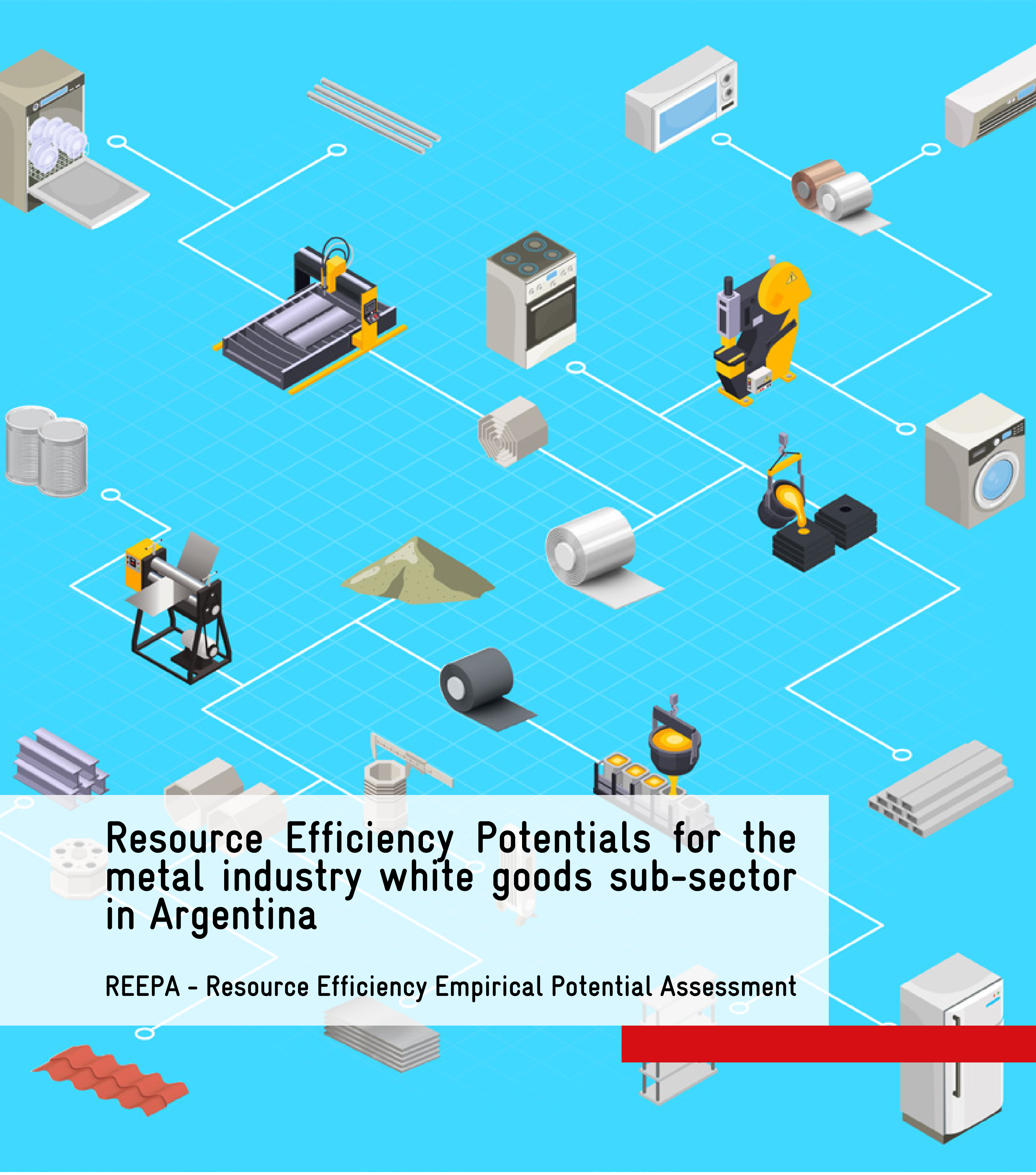

Resource Efficiency Potentials for the metal industry white goods sub-sector in Argentina

REEPA - Resource Efficiency Empirical Potential Assessment

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International Climate Initiative

This paper has been prepared on behalf of the global Initiative for Resource Efficiency and Climate Action project (IREK II) implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH as part of the intergovernmental cooperation between Argentina and Germany.

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).

It focuses on cooperation with selected emerging G20 countries that present resource efficiency challenges and opportunities.

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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What others say

The resource-climate nexus has been broadly discussed and analysed at macro, meso, and micro levels. Various strategies for increasing the efficiency of metal production, known as one of the main contributors to climate change, have been presented based on selected case studies. The innovative REEPA method stands out as a promising solution, likely to significantly boost resource efficiency and easily transferable to other sectors. This method, with its focus on measures associated with products, processes, and the manufacturing environment, can serve as a valuable tool for both businesses and policymakers in making effective decisions and contribute to sustainable development goals.

Prof. Dr. Joanna Kulczycka

Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Board member at International Resource Panel (IRP)

The IRP data showed that the demand for materials in the Global North and Global South has been centred on household and infrastructure consumption, respectively. Even if the Global South focuses on infrastructural activities, the relatively higher population growth has correlated to the household appliance demand. This manuscript is timely in targeting the white goods metal sector as it provides guidance on a comprehensive procedure model for the semi-empirical potential assessment of RE measures. Set in the Argentine metalworking industry, its method and concrete application can be benchmarked. While productivity is key to resource management, system design such as shared economy and product-service systems could be helpful in this product line as well. IRP promotes and supports system thinking in sectors that are impactful to the three major global threats.

Dr. (Anthony) Shun Fung Chiu

University Fellow, De La Salle University (Manila), Board member at International Resource Panel (IRP)

With its 2020 report "Resource Efficiency and Climate Change", the International Resource Panel (IRP) highlighted the material-climate nexus and spread the potential of material efficiency strategies to a wide audience. Inspired by the report, this present work aims to contribute another piece to the puzzle of identifying and prioritizing resource efficiency (RE) strategies in manufacturing industries. The REEPA (Resource Efficiency Empirical Potential Assessment) process model described here combines material flow analysis with an empirical assessment by experts of resource efficiency potentials in the household appliances subsector of metal processing industry in Argentina. Thus, analytically quantified flows of climate-relevant material groups in a well-defined system are related to concrete, promising RE measures – such as optimized design – resulting in robust figures on greenhouse gas (GHG) reduction potentials.

Keisuke Nansai

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In this timely and much-needed report, the authors reframe conversations concerning climate change, biodiversity loss and pollution to take into account resource efficiency as a strategy for addressing all three. They do this by recognizing a sometimes overlooked but critical challenge: resource scarcity. Global demand for natural resources is expected to nearly double from 100 billion tonnes today to 186 billion by 2050. Though focused specifically on the flow of flat steel into "white goods" manufacturing, the study introduces an approach that could be applied much more broadly. It sets a practical foundation for assessing and improving resource efficiency within the entire metal industry, which is one of the most impactful sectors in terms of material extraction and processing. A very welcome contribution towards a more sustainable industrial system.

Nabil Nasr

PhD, IISE Fellow, Associate Provost for Academic Affairs & Director, Golisano Institute for Sustainability Rochester Institute of Technology, Board member at International Resource Panel (IRP)

There is a need to tackle non-energy related emissions through material efficiency measures in resource intensive industrial sectors, as well as supply chains which require the use of cement, steel and plastic, standing both as a challenge and a promise. However, the lack of simple, systematic approaches for the differentiated evaluation of individual material flows and their resource efficiency savings potential, especially for complex products, makes it difficult to prioritize suitable resource efficiency strategies. The present study describes a simple yet robust procedural model that can be used to empirically determine quantitative and qualitative saving potentials through resource efficiency of specific material flows in relation to relevant sectors.

Smail Alhilali

Chief Division of Circular Economy and Chemicals Management, Directorate of Technical Cooperation and Sustainable Industrial Development, UNIDO

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An increase of operational resource efficiency offers several economic advantages for companies: cost savings in material and energy consumption, an increased competitiveness, the opportunity to enter new markets and secure jobs, while reducing the burden on the environment and thus contributing to positive feedback on the corporate image. The study identifies potential measures to improve resource efficiency and reduce GHG emissions in the white goods sub-sector. It highlights certain measures linked to product development and others related to production processes more directly associated with a remarkable reduction of GHG emissions. Due to the possible transferability of these measures, the findings of the study may also be of great interest to other sectors of the manufacturing industry.

Maximilian Müller

Senior Consultant, Resource Efficiency at VDI Center for Resource Efficiency (VDI ZRE), Berlin

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Foreword

The entire world is currently in the midst of unprecedented environmental challenges. Three global crises stand in the way of reaching the Sustainable Development Goals: climate change, biodiversity losses, and contamination. These crises are directly related to the prevailing unsustainable patterns of consumption and production. Any strategy designed to mitigate climate change, protect biodiversity, and reduce contamination must therefore imply changing these patterns.

Along these lines, the International Resource Panel (IRP) has emphasized the need to de-couple economic growth from intense resource use and the impact these uses have on the environment. As demand increases at unsustainable rates, the efficiency with which natural resources and materials are used is therefore a key tool.

Global material extraction (including biomass, fossil fuels, metals, and non-metallic minerals) has increased from 30 billion tonnes in 1970 to an expected 106.6 billion tonnes by 2024, resulting in an average annual growth rate of 2.3% based on soon-to-be-published data from the IRP in Global Resources Outlook 2024.

This challenging situation introduces a new variable: access to scientific evidence and the subsequent use of this data for political and regulatory decision making. Reliable data are key to political planning and development. Strong indicators are also required to measure progress in decoupling material use and its environmental impact from economic growth, proposed by the IRP.

In line with the above, we have observed how strategies have been designed and programmes implemented across the world that integrate sustainable natural resource management into national development plans. An increasing number of countries have passed laws and applied political and regulatory frameworks to support resource efficiency that in turn focus investment on greener economic sectors.

This report aims to verify the potential, relevance, and viability of improving resource efficiency in the metal industry; it aims to shed some light on the information that would be needed to facilitate decision making by the varying players in the production ecosystem.

We invite both our specific target audience and the general public to read this report and consider its recommendations.

Preface

The world's population has doubled in the last five decades, while material extraction has tripled, and gross domestic product across the globe has quadrupled. This situation accelerates climate change, biodiversity losses, and contamination, all of which are associated with unsustainable patterns of consumption and production.

Resource efficiency can therefore help to provide answers to these crises as it aims to reduce the pressure placed on the planet and mitigate climate change. However, enough reliable data on material flows and potential savings is not always available to guide decision making and the development of policies and instruments that prioritise the industrial sectors and material resources which generate the most greenhouse gas emissions.

Information is available for some sectors (particularly base products such as cement and steel) to help decision making and can even be used to compare products made in different parts of the world based on resource efficiency throughout the entire production process. However, would it be possible to estimate the efficiency with which materials are used to produce more complex products, such as those with multiple parts and different materials?

Resource efficiency is generally defined as the relationship between the starting materials (input) and the final product (output). More complex products involve multiple parameters that are not always comparable and this definition reaches its limits. In order to prioritise resource efficiency measures in a relatively straightforward way, we have deliberately focused on flows of materials that are relevant for climate change and we have related them to meaningful resource efficiency measures determined empirically.

We have focused on the white goods sub-sector in this study which includes household appliances such as washing machines, refrigerators, and kitchen appliances as this has been one of the most economically dynamic sectors in recent years and is part of the top three sectors that contribute to climate change, the metal sector. Furthermore, we have selected cold rolled steel sheet as the material that is most relevant for this assessment.

We have associated flows of the selected materials with resource efficiency potential across all links in the supply chain (from raw material production to final production consolidation) by interviewing experts in the sector. The Resource Efficiency Empirical Potential Assessment (REEPA) working methodology was then systematised to direct the efficiency potential assessment in a way that is fast and cost-effective for the various links in the supply chain.

The REEPA method has proved to be straightforward and robust.

> **We carried out fieldwork to identify that rolled steel sheet in the white goods sub-sector has the potential to increase its resource efficiency by up to 15%.**

This potential is mainly related to product development measures, which can be combined and used to improve other measures related to production processes. The results of this assessment can be used by key players in the public and private sector to develop policies and instruments that promote resource efficiency and to further the adoption of solutions that take advantage of efficiency potential within companies.

Introduction 01

What does Resource Efficiency mean?

Resource efficiency is a broad term that includes materials, water, energy, and land. The IRP defines the concept as the achievement of the best results with the least amount of resources, and indicators such as resource productivity (including GDP/resource consumption) can be used to reflect this.

The term covers de-materialisation (material and energy reduction and savings) and re-materialisation (reuse, repurposing, and recycling) strategies with a systemic focus on the circular economy. Resource Efficiency has been identified in three of the Sustainable Development Goals (SDG). In addition, SDG6 references the efficient use of water and SDG7 relates to energy efficiency (Naciones Unidas, 2015).

Goal	Target
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. →	Target 8.4: Improve progressively through 2030 global resource efficiency in consumption and production, and endeavour to decouple economic growth from environmental degradation...
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable. →	11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change...
Goal 12: Ensure sustainable consumption and production patterns. →	Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources.

What does resource efficiency mean for the production sector?

