Circular cities for Chile

A vision beyond decarbonization

enel

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Preface

One of the 21st century's greatest unresolved crises is climate change. We live in a time of great difficulties that are turning into opportunities to accelerate the transition to a more just and planet-friendly society. We must focus on finding innovative, timely, and beneficial solutions for the planet and humanity. Undoubtedly, the impacts of climate change require us to prioritize actions in the short term to adapt and avoid significant effects.

The current climate crisis is evidence of unsustainable production and consumption processes. Its effects have led to biodiversity loss and reduced ecosystem resilience, becoming a social emergency in many countries. Rising temperatures and extreme weather events affect life throughout territories, particularly in the most vulnerable communities. Although actions have been insufficient, we still have time to reverse some effects by seeking innovative solutions and creating new models. But we must do so collectively and decisively.

In this scenario, cities have a fundamental role because they will consolidate population and development activities in the future. This phenomenon is already a reality in Latin America, with megacities such as Sao Paulo and Buenos Aires. Urban development centers require a different approach that solves their increasing polluting emissions while proposing a new model for consumption and services to its citizens.

All parties must play a role in this search for solutions and call to action. Companies must integrate sustainability strategically, modifying their industrial and production processes; people must rethink their consumption decisions; public policies must promote a new development model with concrete and long-term territorial solutions. Working together will be the key to achieving a balance between progress and the planet's health.

This document is the outcome of a study of three Chilean cities in collaboration with the public sector, civil society, and academia. Its purpose is to reflect on our cities' and communities' capacity to integrate the circular economy principles, thus rethinking the linear model of production and consumption. We considered three sectors for our analysis due to their weight in global emissions and the importance of the services they provide to cities: energy, construction, and food. By combining their efforts, these sectors could multiply the positive impacts on society, the economy, and the environment.

We hope this work inspires the implementation of concrete actions in cities, which, in our opinion, is vital when addressing climate change. A consistent transformation of their processes and operating mechanisms will allow us to make them more resilient and prosperous places for current and future generations.

However, the sense of urgency demands that we step on the gas. We must seek solutions now to forge cities that place the conservation of natural resources, emissions reduction, and quality of life for all people at the center of their priorities.

Fabrizio Barderi
General Manager
Enel Chile

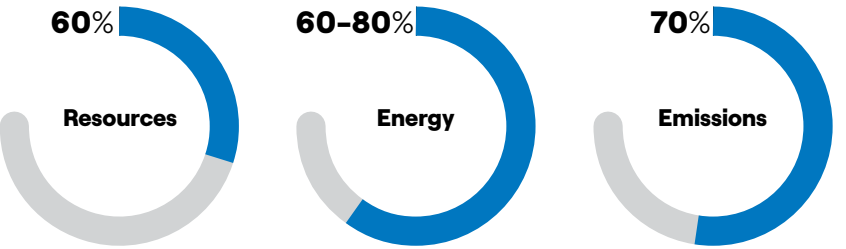
Introduction

Cities are development hubs that cover only 3% of the earth's surface, yet they concentrate more than half of the world's population and generate 80% of global GDP[1]. According to United Nations projections, approximately 70% of the population will live in cities by 2050[2] due to urban-rural migration and migration between nations. Due to urbanization, studies expect cities to consume 80% of the food produced worldwide by the same year[3].

As hubs of industrialization, development, and information, cities demand 60% of the planet's resources, consume between 60% and 80% of energy[4], and generate approximately 70% of GHG emissions[5], mainly from fossil fuel consumption in energy and transportation.

Chile's cities are no exception. The 2017 Population and Housing Census indicated that the country has 17.6 million inhabitants concentrated in large conurbations, among which Santiago, the political and administrative capital, stands out, where 58.9% of the population lives.

Globally, population density and urban growth increase demand for goods and services, presenting significant challenges for energy and food supply chains, waste management, and building systems. The Covid-19 pandemic, which emerged in December 2019 and spread rapidly worldwide, further evidenced such challenges. The crisis exacerbated underlying inequalities and disrupted city life, compromising social connections, public health, and the economy, especially in the most vulnerable communities[6]. The impact of climate change and the fragility this pandemic revealed forces us to rethink how we evolve and adapt.



Objectives of the document:

(1) Develop a circular economy vision for Chile's cities.

(2) To collect data on materials, energy, emissions, and indicators based on public information.

(3) Identify circularity opportunities for decarbonizing three economic sectors: energy, construction, and food.

(4) Propose circular interventions for studying cities with circular economy principles and business models.

Circular cities make a new structure of development a reality incorporating principles, foundations, and strategies of a circular economy. They are cities that ideally have rethought how products, materials, and assets are used, preserving their value over time, avoiding waste generation, and regenerating natural systems. By design, circular cities use renewable energy and local supply chains and maximize energy efficiency. They also embrace digitization, asset reuse, shared-use platforms, servitization, material valorization, and waste reduction. They aim to combine economic development, environmental sustainability, and social inclusion to counteract climate change by decarbonizing value chains and promoting fair transition and equity.

