each proposal.

Finally, once the measures have been discussed, and with the consensus between all intervening players, the implementation phase could be set in motion in accordance with the scope of each measure:

- **For Measures 1 and 2**, cooperation between the Ministry of Science and Technology, academia, technology centres, the Agency and the businesses in the relevant sector to advance the research and development of lighter components that will be used as replacements.
- **For measures 3 and 4**, work with government (Ministry of Economy) to implement incentives such as a trade-in programme and finance that will contribute to the replacement of farm machinery, trailers and semi-trailers.
- **For measures 5 and 7**, a study from the Argentine Standardization and Certification Institute (IRAM) to develop technical standards on spent foundry sand and on the classification of metal swarf.
- **For measure 6**, work with government (Secretariat for Industry and Productive Development and the corresponding secretariat in the Ministry of the Environment and Sustainable Development) to develop a regulation allowing the use of spent foundry sand as secondary raw material.
- **For measure 8**, work of the national administration with the legislative and executive branches in the provinces to harmonise legislation to free up impounded vehicles.
- **For measure 9**, debate and approval by the Congress of the bill modifying national tax law.


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Conclusions

The objective of this paper has been to *"contribute to the debate on public policies in Argentina to help achieve greater efficiency in the use of resources and the decarbonisation of the metal industry"*, proposing a number of legal, technological and economic measures focussed on the use of secondary raw materials and the replacement of certain alloys with stronger alloys that would allow the manufacture of lighter components.

The process of defining the proposed measures included a general survey of the metal industry that yielded information on its evolution over the years and on its current situation. On the basis of this information, the sectors or sub-sectors in the metal industry with the greater opportunities for decarbonisation in line with this project were identified. From this point, a selection of sectors in the metal industry is made, taking the foundry sector as a primary producer of ferrous and non-ferrous alloys, the trailer and semi-trailer sector, the farm machinery industry. Based on the analysis of the data obtained, different measures are proposed. These are then discussed with relevant leading figures in the public and private sectors, development of standards, academia and research.

These interactions produced very important contributions to the paper, and the responses received made it possible to refine the measures, define their viability and validate them. Although the measures are at an early stage of development, these interactions have allowed the creation of essential spaces for discussion to take coordinated action to bring about the decarbonisation of the metal industry, and to adapt and apply tools, regulations and incentives to extend widely the application of the measures.

The initial conclusions of the paper suggest the following:

- A reduction of the country's emissions could be expected from the implementation of the proposed measures. This would translate into a contribution by Argentina to the commitments made with the second nationally determined contributions[58] submitted to the United Nations Framework Convention on Climate Change (UNFCCC), concerning greenhouse gas emissions by the year 2030.

- The proposed measures are intended to contribute to an efficient use of resources and to the decarbonisation of the metal industry, resulting in less pressure on the environment and on climate change. They propose an increase of recycling to reduce the use of non-renewable resources (lower requirements of virgin mineral), which translates into a positive impact on the environment. In addition, some of the measures involve

58 The nationally determined contributions (NDC) are the commitments made by the countries that are party to the United Nations Framework Convention on Climate Change (UNFCCC). NDCs must be implemented to intensify action against climate change, either to reduce greenhouse gas emissions or to adapt to the impacts produced by this phenomenon.

technological development which can bring economic benefits to the country's metal industry, increasing the opportunities in both national and international markets.

- Although the implementation of the measures is considered to be technically and economically viable, for some of them, modifications to legislation or new legislation are required, which means that the implementation could be delayed in the absence of consensus. However, the presentation of and debate on these proposals must be advanced as a first step towards achieving the objective.

- Key social players from both the public and private spheres (industry, academia, science, technology, legislative organs, etc.) must be involved. It is this joint commitment that can foster projects focussed on the design and development of alloys, the manufacture of new products to produce equipment, the necessary changes to industrial processes, the introduction of secondary raw materials that increase recycling rates, etc., all of which contribute to reducing greenhouse gas emissions.

- It is essential that the Government is involved and sets out public policies intended to implement the proposed measures for the metal industry. Argentina has made an important commitment and faces challenges to reduce greenhouse gas emissions and promote the efficient use of resources. This can be a great opportunity to advance significantly the economic development of the country.

- Due to the difficulty in accessing some quantitative information on the industry's value chain, some of the calculations for the reductions of greenhouse gas emissions are approximations. Further specific studies will be necessary to obtain information of better quality, to be more precise and able to quantify the actual impact of the proposed measures.

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