Resource efficiency in the production sector focuses on meeting a predetermined production target (output) with the minimum input. The concept involves searching for technical strategies, business models, consumer preferences, and political instruments that lead to a substantial reduction in the high-volume materials produced and the energy consumption required to ensure human well-being (Allwood, Ashby, & Gutowski, 2013). These materials include biomass, fossil fuels, metals, and non-metallic minerals.

What resource efficiency strategies can be applied in this industry?

The Resource Efficiency Centre at the German Association of Engineering proposes that resource efficiency among companies from several fields can be improved from a technical point of view.

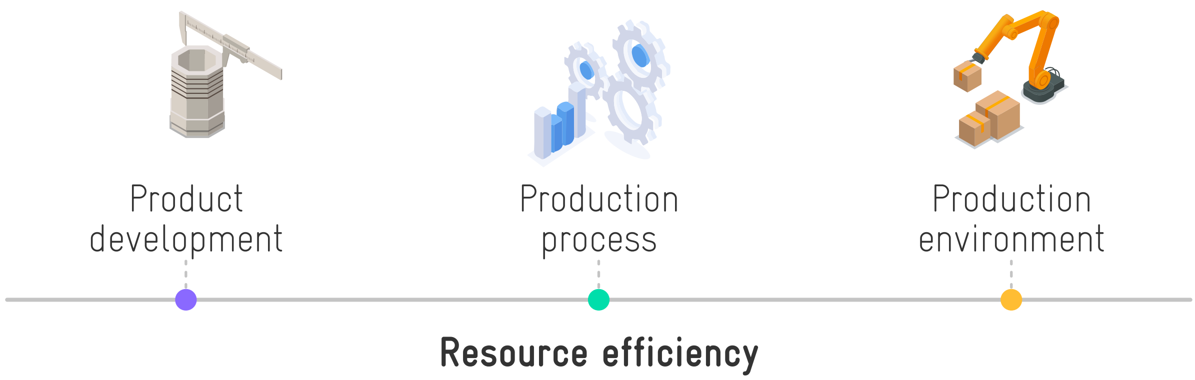
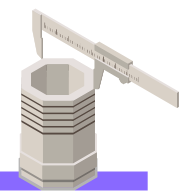


Figure 1. Application of resource efficiency

It should be noted that changes in one field can influence processes in other fields. Therefore, the entire flow of materials and production must always be considered.

What measures are related to the "product development" field?



Strategies and measures related to products are focused on the development phase and influence product characteristics. They generally focus on promoting less material use from design, replacing materials, extending the service life of the product, or facilitating product reuse and recycling. However, companies cannot always decide on the product design as its specifications are determined based on customer requirements and they can sometimes be difficult to adapt or put into practice.

This field includes measures such as:

- Product redesign
- Miniaturisation
- Design to recycle
- Design to repair
- Material replacement

What measures are related to the "production process" field?

Strategies and measures related to the process cover process optimisation and internal recycling. Process optimisation involves three fundamental measures that include the following examples:

- optimising process parameters
- improved/efficient process management
- developing and implementing new processes

What measures are related to the "production environment" field?

Strategies and measures that are independent of products and processes are those described as being part of the production environment. They include, among others:

- Storage and stockpiling arrangements
- Reducing transport
- Decreasing maintenance

What is the motivation behind this study?

As noted, resource demand is increasing at alarming rates. It is expected to surpass 100 billion tonnes in 2024 and it is estimated that raw material consumption will reach 186 billion tonnes by 2050. Continuing along these lines increases the probability that we alter how our planet's natural systems and climate work in an irreversible way.

According to the IRP, the proportion of greenhouse gas (GHG) emissions associated with material production increased from 15% in 1995 to 23% in 2015, which in absolute terms is an increase from 5 Gt of CO2eq to 11 Gt of CO2eq, more than double. The most significant material groups in terms of emissions are metals (4.8 Gt), non-metallic minerals (4.4 Gt), and plastics such as rubber (1.5 Gt) (IRP, 2020).

The management and treatment of these materials are therefore of the utmost importance when developing and implementing climate strategies.

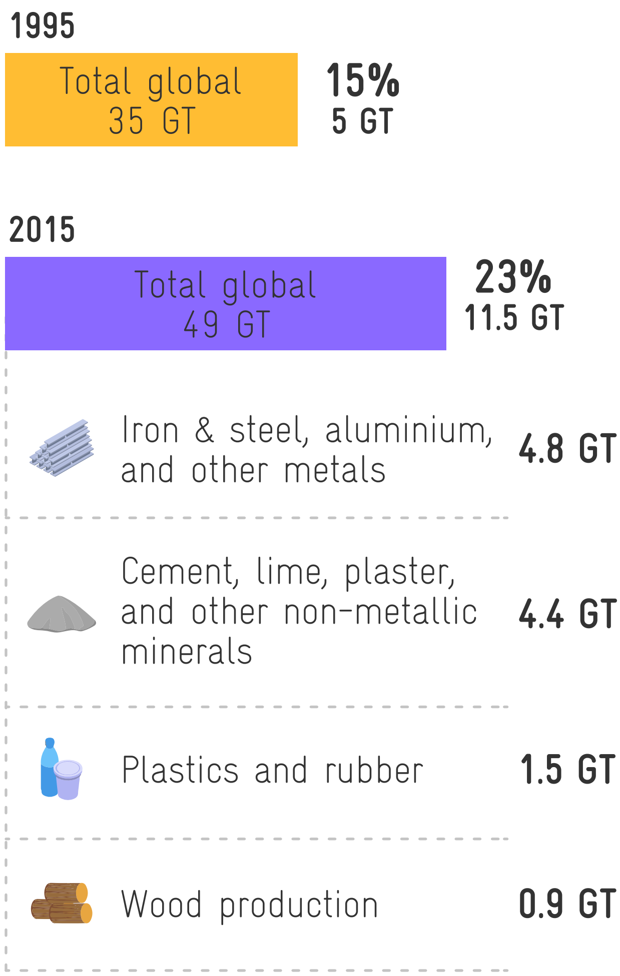


Figure 2. IRP. Emissions from material production as a proportion of global emissions in 1995 and 2015.

Tackling the problems associated with climate change is one of the most pressing challenges of our time. As highlighted by the Intergovernmental Panel on Climate Change (IPCC), global warming is likely to exceed 2°C by the end of the 21st century if additional initiatives are not adopted to reduce GHG emissions. Reaching the targets set out in the Paris Agreement and capping global warming to 1.5°C or "significantly less than 2°C" is a global challenge that requires a long-term commitment and serious efforts must be made by many different sectors, which includes developing resource efficiency strategies (IPCC, 2018).

On the other hand, emerging markets within the G20 are showing strong industrial growth and an increase in both resource consumption and GHG emissions. Material use in G20 countries is expected to increase from 65.4 billion tonnes in 2015 to 142.2 billion tonnes in 2050 if current trends continue (IRP, 2018).

In this context, key players and authorities on the matter recognise that mitigation strategies and measures must be developed in a sustained and systematic way if they are to be effective, and be based on material flows, their climate relevance, and potential to reduce GHG emissions, among others.

Our experience with activities in the metal industry in the "Initiative for Resource Efficiency and Climate Action (IREK II)" project, implemented by the German Corporation for International Cooperation (GIZ), provides an opportunity for further study on describing and analysing the flow of materials that are relevant to climate problems. This particularly focusses on steel sheet metal and we have systematised this study in a specific work procedure.

The understanding of practical resource efficiency strategies identified as part of the training activities developed by the Argentine Metal Industries Association (ADIMRA) within the framework of the project and with the support of the Resource Efficiency Centre (ZRE) at the German Association of Engineering (VDI) contribute towards this analysis. Integrating this knowledge into the fieldwork will allow us to assess the resource efficiency potential and define a starting point to later estimate the potential to reduce GHG emissions.

What are the characteristics of this study?

The aim of this study is to develop a demonstration case in which the importance, viability, and proportionality of the applied method can be verified based on flows of relevant semi-finished products (input materials, rolled steel sheet) for the white goods sub-sector within the metal industry. The study does not attempt to provide an overview of all material groups or sectors throughout the value chain of the selected product group, rather it considers the flows of a specific material. To this end, it should be noted that material flows from individual companies are not considered, as the material flows for the sector as a whole are analysed.

This analysis applies to the sector under study and within the limits of a system set-up to assess flows of the selected material, covering its specific flows. Therefore, this analysis does not cover final products made using the selected material (rolled steel sheet) due to the complexity of such products and the variety of other materials they contain. Resource efficiency can be described as an economic principle, in this sense the minimum economic principle where the aim is to obtain a certain output with the minimum input. In this study we have applied this principle by only considering the selected materials used to obtain in-process products and/or parts, not the final products of the chosen sector.

Due to the pilot nature of this study, based on the novel REEPA method, we paid particular attention to describing the study procedure in a way that would allow it to be transferred to other sectors and material groups, after taking empirical observations and expert opinions into account.

What are the objectives of this study?

Overall objective: to provide recommendations for improved data management in the area of resource efficiency in the metal sector as a way to contribute to mitigating the effects of climate change in a way that such data can be used by key players in the public and private sectors.

Specific objective 1

To develop a working methodology for data management in the field of resource efficiency assessment.

Specific objective 2

Qualitatively and quantitatively assess the resource efficiency potential in the metal industry for the specific case of the selected material.

What were the working hypotheses? (H: working hypothesis)

Hypothesis for Specific Objective 1

H1. The resource efficiency potential of a given subsystem can be assessed qualitatively and quantitatively with a simple and limited procedure.

H2. This methodology can be extrapolated to any sector where the resource efficiency potential of a subsystem is to be assessed.

Hypothesis for Specific Objective 2

H1. Flat steel products for the white goods sub-sector have a resource efficiency potential of more than 5%.

H2. The resource efficiency potential can be assessed with the proposed methodology by considering the subsystem processes of cutting and forming steel sheet for cabinets used in the white goods sub-sector.

02

Procedure model – "REEPA – Resource Efficiency Empirical Potential Assessment"

Where to begin?

Any organisation, project, customer, or client can study the resource efficiency potential of a particular material from a specific production sector using the REEPA model described in this chapter.

The first step consists of setting up a working team of experts that cover the requirements for developing and completing the study, particularly those related to the material and the production sector under study. In a first approximation, a minimum team is comprised of a Project Manager, an expert in the material flows for the sector, an expert in resource efficiency potential for the sector, an expert in scientific methods, and an institutionalisation expert, as set out in Figure 3. An external reviewer with expertise in the sector and/or material under study is recommended as this would add value to the project.

Acronym	Role
PM	Project Manager
MFE	Expert in material flows for the sector
REE	Expert in resource efficiency potential for the sector
SME	Expert in scientific methods
IE	Institutionalisation expert

Figure. 3 Role definition

This team is responsible for defining the scope of the study, setting out a roadmap with a detailed timetable, and defining the information, documentation, material, and contact requirements to complete the proposed activities correctly. This information should be validated by the client. See details of the procedure in REEPA - Resource Efficiency Empirical Potential Assessment.

What are the next steps?

A 4-phase procedure to carry out the study is implemented once the scope of the study and detailed timeline with milestones and deliverables have been agreed upon. The 4 phases are: initiation phase, material flow and data management phase, resource efficiency potential assessment phase, and information consolidation and preparation of the final report phase. An outline of the proposed procedure model is provided in Figure 4.

01 Start: more precise definition of system boundaries

02 Analysis of pertinent material flows

03 Empirical study on material efficiency potential (Structured according to the following strategies: recycling, optimised production, optimised design)

04 Compilation, evaluation and contextualisation of the results, formulation of recommendations for action and description of method

Figure 4. Outline of the proposed procedure model

01 Initial phase

This phase involves preparing all the study tasks. It includes defining the system boundaries (sector(s) and material(s)) as well as agreeing on how the work is to be performed using specific management platforms and discussing and exchanging ideas on the proposed method to carry out the study. The working hypotheses should be established at this point, and a robust and systematic methodology should be agreed upon that defines and substantiates each of the criteria adopted. It must be possible to validate and replicate the methodology by maintaining the fundamental concepts and criteria.

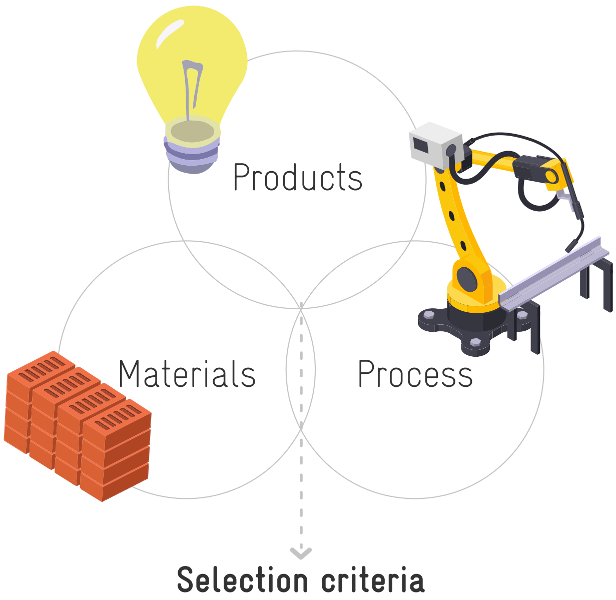
System boundaries

The boundaries of the system to be assessed should be defined so that reduced models can be used that simplify the analysis. In this sense, the proposed methodology involves selecting representative sub-sectors within the sector to be assessed and describing criteria for this purpose.