Enel is committed to the fight against climate change and transitioning to a sustainable city model. We have included these principles as strategic pillars in our business model for years. As of 2018, together with key global institutions and stakeholders, we worked towards developing the concept of "circular cities" and have published four papers conceived as a contribution to decision-makers in the transition of cities towards a circular economy.

This document discusses Chile's cities, focusing on three cities in different geographical contexts: Antofagasta in the north, Santiago in the center, and Concepción in the south. The analysis centers on three sectors with the most significant potential for decarbonization: energy, construction, and food. The work focuses on collecting public data on flows of raw materials, energy, waste, and emissions and proposing circular interventions for these cities. Therefore, making it possible to promote the development and implementation of territorial public policies, innovation, new business models, financing at different capacities, and new sources of employment.

Enel conceives this document as a guide that we hope will allow us to deepen and contribute to a circular economy and identify collaboration between the various sectors interacting in Chile's cities.

1.

Cities, climate change, and circular economy

An essential nexus

Since the industrial revolution, human activities have affected the concentration of greenhouse gases (GHG) in the atmosphere, generating an imbalance in weather patterns. Scientists have established the various impacts on all regions of the planet, with extreme weather events, drought, and rising sea levels. According to the latest report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), human intervention in climate processes is undeniable[7]. In the 2015 Paris Agreement, the United Nations approved the main guiding tools to advance in mitigating and adapting to climate change in cities, setting out the Sustainable Development Goals of the 2030 Agenda[8]. Seventeen objectives set a global agreement to achieve economic, social, and environmental goals. The COP26 held in 2021 in Glasgow, Scotland, was an important meeting to evaluate progress and improve the commitments adopted by the countries. Closing statements called for a gradual reduction of fossil fuel use, given their responsibility for the climate crisis[9], and stressed the leading role of cities in addressing these issues[10].

Chile is also part of these commitments. In 2020 it defined its Nationally Determined Contributions (NDCs), which establish adaptation and mitigation goals for reducing CO_2 emissions, including avoiding a global temperature increase above 2°C and improving the quality of life and sustainability in national and local development.

The strategy incorporates adaptation and mitigation components to advance commitments related to conserving the marine and terrestrial ecosystem and promoting a circular economy[11].

Chile focuses on circular economy efforts at the territorial level, searching for sustainable development. In 2021, the "Roadmap for a Circular Chile by 2040" was defined, with seven goals and four fundamental axes. One of them, the axis of Circular Territories, states: "Regions in this country must address climate change focused on their local realities, taking into account particularities and leveraging their potential. Therefore, facilitating sustainable and regenerative use of natural resources, generating welfare for its inhabitants."

Let us talk about a new economy

Current forms of production and consumption – which primarily come to supply the growing needs of cities and their inhabitants – have an essential connection to climate urgency. Global commitments are a call to action for sustainable development, but efforts so far appear insufficient.

Mitigation initiatives have focused on two areas: replacing electricity generation with renewable sources and implementing energy efficiency measures. However, according to the Ellen MacArthur Foundation, energy conversion accounts for only 55%

Since the industrial revolution, human activities have affected the concentration of greenhouse gases (GHG) in the atmosphere, generating an imbalance in weather patterns.

of global GHG emissions. The remaining 45% is primarily associated with using fossil fuels in manufacturing products derived from working the land, producing food, electronics, clothing, and other goods used and consumed daily throughout the planet[12]. In these value chains, we find the potential of a circular economy.

Lineal Model vs. Circular Model

Until the end of the 20th century, industrialization and mass production prospered through a linear model, given the downward trend in raw material prices. Based on the extract-produce-dispose triad, this model formed the basis for the development of today's society, generating and increasing GHG emissions, waste, energy losses, and single-use products or products used only for a few hours, such as private vehicles.

This market trend has taken a step back in the last twenty years. Commodity prices have been rising and are experiencing unprecedented volatility. Markets are tightening due to the depletion of reserves of necessary critical materials, including those that are strategic for the energy transition - fundamental to climate urgency. At the same time, three billion people are expected to move into the middle class by 2025, and these groups, with greater purchasing power, will further increase the demand for earth's resources[12].