Likewise, the types of products and materials to be assessed as well as their transformation processes should be selected for the chosen sub-sectors, stating the criteria to be used. Some of these criteria could be associated with: availability of public information, impact of the selected product on the market, amount of material used, etc.

Some relevant criteria related to the materials are: volume of material produced and used, availability of public information, material origin (domestic or imported), qualities involved, etc.

Criteria relating to manufacturing processes include the impact of such processes on the amount of scrap generated, information availability, etc.

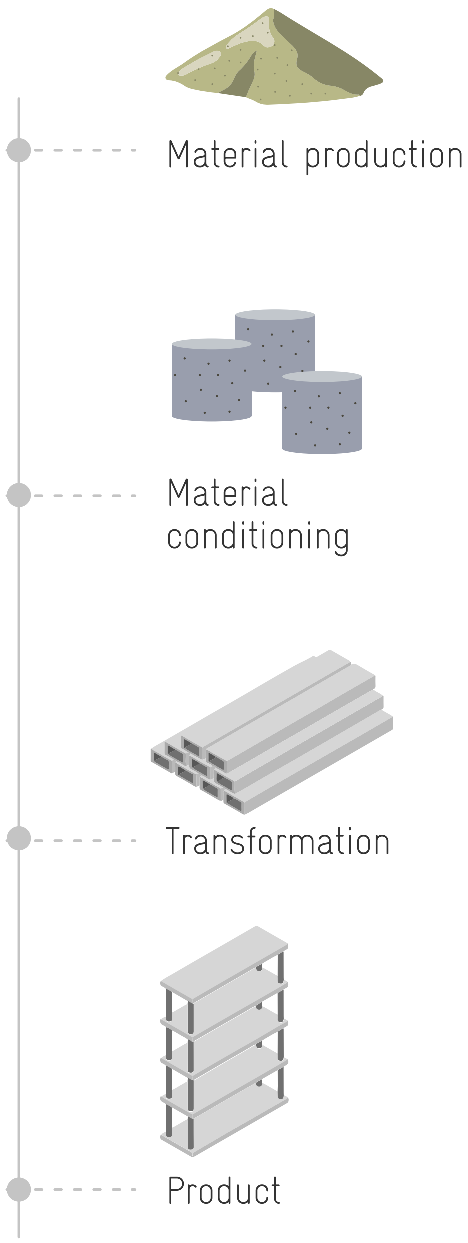


02 Material flows and data management phase

This phase involves: a) qualitative and quantitative description of the selected materials according to the defined system boundaries; and b) development of the value chain. It also involves describing the data collection procedure and producing a list of information sources (existing sources and any ad-hoc sources). The data collection procedure should be agreed with the client and validated by an external reviewer.

The material flow must be described from the point the material is produced, covering its treatment and transformation to a finished product within the specified system boundary.

In general, public information sources on the material flow that can be referenced should be used. These sources could be statistical data and reports on the sector, information from chambers of commerce, companies (particularly those producing the material), reports from government bodies, etc.



03 Material efficiency potential field study phase

This phase comprises analysing and selecting potential resource efficiency measures (product development, production process, production environment) for the system under study (with its selected sub-sectors, materials and processes). The field study should be carried out using two levels of consultation tools: one general wide-scale level, and another that is aimed at experts who provide specific information through personal interviews.

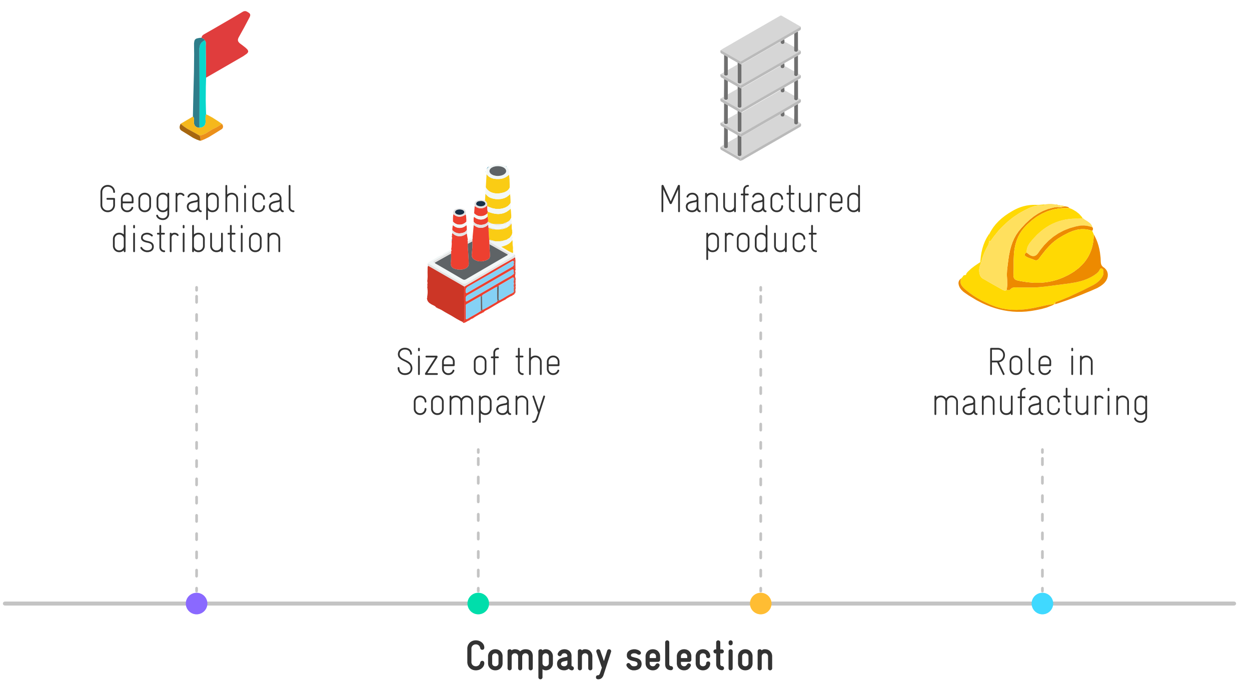
A document should be prepared describing the rationale, objective, and form in which this consultation is to be carried out that can be used in the interviews and questionnaires. This document should contain a form to be filled out by the people consulted containing questions on the impact levels of various resource efficiency measures that are grouped according to the type of resource efficiency measure being considered (product development, production process, production environment). Examples should also be provided for each set of proposed measures to clarify the study approach for the person being interviewed and/or responding to the questionnaire. This document should enable them to select the type of measure that could be applied to increase the resource efficiency of the selected material for the defined sector, and also estimate the relative impact of such an increase.

In the first instance, the questionnaire form should be sent to as large a group of people/companies as possible with qualitative information to be filled out. This provides access to an initial survey with a larger sample size and faster response.

Initial ideas are developed based on the information gathered and a second more specific consultation process is carried out with companies and/or experts in the form of an interview. This is accompanied by a second questionnaire that asks for more quantitative details. This questionnaire should be sent to the interviewee prior to the interview to make the interview more focussed and efficient.

The companies and/or experts selected in both instances should be done following pre-defined criteria. Aspects such as geographical distribution, company size, the role played in manufacturing the product under study (producer of material under study, raw material conditioner, parts manufacturers, and parts suppliers, manufacturer of the final product where the material under study is used), and the type of product manufactured.

Chambers of commerce can be approached to provide information and facilitate contacts with these companies as part of the selection process. Public information can also be used to identify companies from each of the sub-sectors that are important for the study.



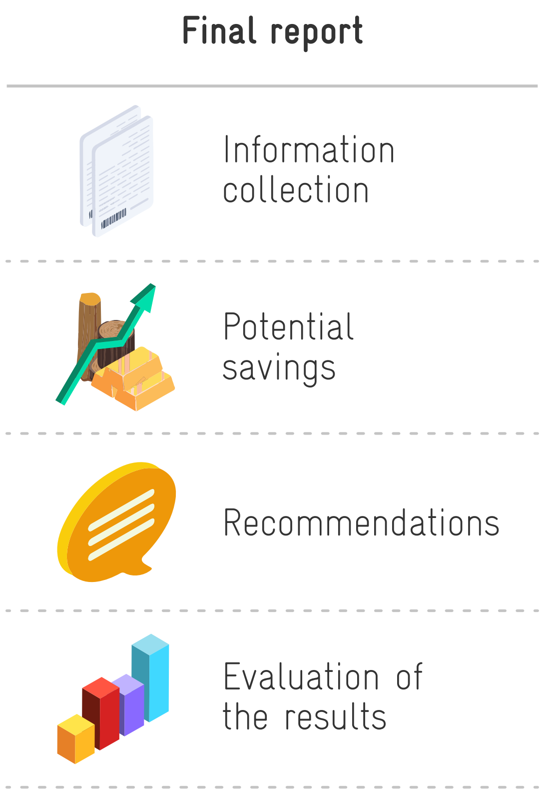
04 Compilation, evaluation, and contextualisation of the results and Final Report phase

The information collected is compiled in this phase and the results of the material flows and the potential savings of the resource efficiency measures are evaluated.

Recommendations for actions that could help with implementing the resource efficiency measures identified as having the greatest potential are also developed, both from a company level and within the business context, including policies and instruments to promote business development.

Following the initial assessment and evaluation, a “Preliminary Report” is produced (including preliminary infographics) and submitted to the key players interviewed for review; the aim is to guarantee the confidential nature of the consolidated information. This defines the first review process, from which the observations and contributions from the evaluators and experts are assessed and incorporated.

Following this step, the “Final Report” is developed (with final infographics). To conclude this phase, the final editing and design of the Study is then completed so it can be published and made available to key players and organisations to promote resource efficiency among the companies and within the sector analysed.



A preliminary list of the activities to be carried out in each phase of the study are provided below.

01 **Initial phase**	1.1. Define system boundaries 1.1.1. Define sub-sectors 1.1.2. Define material groups 1.2. Create the Roadmap 1.2.1. Agree on proposed study method 1.2.2. Establish technological platforms to be used 1.2.3. Produce the Roadmap
02 **Material flows and data management phase**	2.1. Select and describe materials 2.2. Describe the data collection procedure 2.3. Draw up a list of information sources 2.4. Agree on the data collection procedure with the client and validate it with an external reviewer
03 **Material efficiency potential field study phase**	3.1. Analyse and select resource-efficient measures for the selected materials/sectors 3.2. Draft survey forms (interviews/questionnaires) 3.3. Gather information through interviews with Key Players 3.4. Develop initial ideas based on the information gathered 3.5. Consult the interviewed experts/company representatives again to validate and expand on initial ideas
04 **Compilation, evaluation, and contextualisation of the results and Final Report phase**	4.1. Produce survey report 4.1.1. Evaluate the results of the material flow and resource efficiency potential surveys for the selected material/sector 4.1.2. Develop recommendations for action on data management for resource efficiency 4.2. Consolidate the Preliminary Report of the study 4.2.1. Produce the Preliminary Report 4.2.2. Send the Preliminary Report to key players (reviewers) 4.3. Produce the Final Report of the study 4.3.1. Update the final version of the study 4.3.2. Edit and design the Final Report

An Activity Diagram setting out the processes considered is provided in Figure 5.

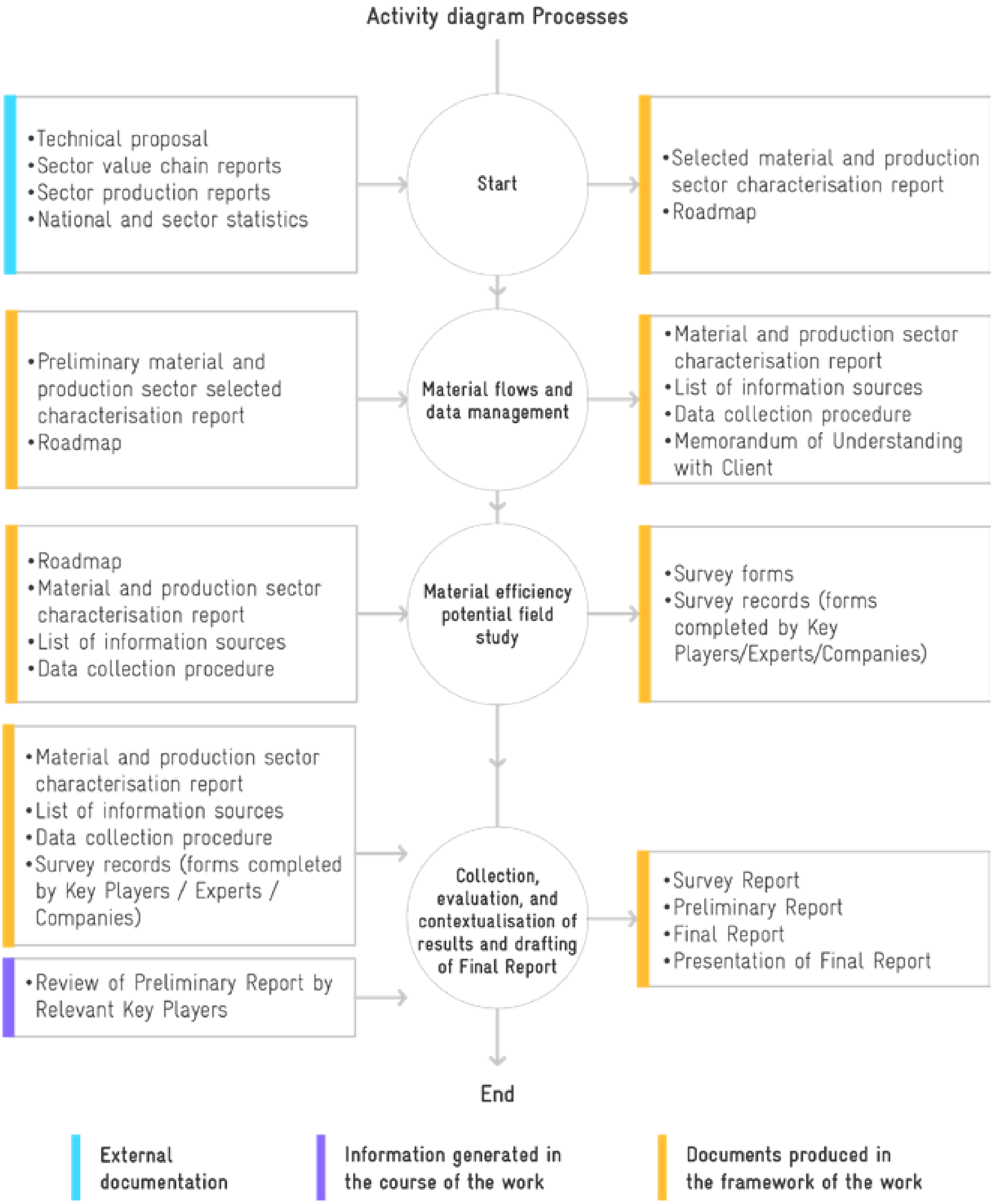


Figure 5. Process activity diagram

03

Definition of system boundaries

This case study aims to provide better data management to assess potential resource efficiency measures that can be applied to the metal sector. To do so, it would be appropriate to carry out the assessment on a reduced system by defining specific materials and the sub-sectors in which they are relevant.

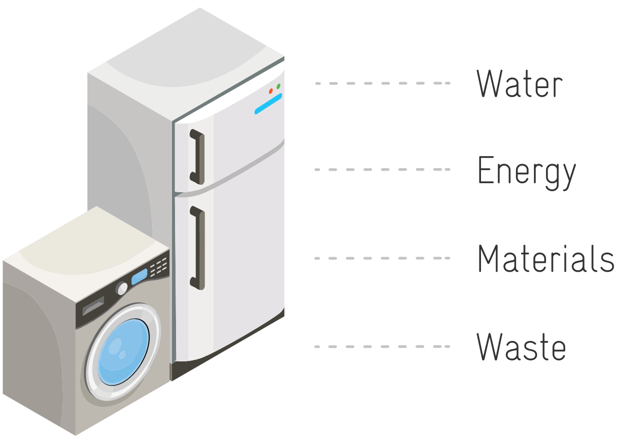
To do so, it would be appropriate to carry out the assessment on a reduced system by defining specific materials and the sub-sectors in which they are relevant.

What are the selected materials and production sectors?

Sub-sectors

The system under study within the metal product sector is limited to industrial processes associated with the white goods sub-sector (household appliances).

This sector has a relevant share in metal products manufactured in Argentina. It also encompasses a large number of processes and materials that impact the input resources used (water, energy, materials, etc.) and the waste streams generated. This sub-sector is also deemed to have significant potential for improving Resource Efficiency.



Materials

We have considered the flow of flat product materials used to obtain steel sheet with different coating processes. Note that steel manufacturers within the aforementioned production sectors have not been considered as part of this study.

In Argentina, the manufacture of this type of product involves the processing stages shown in Figure 6.

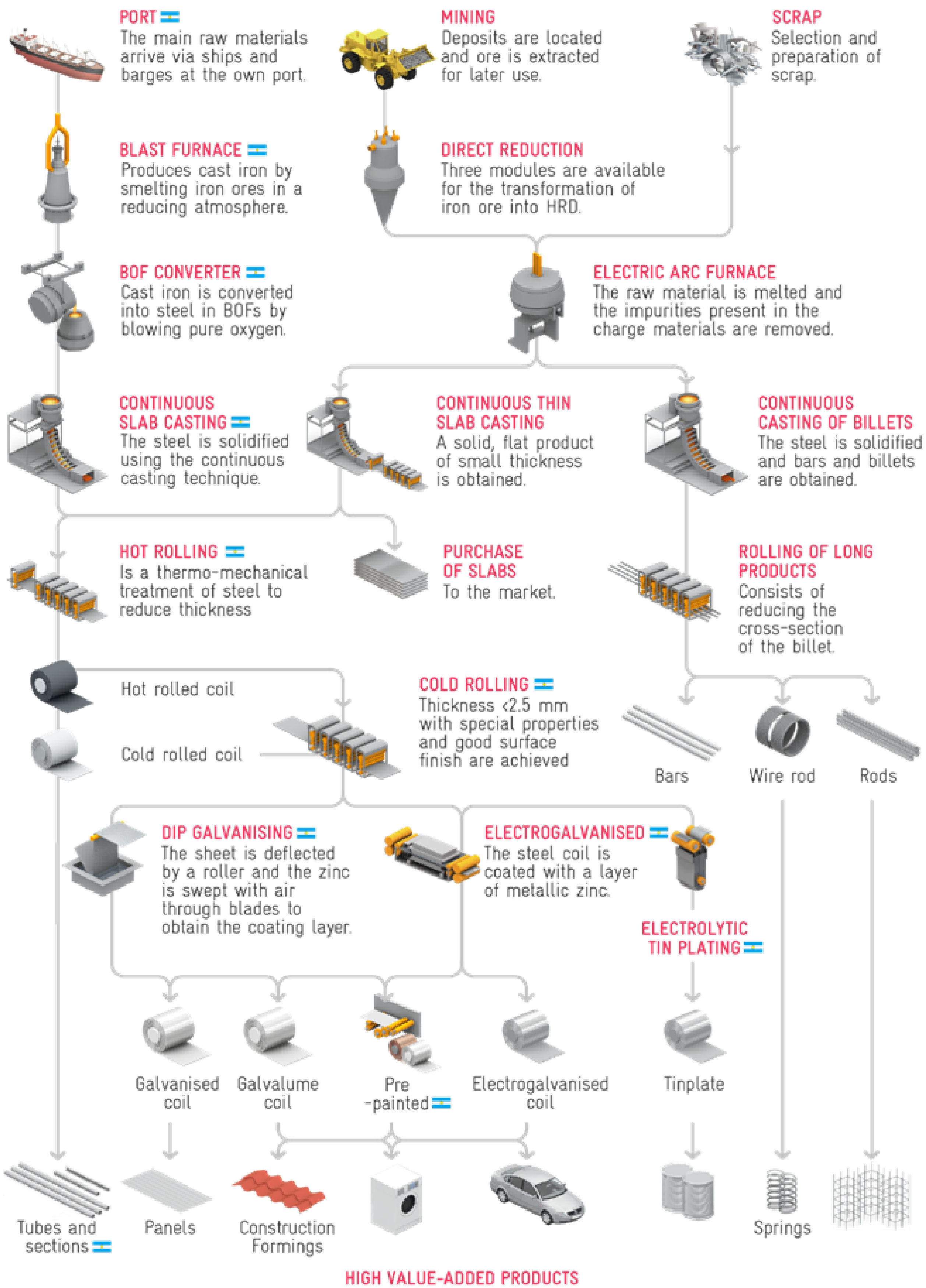


Figure 6. Processing stages to manufacture rolled steel products to be used in white goods applications, among others (Ternium, Online).

How is the production of rolled steel sheet characterised in Argentina?

As a frame of reference for the study, in 2022 a total of 5.09 million tonnes of steel were produced in Argentina, based on information from the Argentine Chamber of Steel. This includes hot-rolled and subsequently cold-rolled flat products, and semi-finished products used in several applications such as white goods, and sheet metal for vehicles, and agricultural and construction machinery. We have only considered the white goods sector in this study, which involves varying grades of steel: low carbon steel, and high, very-high and ultra-high strength steels (Cámara Argentina del Acero, 2023).

Ternium Argentina, the sole manufacturer of cold-rolled sheet in the country, reported in its 2022 Annual Report and Financial Statements (Ternium, 2022)that of the 2.4 million tonnes of flat-rolled products produced in Argentina in 2022, 2.3 million tonnes (95%) were used in the domestic market. Of these, 1.3 million tonnes of coated cold-rolled sheet were used in the domestic market, around 8% of which was used in the white goods sector, equating to around 100 thousand tonnes of coated cold-rolled steel sheet.

A distinction must be made between the use of coated and uncoated rolled steel sheet products used in the white goods sub-sector. Out of the total production of rolled steel products, 47% are coated steels, 50% are uncoated steels, and 3% are other semi-finished products (Figure 7). Note that coated steels include various types of semi-finished products: galvanised steels, zincalume/galvalume, electrogalvanised steels, and pre-painted steels.

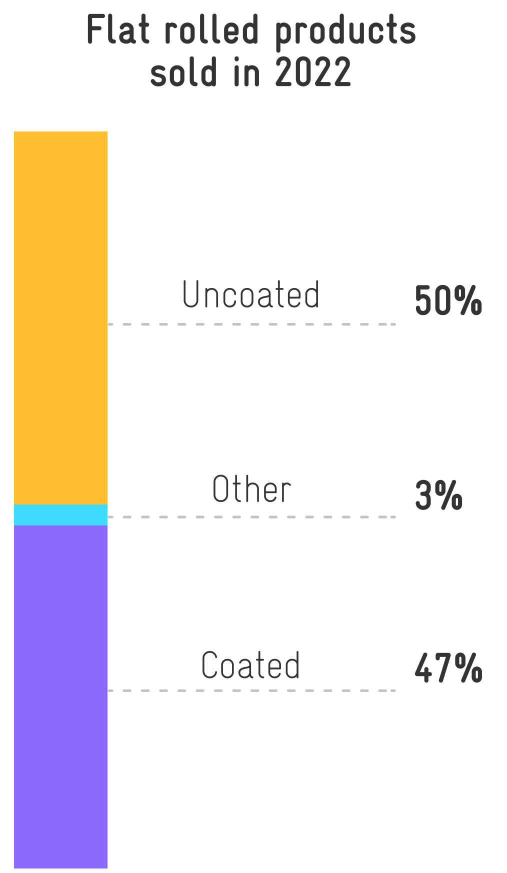
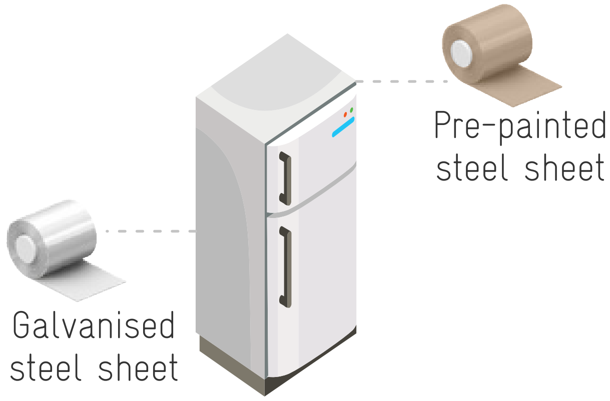


Figure 7. Distribution of rolled steel sheet products manufactured in Argentina

Coated steels are obtained by hot-dipping different types of alloys. With **zincalume/galvalume,** the product is dipped in an aluminium/zinc alloy on both sides. This process provides excellent corrosion protection for aggressive environments and gives a service life that is up to 6 times longer compared to standard galvanised products. It is suitable for subsequent forming or bending processes. The coating provides a combined barrier effect and galvanic protection that improves its performance in different applications.

With **galvanised steel** products, the sheet is hot-dipped in a bath of molten zinc. This produces a layer of zinc on the sheet which acts as a physical barrier between the steel and its environment, protecting it from rust and corrosion caused by moisture, air, and other environmental elements. **Electrogalvanised steels** are produced using an electrolytic process in which thin layers of zinc can be deposited on the sheet, and is particularly sought after by the automotive and white goods sectors.

Pre-painted sheet includes galvanised sheet (or zincalume) which is then put through a continuous painting process to provide a surface treatment that includes an anti-corrosion primer and a finishing coat of enamel. Pre-painted steel sheet has excellent corrosion resistance, flexibility, and aesthetic properties. The product is delivered with a film to prevent damaging the coating during forming and assembly processes. The film must be removed immediately to avoid transferring adhesive to the steel sheet and irreversibly damaging the coating. This procedure can be used to produce sheet in various colours.



Galvanised steel sheet and pre-painted steel sheet are the most commonly used in the white goods sub-sector.

How is rolled steel sheet processed in the white goods sub-sector?

With regards to resource efficiency potential, this study was limited to steel sheet **cutting and forming** processes (stamping, drawing, and bending) to manufacture products in the aforementioned sector.

A wide range of steels is used to manufacture household goods, most of which are coated steels. We have developed the diagram in Figure 8 based on information provided on Ternium's website (Ternium, Online) on the processes involved in obtaining materials to produce white goods.

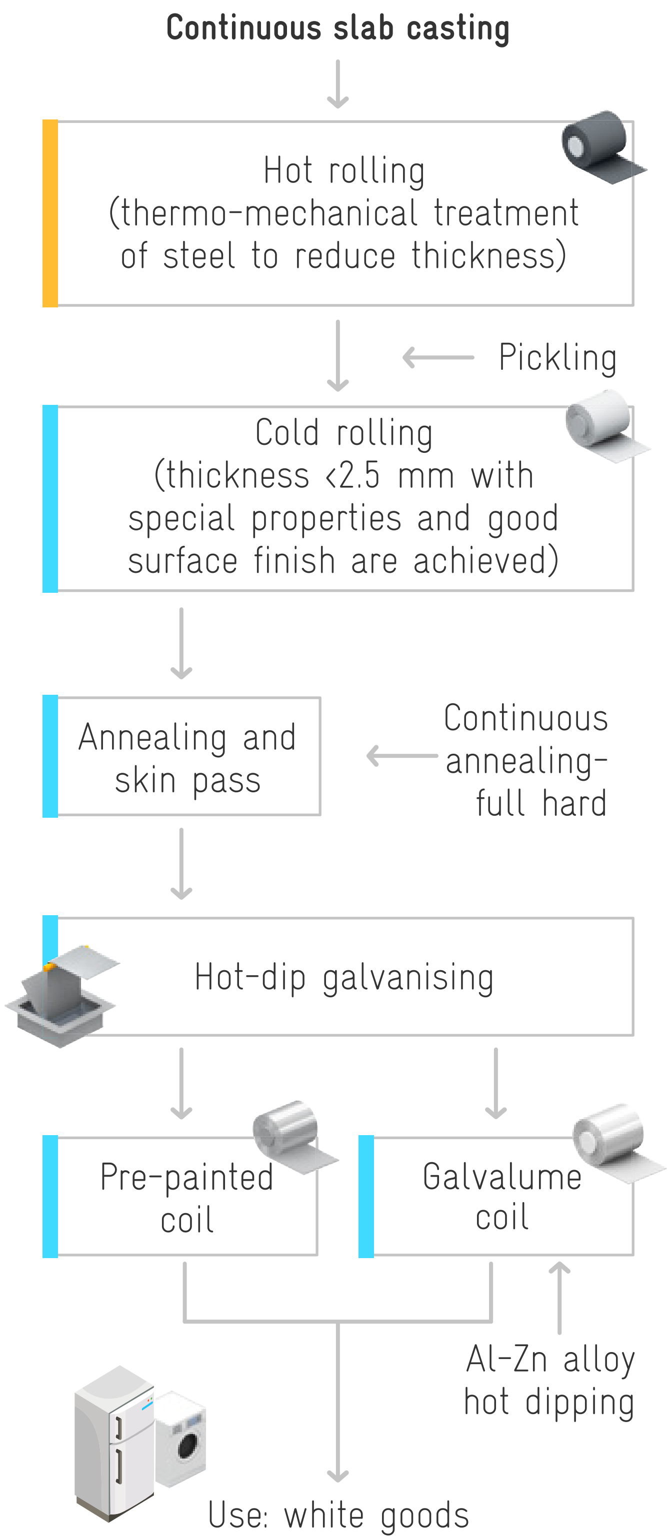
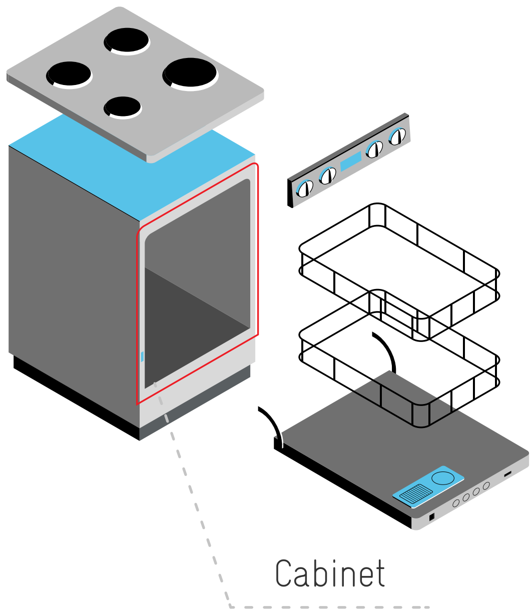


Figure 8. Processes involved in obtaining end-use steels for white goods

A **cabinet** used for certain household appliances is selected as a study component for this assessment on the white goods sub-sector as it is one of the parts that uses the greatest amount of sheet metal. The types of materials (alloy, thickness, finish, etc.) used for these components are also relatively homogeneous.



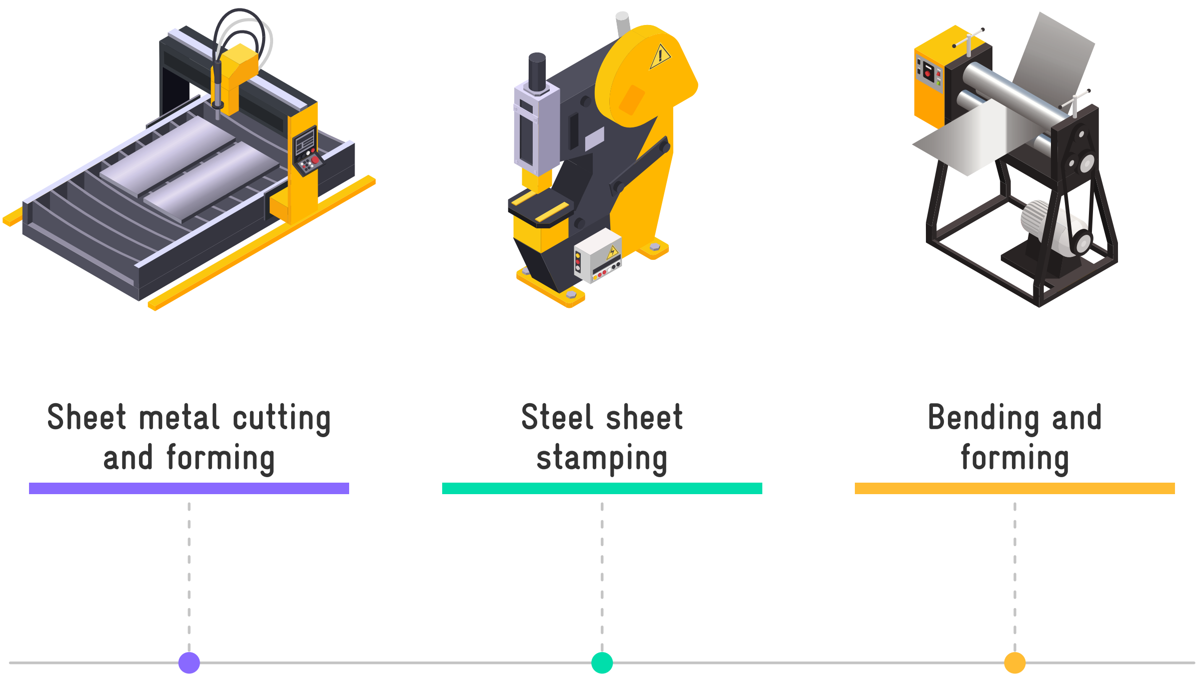
Cabinets are mainly produced with galvanised or electrogalvanised products that are pre-painted with special enamels. The materials are available in a wide range of colours to meet the requirements of industrial applications. These components often meet highly aesthetic demands in addition to general performance requirements. Steel products for them are supplied in coils with thicknesses of 0.40 - 1.24 mm and widths of 700 - 1220 mm.

Zincalume made with low carbon steel grades framed under the IRAM-IAS

U500-204/05 and 12 standards are generally used in this type of application; these standards define the mechanical properties, thicknesses, and characteristics of the coating. Electrogalvanised steels on the other hand are framed under the IRAM-IAS U500-70 and U500-254 standards.

The main processes to manufacture cabinets are:

- **Sheet metal cutting and forming:** firstly, sheets of steel are cut into panels according to the required dimensions and design to manufacture the cabinets. Cutting tools such as shears or lasers are used to obtain the desired shapes.
- **Steel sheet stamping:** the cut sheets are stamped in a process using the appropriate dies and punches. This is how individual parts such as the front, side and rear panels of the cabinets take shape.
- **Bending and forming:** once stamped, the sheets can undergo a bending and forming process to obtain the required final shapes. This involves bending and shaping the parts using forming tools and dies, ensuring that the parts fit together correctly and form the structure of the corresponding household appliance.



Processes in the manufacture of cabinets

Which product lines were selected for the study?

The material flow and the cabinet manufacturing processes (considering the aforementioned cutting and forming processes) were analysed for three white goods products. The following criteria were considered to select these products:

- number of units produced in the last year (2021)
- amount of material involved in the cabinet (estimate)

A comparative table of the number of units of different types of household appliances produced in the last few years is provided in Figure 9 (Ministerio de Desarrollo Productivo, 2022).

Period (year)	Gas ovens	Heaters and radiators	Washing machine	Dryers	Refrigerators	Freezers	Air conditioners
2012	855,249	400,403	1,444,799	535,211	897,123	333,989	1,548,830
2013	769,397	319,680	1,321,112	540,994	840,199	321,257	1,652,856
2014	656,100	256,031	1,048,467	461,070	645,166	291,998	1,432,759
2015	872,912	517,460	1,519,945	580,959	1,125,509	245.678	1,787,993
2016	713,564	819,783	1,143,024	521,396	879,395	160,595	1,141,636
2017	857,287	863,736	1,327,578	515,300	1,003,461	214,014	1,049,747
2018	645,072	667,734	894,131	353,657	678,017	134,632	1,193,775
2019	572,900	640,246	855,826	275,341	574,477	84,733	785,297
2020	435,829	562,751	816,538	252,052	624,801	106,988	891,776
2021	613,920	786,012	1,065,556	304,531	878,539	180,311	1,430,537

Figure 9. Number of household appliances produced in Argentina in recent years
Source: Ministry of Productive Development 2022 based on data from the Argentine National Institute of Statistics and Censuses (INDEC).

As can be observed, the most produced appliances in 2021 were Air Conditioners (1,430,537 units), Washing Machines + Dryers (1,370,087 units), Refrigerators + Freezers (1,058,850 units) and Gas Ovens (613,920 units).

To assess the amount of material used in the cabinet, the surface area of a standard product for each category was considered, taking into account the volume of each product. These dimensions were taken from product data sheets which is public information (Electrolux, Online) and (Eskabe, Online).

The dimensions of the cabinets and the sheet metal surface for the different products analysed are shown in Figure 10.

Product	Make / Model	Dimensions (m)			Cabinet surface m2/unit
		Width	Height	Depth	
Washing machine	Electrolux ELA06W	0.6	0.85	0.55	2.61
Refrigerators	Electrolux DFN3000B	0.613	1.536	0.673	4.78
Oven	Eskabe Q1B	0.52	0.85	0.565	2.43

Figure 10. Cabinet dimensions and sheet metal surface of analysed products

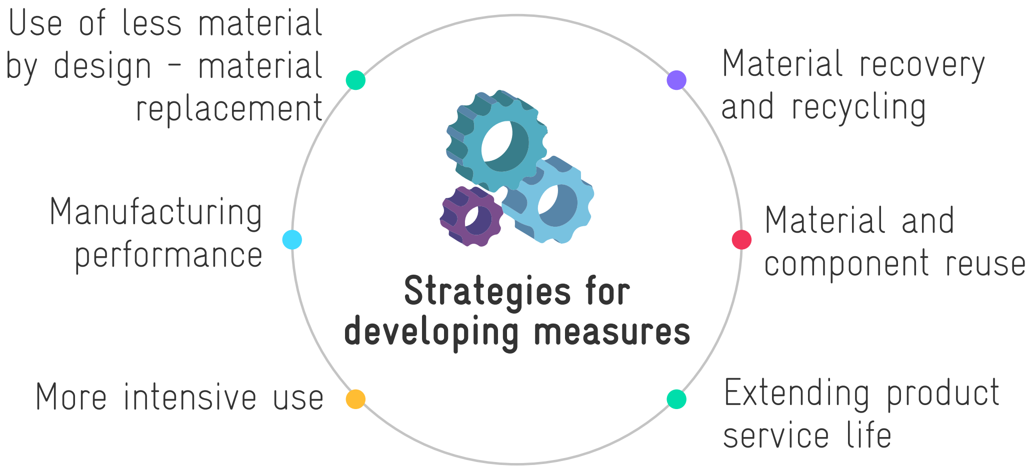
Refrigerators, Washing Machines, and Ovens have been chosen given the amount of steel sheet used to make these most-produced household appliances.

04

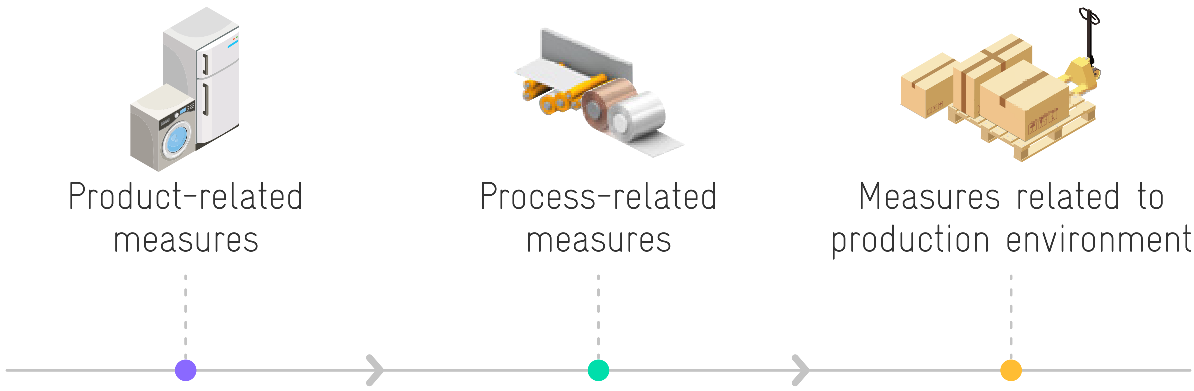
Identification of Case Study

Identification of resource efficiency measures

Various strategies were analysed to assess the improvement potential of resource efficiency measures. The following strategies were considered to further develop the measures as a result of this analysis:



Based on the strategies selected, a series of measures associated with each one were proposed, which can be classified according to:



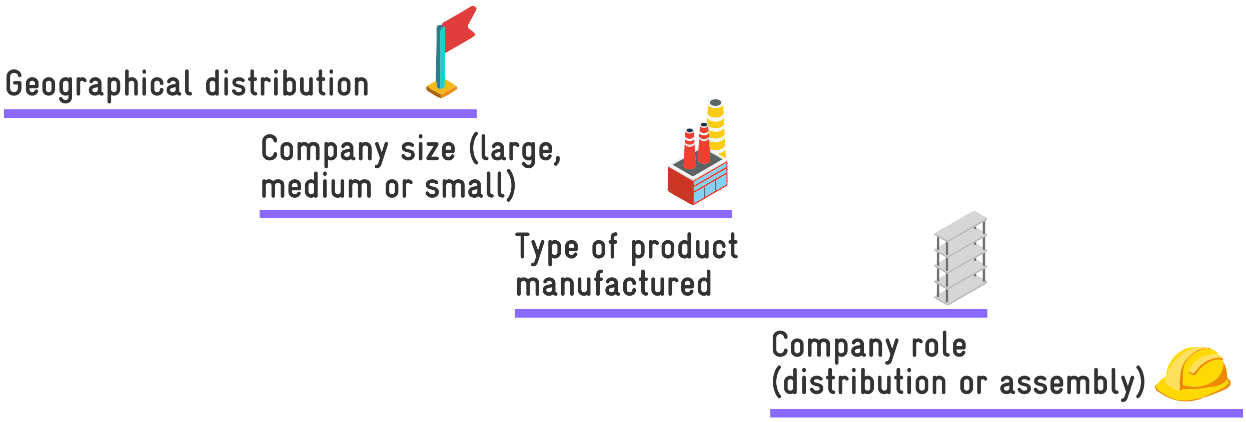
Some examples were created for each of the measures in the study sector and they were included in the Survey-Questionnaire form (refer to REEPA - Resource Efficiency Empirical Potential Assessment).

Identification of companies to be consulted

Companies in the sector were consulted to gather information on the potential that these measures could have on the system under study. This was done in two ways: through surveys and interviews. A specific form was created for each company (refer to REEPA - Resource Efficiency Empirical Potential Assessment), and respondents were asked to give a weighting to the impact of the pre-established resource efficiency strategies and measures.

The first consultation round was widely disseminated to various players in the sectors via email (approximately 20 respondents).

A search was carried out on companies associated with the sector and respondents were selected based on the criterion to ensure representation in the sample that respects the proportion of the different types of roles in the market. The following criteria were defined to obtain representation in the sample based on public information (Ministry of Productive Development, 2022).



It is important to consider that the frame of reference for this study (the domestic household appliance sector) is part of the metal industry value chain and it includes a wide range of products that are divided into three main categories: **white goods, brown goods,** and **small household appliances.** According to official data, there are 400 companies in the sector which includes micro, small, medium, and large enterprises. If parts manufacturers and parts suppliers are excluded, there are 161 manufacturing companies. Around 80 companies account for about 90% of the total market. The sector accounts for around 15,000 direct registered jobs, contributing 1.5% of industrial value added and 1.3% of national industrial employment. The distribution of companies in the sector by size is shown in Figure 11.

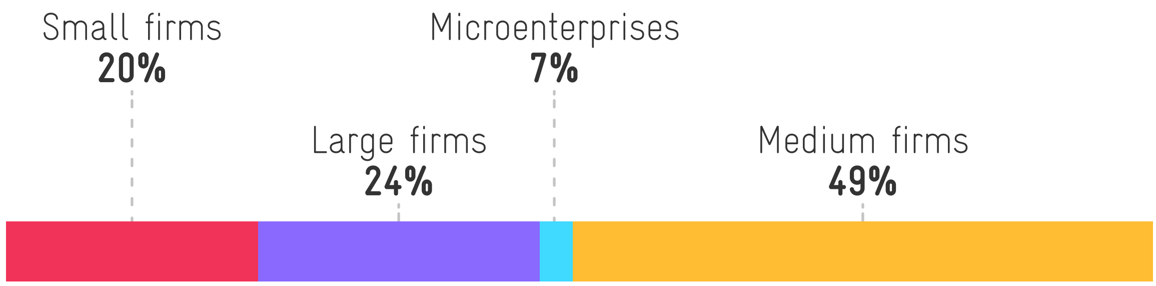


Figure 11. Distribution of companies in the domestic appliance sector by size[1] (figure developed by authors based on information provided by Ministerio de Desarrollo Productivo, 2022)

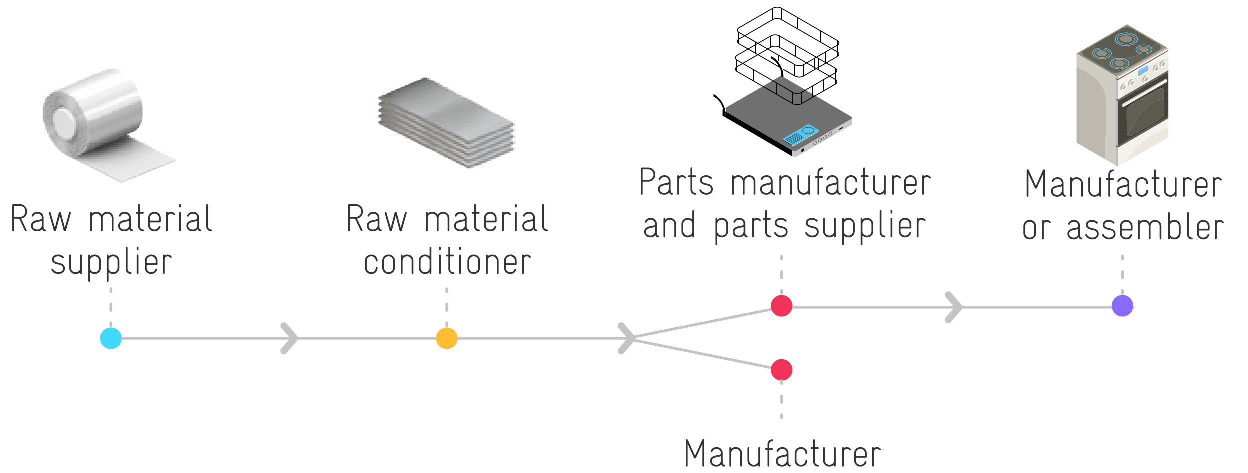
[1] Refer to Resolution 23/2022 of the Secretariat of Small and Medium Enterprises and Entrepreneurs issued by the Ministry of Productive Development of Argentina: Micro enterprises have up to 15 employees, a Small enterprise from 16 to 60, a Medium enterprise from 61 to 655, and a Large enterprise more than 655 employees. https://www.argentina.gob.ar/normativa/nacional/resoluci%C3%B3n-23-2022-363008/texto

The vast majority of manufacturers are located in industrial areas surrounding the province of Buenos Aires (53%), in the Autonomous City of Buenos Aires (24%), Santa Fe (13%) and Córdoba (7%), which combined account for almost all enterprises. While it does not have the largest number of companies, the city of Rosario (Santa Fe) is the main producer of white goods in Argentina. Almost 70% of the country's refrigerators are manufactured there. The sector is labour-intensive relative to the industrial average. However, the use of continuous process technologies with high degrees of mechanisation and automation has increased significantly in recent years.

Companies can be classified according to their role in the production sector which includes:

a) Raw material producer	Raw material producers include parts manufacturers. For this case study, it is the steel industries that produce the sheet metal which define the material quality in terms of chemical composition, thickness, coating, etc.
b) Raw material conditioner	These companies receive the sheet metal from the raw material producers, process it in some way, and may perform initial operations on it. For this case study, these companies receive steel coil, straighten it, and cut it, delivering the materials ready to be processed.
c) Parts manufacturers and parts suppliers	These companies transform the goods provided by the raw material producer, manufacturing metal-mechanical parts and components.
d) Manufacturers and assemblers	They define the product design, characteristics and technical specifications and are responsible for assembly, finishing, and after-sales services.

In the context of this study, the manufacturers, are also parts manufacturers and parts suppliers as they transform raw materials into parts of components of the products and then assemble them.



Considering the details provided in Figure 10, the proportion of each product out of the total units manufactured in 2021 is presented, alongside the annual amount of sheet metal used in each product (expressed as surface area) and the resulting relative weight of the material for each product.

Product	Units produced in 2021	% of units	Cabinet surface area (m2/unit)	Annual cabinet sheet metal area (m2/2021 units)	% sheet metal
Refrigerators / Freezers	1,058,850	34.8	2.61	5,061,303	50
Washing machines / dryers	1,370,087	45	4.78	3,575,927	35.3
Ovens	613,920	20.2	2.43	1,491,826	14.7
Total	**3,042,857**	**100**		**10,129,056**	**100**

Figure 12. Representation of each product according to total units produced during 2021 and area of sheet metal used (prepared by authors based on information provided by (Ministerio de Desarrollo Productivo, 2022)

Based on the information consolidated in Figure 12, the most significant criterion considered was the impact of each product on the consumption of sheet metal and this was defined as a criterion (type of product manufactured) to select the companies to be consulted.

Considering the criteria mentioned above, the composition of the sample to be consulted should be based on the following distribution:

Sub-sector companies consulted (20 companies)

By size

Large (5)	24%
Medium (10)	49%
Small (15)	24%

By role (*)

Assemblers (8)	40%
Parts manufacturers and parts suppliers (12)	60%

* Only Assemblers and parts manufacturers and parts suppliers are contemplated

By location

Autonomous City of Buenos Aires (5)	24%
Buenos Aires Province (11)	53%
Santa Fe (3)	13%
Córdoba (1)	7%

By product

Refrigerators (10)	50%
Washing machines (7)	35%
Ovens (3)	15%

The companies to be consulted were selected based on these considerations and the survey form was sent to them (refer to REEPA - Resource Efficiency Empirical Potential Assessment).

Interviewee selection

The following aspects were considered to select the experts to be interviewed:

- Seek representation of various process steps and roles (raw material manufacturer (rolled sheet), raw material conditioner, parts manufacturer and parts supplier, manufacturer and assembler

- Seek representation of the different products manufactured

The interviewees included representatives of Ternium (raw material manufacturer), Sidersa and Laminación Basconia (raw material conditioner), and Visuar (manufacturer and assembler, manufacturer of own-brand products and leading global branded products). The profile of the interviewees included directors and managers from Engineering, Product, Research and Development, Quality, Operations, and Communication and Well-being.

The aim was to select people from the sector represented by the selected companies that had the greatest knowledge possible of the sector, products, and resource efficiency environment. This was so that their contributions could enrich the study based on their training and years of experience. A specific survey form (refer to REEPA - Resource Efficiency Empirical Potential Assessment) was used for the interviews which was sent out prior to the interview.

05 Results

Collection and evaluation of results

Figure 13 summarises the results of the consultations and interviews. Responses that were mentioned at least once are highlighted. This allows us to identify measures with the greatest resource efficiency potential in relation to the use of steel sheet for refrigerators, washing machines, and ovens.

The "product-related measures" of **product redesign** and **material replacement** should be highlighted as they present a resource efficiency potential of up to 10%. **Process improvement** and **development of new processes** are the "process-related measures" that stand out the most. The focus on **other non-structural metal components** that use rolled steel sheet such as motors and compressors also stands out with a potential of 15%.

PRODUCT-RELATED MEASURES	0%-5%	5%-10%	10%-15%	NOT APPLICABLE
Product redesign	x	x		
Miniaturisation				x
Design for recycling	x			x
Design for reuse	x			x
Material replacement	x	x		
Other (specify) Other non-structural or internal metal components (e.g. motors, compressors, etc.)			x	
PROCESS-RELATED MEASURES	**0%-5%**	**5%-10%**	**10%-15%**	**NOT APPLICABLE**
Optimising process parameters	x			x
Process improvement	x	x		
Developing new processes		x		
Other (specify)				
NON-PRODUCT AND NON-PROCESS RELATED MEASURES	**0%-5%**	**5%-10%**	**10%-15%**	**NOT APPLICABLE**
Storage/stockpiling arrangements				
Reducing transport	x			
Decreasing maintenance				
Other (specify)				

Figure 13. Results obtained from the consultations carried out (created by authors)

The following figures show the relative weight of the responses to the product-related and process-related measures based on the positive responses received to each of the above options.

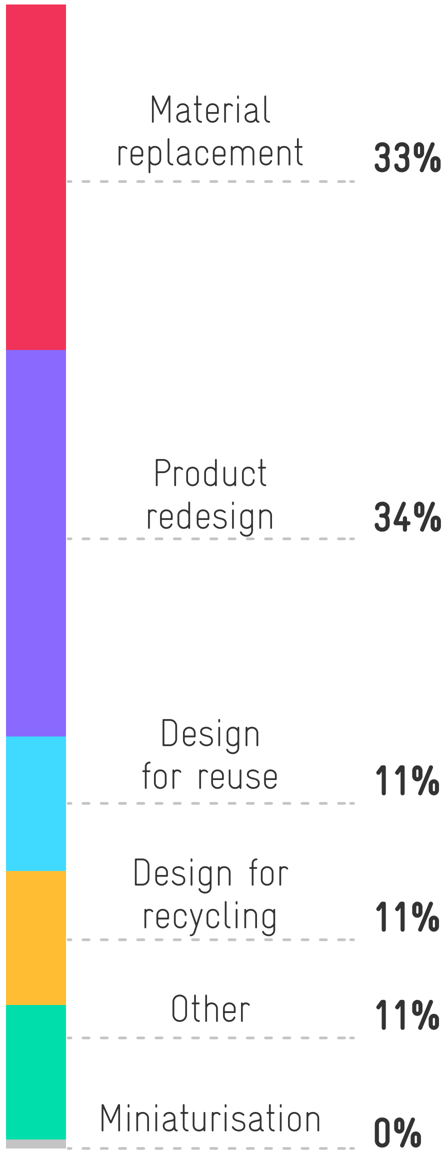


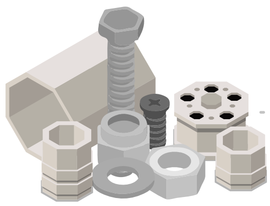
Figure 14. Relative weight of product-related resource efficiency measures based on consultations (created by authors)

Product-related measures

Product redesign and **material replacement** were the **most frequently chosen** options by respondents (34% and 33% respectively), who noted that these measures have a **resource efficiency improvement potential of up to 10%.**

Design for recycling and **design for reuse** were selected by 11% of respondents, considered to have an **improvement potential of up to 5%.**

Other measures such as work on **other internal metal components** were also selected by 11% of respondents with an **improvement potential of up to 15%.**



Internal components
15%
(improvement potential)

On the other hand, the miniaturisation option was not selected by any of the respondents; this could be related to the perception in the sector that this is a complex issue currently under development and is more long term, but that it should be addressed.

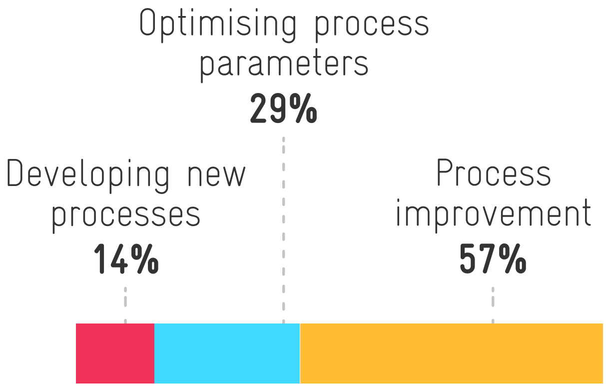
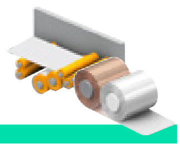


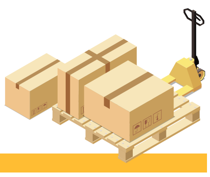
Figure 15. Relative weight of process-related resource efficiency measures based on consultations (created by authors)

Process-related measures



In this case, **57% of respondents** considered that **process improvement** has a potential of **up to 10%**, while the **incorporation of new processes** was mentioned by 14% of respondents. **Optimisation of process parameters** was chosen by **29% of respondents** who considered it to have an improvement potential of **up to 5%.**

Non-product and non-process related measures



Only **one respondent** selected one of the measures from this group. The measure considered was **transport reduction,** indicating an improvement potential of **up to 5%.**

Combined measures

With regard to the possible combined impacts that the measures mentioned could have, the respondents highlighted that product-related measures could have an impact on processes, such as product redesign which usually involves analysing and improving processes or development of new ones. The same could apply to process-related measures in which the improvements can be combined because they are different: for example there could be a "step change" with one measure due to a change in technology, while another measure will provide a gradual change in response to a process of continuous improvement.

While some respondents noted that the potential of product-related measures cannot be added together in a linear way, others noted that measures such as product redesign are often associated with material replacement as higher-strength steel is used and less material is required to produce the final product.

Measures with no positive response

An analysis of the responses received shows that out of the "product-related measures" referring to actions by companies (product redesign, miniaturisation, design for recycling, design for reuse or material replacement), miniaturisation was not selected by any company.

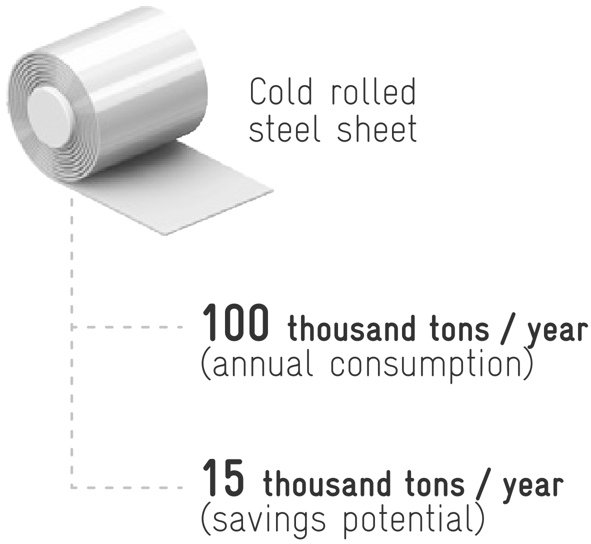
Note that miniaturisation is an attempt to reduce the size of household devices or appliances. This technological process is often considered a parameter that proves a company's progress in terms of development in the IT and electronics sector.

In the white goods industry, miniaturisation refers to creating smaller, more compact, and more efficient appliances, which improves both functionality and performance. For example, the miniaturisation of electronic components has allowed more energy-efficient refrigerators to be created that have a greater storage capacity in a reduced space. More compact and efficient washing machines and dryers have also been developed, which have improved performance and a positive impact on the environment.

In short, miniaturisation in the white goods industry promotes the creation of more efficient, compact, and functional appliances. The consultation process also showed that the sector is not considering options to apply this possible technological alternative associated with the efficient use of rolled steel sheet.

Potential GHG emission reductions

Around 100 thousand tonnes of cold-rolled steel sheet are used in the white goods sub-sector every year. **Based on the resource efficiency potential identified, around 15 thousand tonnes of this material could be saved per year.** As each tonne of steel produced generates 1.45 tonnes of CO_2eq, **the savings potential of rolled steel sheet used in the white goods sub-sector in Argentina would reduce GHG emissions by approximately 21.75 thousand tonnes of CO_2eq per year, equating to 0.36% of annual emissions from the metal industry.**



Methodology applied to the field study

We have developed a working methodology for a field study on material flows and the resource efficiency potential of rolled steel sheet used to manufacture household appliances. This methodology was subsequently adapted based on our experience putting it into practice, organising it into 4 phases that can be applied to new studies:

Phase 1

Definition of system boundaries

Phase 2

Analysis of material flows

Phase 3

Field study on material efficiency potential, and

Phase 4

Collection, evaluation, and contextualisation of results

Other relevant aspects related to the methodology were identified throughout the study process, namely:

- The identification and interaction with key players in the public and private sectors as a source of information is key, as is making contact with potential experts and leaders in the sector who can take part in the survey.

- Defining the system boundaries precisely in terms of materials and the sectors for which the study will be carried out is also essential.

- Resource efficiency measures were classified as those associated with products, processes and the production environment. These measures were key in enabling respondents' to understand the approach to the field study. The same applies to specifying efficiency potential ranges, since the aim in this type of study is not to be precise, but to obtain indicative values. This also facilitated the analysis of the survey data.

- Obtaining inputs and feedback from the people consulted in both the interviews and questionnaires was not easy; therefore, a broad base of contacts including sector leaders should be consolidated for the survey process. In addition, the response times of those consulted were longer than expected at the beginning of the study. The selection of interviewees is decisive in this respect. Their responsibility and the commitment with which they respond to the survey is crucial, as is their knowledge of the subject matter, as the information they provide forms the basis for the conclusions and recommendations.

- Conducting interviews proved to be a more convenient strategy than sending questionnaires via e-mail, as the number of responses obtained in the latter case was limited. It was also possible to further question the opinions expressed by the respondents during the interviews.

- It is essential to define the scope and direction of the evaluation, particularly for the results and the conclusions process; this improves the analysis process and the consolidation of the final report so that the study adds value to key players in the public, private and academic sectors (the main target audience of the study).

- The methodology applied to develop the study, gather the data, and reach the conclusions can be validated by sending a preliminary version to the sectoral experts (companies, academia, and chambers of commerce in the sector).

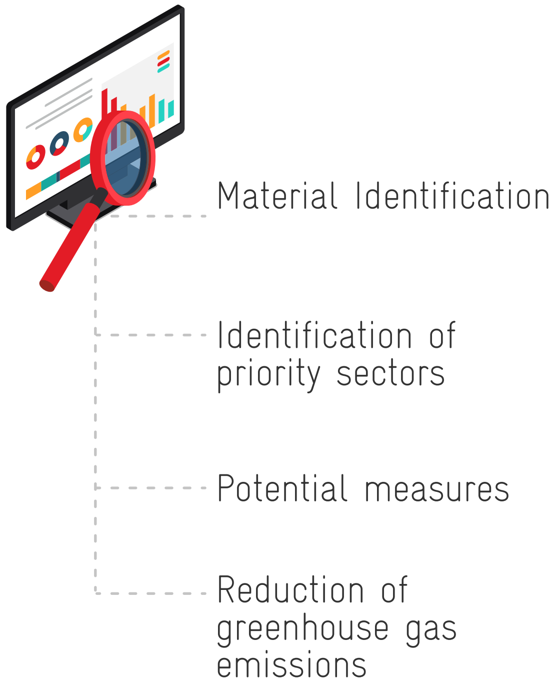
By obtaining specific results from the field study, it is evident that the methodology applied proves to be cost-effective in terms of time and resources. It also provides realistic data that can help identify the sectors and materials within which priority lines of action can be determined that improve resource efficiency in production and contribute to reducing GHG emissions. These lines of action are aimed at both public and private companies and organisations within the business environment.

06 Conclusions

Resource efficiency data management

A package of recommendations has been drawn up based on the work carried out which would progress towards improving the management of resource data associated with the metal industry.

This has been done by developing a tool to assess resource efficiency potential by analysing the flows of materials used in a given production sector. The study results thus contribute to identifying priority materials and sectors, as well as potential measures to improve production efficiency and reduce GHG emissions.



Resource efficiency potential of rolled steel sheet in the white goods sub-sector

The study also revealed that flat steel products for the white goods sub-sector could have a **resource efficiency potential of around 15%.** This was determined by analysing and applying **measures related with product development** (mainly those related to product redesign and material replacement) and **process-related measures** (improving existing processes and developing new production processes). These are associated with a CO_2eq emission reduction potential of around 0.4% of the annual emissions from the metal industry in the industrial process and product use category.

Methodology applied

The proposed methodology can be used to obtain a qualitative and semi-quantitative assessment of the resource efficiency potential in production sectors by analysing different sub-systems. It could therefore be argued that this methodology can be **replicated for other materials and sectors.** An initial screening could be carried out to **identify priority sectors and materials** for which business support instruments and policies can be designed or adapted.

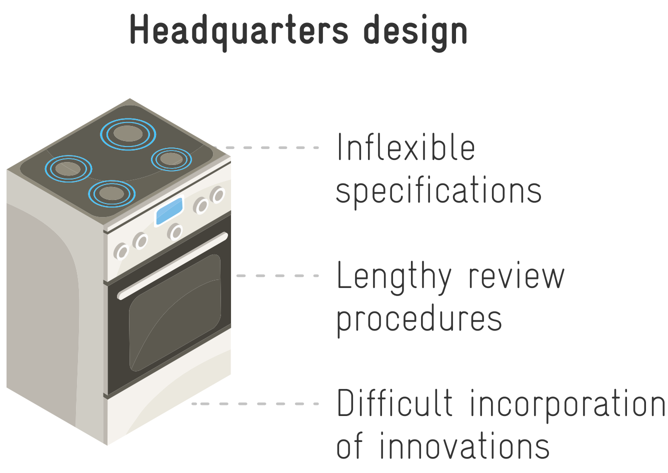
Prioritised and non-prioritised measures

Product redesign, material replacement, and process improvement are the measures most within the reach of companies involved in the rolled steel sheet value chain used in the production of household appliances. These measures can potentially be implemented in the short term.

In contrast, data gathered in the study indicate that miniaturisation (involving the development of a new concept and product) and the development of new processes needs more time to be fully implemented and carried out.

Barriers encountered

The main barrier detected during the interviews on product-related measures was the limitation that some key players in the production chain face; this particularly applies to final assemblers that work as subsidiaries of multinational companies, produce products for global brands, and operate with designs "downloaded" by the parent companies. In these cases, the specifications are not flexible or the review procedures are lengthy (over 18 months), making it difficult to incorporate innovations (product redesign, material replacement, other measures) into their products. In contrast, this situation does not apply to companies with their own product designs, which would be in a more favourable situation to implement the measures proposed under the "product development" field.



Most of the companies involved in the study do not have Research and Development (R&D) areas, which could be why product development and processes that focus on resource efficiency are limited. This point may represent an opportunity for improvement - developing and strengthening R&D areas that promote joint work by different entities in the value chain in the form of a production cluster.

This would improve interaction between the players and also in terms of technical aspects, as observed in this study. In this sense, R&D areas could be developed that are internal to a company or could be created within chambers of commerce or R&D institutions to improve access to such structures.

Collaboration between the players in the value chain

The limited collaboration on technical aspects (product design, material replacement, process specification changes, among others) between the different links in the value chain should be addressed by both companies and public and private organisations in the business environment; the aim would be to help the development and implementation of resource efficiency measures that impact the different links in the value chain.

Overcoming this constraint could shorten the time required to implement the resource efficiency measures. It would also enrich the development processes for new products and processes, leading to better results in terms of resource efficiency and GHG emission reductions. The role of different organisations from the business environment as facilitators and points of contact between companies in the sector will be key to doing so.

Incentivising instruments and policies

While there are incentivising instruments and policies for companies at government level, they are not usually applied to resource efficiency and emission reduction initiatives. This is often due to design issues, a lack of information, and limited technical capacities (the subject matter and type of measures are not prioritised). Demand is another issue, as companies do not prioritise these matters among the initiatives to be applied, or do not have or foresee elements that would demonstrate the potential that these kinds of measures can represent in terms of competitiveness.

Specialised information on the resource efficiency potential of particular materials in prioritised sectors (such as the data generated in this field study) can be a decisive input for **government decision-makers** when choosing the different types of initiatives or company projects regarding specific support instruments and policies. One of these instruments in Argentina is PRODEPRO (Supplier Development Programme), which seeks to promote coordination between companies in the different links of the value chain to develop common projects that are strategic at the sectoral level. These include the innovation and development of more resistant materials that reduce the quantity of materials used to manufacture certain product lines.

07 Recommendations

The recommendations arising from the methodology set out for the field work are presented below. The recommendations would allow the different players to identify lines of action to be developed.

For production sectors

- Incorporate resource efficiency potential assessments into business management
- Create accounting procedures and audits on the use of materials and supplies
- Quantified reporting on resource efficiency and its impact on GHG emission reductions
- Develop and/or strengthen an internal R&D area within the company or through agreements with R&D institutions to identify and explore opportunities to improve efficiency with a broader view of everyday activities (new designs, miniaturisation, among other longer-term ideas that are outside the paradigms of the production areas)
- Connect with other players in the customer-supplier value chain to develop new products, materials and processes

For supporting organisations (chambers of commerce, academic and technological organisations)

- Create a favourable environment to develop sectoral clusters (incorporating the production, academic, regulatory and political decision-making sectors) that promote the development of new products, materials, and processes with greater resource efficiency
- Incorporate the concept of resource efficiency into the agendas of environment, sustainability and climate change committees
- Promote the importance of resource efficiency and its impact on sustainability in general and climate change in particular across academic and training environments

For policy and decision makers

- Incorporate and/or strengthen the concept of resource efficiency within the priorities of public, environmental, climate change, R&D, and product development policies
- Gather data through studies applying REEPA to identify priority materials and sectors to work on further, aiming to identify relevant material flows that help to guide and focus promotional instruments
- Adapt existing promotion instruments in a way that prioritises entrepreneurial initiatives that improve resource efficiency
- Develop new instruments that specifically support this area
- Incorporate measures arising from sector studies applying REEPA into climate change mitigation action plans and Nationally Determined Contributions

For cooperation agencies

- Apply the REEPA methodology to identify priority materials and production sectors where resource efficiency and GHG emission reduction measures and programmes should be prioritised in a fast and cost-effective manner

Concluding Remarks

While resource efficiency potential was identified for the selected material and sector, given the magnitude reported by the respondents, it would be useful to analyse the resource efficiency potential of other materials in the sector. Furthermore, it would also be important to repeat the study for other sectors and materials to gather information on which materials and sectors have the greatest potential to develop or adapt efficiency and climate change policies within a reduced time frame.

The results achieved regarding the resource efficiency potential and emission reductions of a specific sector correspond with those relating to measures and structures incorporated in National Action Plans to mitigate climate change. Public organisations that manage climate change programmes and policies could therefore adopt resource efficiency matters within these plans by promoting the implementation of measures with the greatest potential.

Glossary of Acronyms

Acronym	Definition
ADIMRA	Argentine Metal Industries Association (Asociación de Industriales Metalúrgicos de la República Argentina)
BMUV	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and Consumer Protection - Germany.
G20	The Group of Twenty
GEIs	Greenhouse Gases
GIZ	German Agency for International Cooperation
IRAM	Argentine Standardization and Certification Institute (Instituto Argentino de Normalización y Certificación)
IKI	Germany's International Climate Initiative (Internationale Klimaschutzinitiative)
IREK II	Initiative for Resource Efficiency and Climate Action II
IRP	International Resource Panel
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally Determined Contributions
REEPA	Resource Efficiency Empirical Potential Assessment

References

Allwood, J. M., Ashby, M. F., & Gutowski, T. (2013). Material efficiency: providing material services with less material production. Retrieved from royalsocietypublishing.org: https://royalsocietypublishing.org/doi/full/10.1098/rsta.2012.0496

Cámara Argentina del Acero. (2023). Producción Siderúrgica Argentina 1960 - 2023. Retrieved from https://www.acero.org.ar/: https://www.acero.org.ar/wp-content/uploads/2023/09/Produccion-Siderurgica-Argentina-1960-2023-.pdf

CEPAL. (2023). Escenarios prospectivos al 2030 de los indicadores de los ODS. Retrieved from cepal.org: https://repositorio.cepal.org/server/api/core/bitstreams/f39bbae0-64da-4f23-9459-0ac07538402a/content

Circle Economy. (2023). The Circularity Gap Report. América Latina y el Caribe. Retrieved from circularity-gap.world/lac: https://www.circularity-gap.world/lac/es

Electrolux. (Online). Manual Heladera Electrolux DFN3000B. Retrieved from i.electrolux.com.ar/: https://www.manual.ar/electrolux/df3000b/manual

Electrolux. (Online). Manual Lavarropas Carga Frontal Electrolux ELAF06W. Retrieved from http://i.electrolux.com.ar/Manualesdeuso/183800%20(LAVARROPAS%20ELAF06W)%20-%20183810%20(LAVARROPAS%20ELAF07W)%20-%20183820%20(%20LAVARROPAS%20ELAF08W)_manual%20de%20usuario.pdf

Eskabe. (Online). Cocina CO Q10 B. Retrieved from eskabe.com.ar: https://www.eskabe.com.ar/product/co-q10-b/

IPCC. (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report. Retrieved from https://www.ipcc.ch/: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/09/IPCC-Special-Report-1.5-SPM_es.pdf

IRP. (2018). Resource Efficiency for Sustainable Development: Key Messages for the Group of 20. Retrieved from resourcepanel.org: https://www.resourcepanel.org/reports/resource-efficiency-sustainable-development

IRP. (2020). Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future. Retrieved from resourcepanel.org: https://www.resourcepanel.org/reports/resource-efficiency-and-climate-change

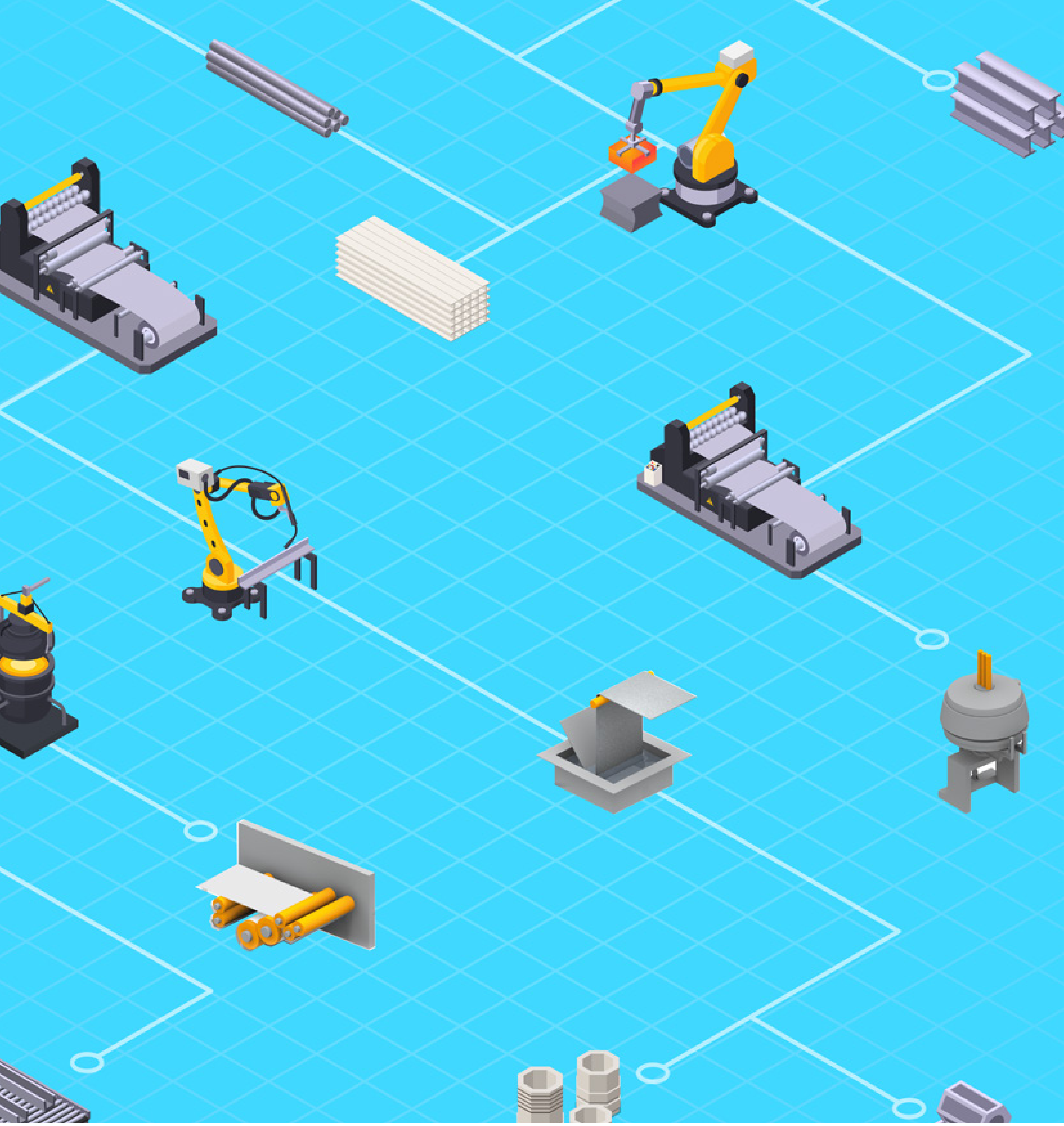
Ministerio de Desarrollo Productivo. (2022). Electrodomésticos y Eficiencia Energética. Retrieved from argentina.gob.ar: https://www.argentina.gob.ar/sites/default/files/2021/03/30_-_electrodomesticos_y_eficiencia_energetica.pdf

Ministerio de Economía. (2021). Informes de Cadenas de Valor. Siderurgia. Retrieved from argentina.gob.ar: https://www.argentina.gob.ar/sites/default/files/2021.11.24_sectorial_-_siderurgia_version_web.pdf

Naciones Unidas. (2015). Agenda 2030 para el Desarrollo Sostenible. Retrieved from Asamblea General: https://www.un.org/es/ga/70/resolutions.shtml

Ternium. (2022). Memoria y Estados Financieros 2022. Retrieved from ar.ternium.com: https://s2.q4cdn.com/156255844/files/doc_financials/arg/2022/4Q2022/TXAR-Memoria-2022.pdf

Ternium. (Online). Acero Ternium. Retrieved from amcen.ternium.com/es: https://amcen.ternium.com/es/hecho-con-acero



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