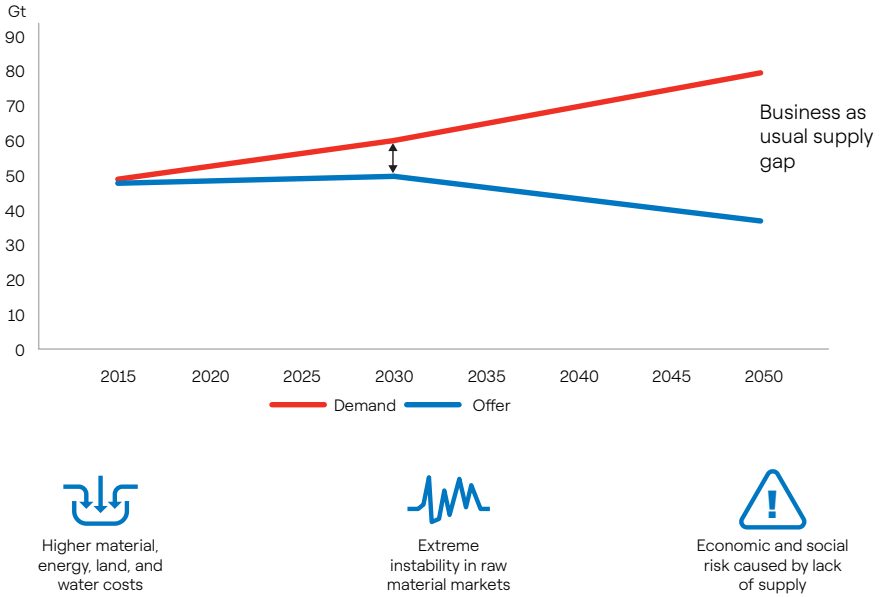
According to Accenture, by 2030, the current economic system will have a gap of 8 billion tons between the demand and supply of raw materials[13].

This linear form of production and consumption, which depends mainly on the extraction of raw materials and fossil fuels and generates thousands of tons of waste, is unsustainable[14]. The development system, which has given so much to humanity, must change.

Planetary boundaries have been crossed[15] with severe consequences for natural ecosystems. Negative externalities - such as water, air, and soil pollution - are detrimental to the availability of resources for future generations and directly influence the loss of biodiversity and people's quality of life.

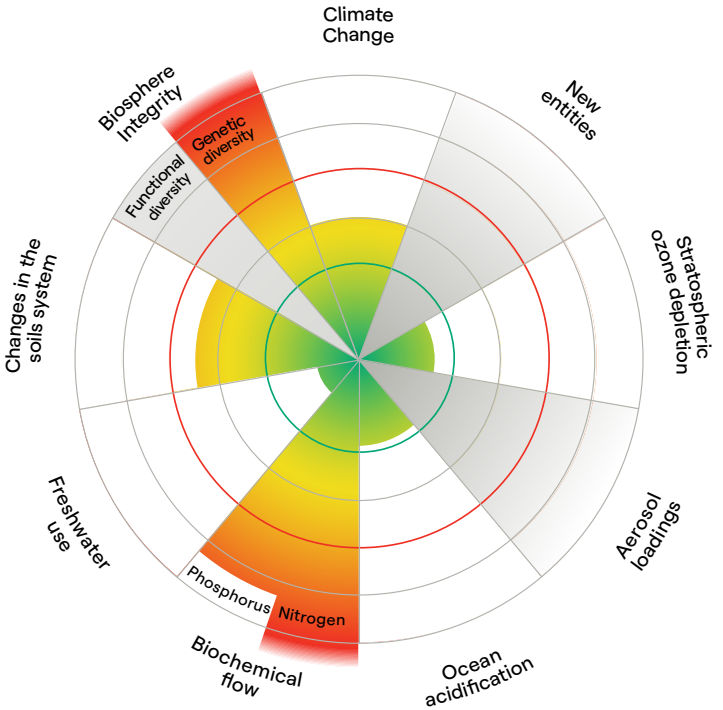
The circular model aims to transform the way resources move through our economy: energy comes from non-conventional renewable sources (NCRE), technology and innovation generate new circular business opportunities, and materials can be reused, repaired, redesigned, remanufactured, and recycled, while organic nutrients can be reintegrated into the natural system[12]. This system, recognized as regenerative of natural ecosystems, addresses the problem of waste and pollution while opening the opportunity to create value among society, academia, institutions, and businesses, and drives the achievement of the Sustainable Development Goals (SDGs).

Resource supply/demand imbalance (2015/2050)



Source: Adapted from Accenture Strategy (2015). The Circular Advantage.

Planetary boundaries



Source: Adapted from W. Steffen, K. Richardson, J. Rockström, et al. 2015. Planetary boundaries: guiding human development on a changing planet. Science 347(6223). Note: Boundaries: New entities, aerosol loading, and functional diversity have not yet been calculated.

Fundamental principles of a circular economy[16]:

Eliminate waste and pollution

In a circular economy, waste is a design flaw; therefore, it is vital to avoid its generation from the outset to reduce the costs and impacts associated with its management. Under this principle, products are designed so that their materials re-enter the economy at the end of their use.

Circulate product and materials

Under this principle, products and materials circulate in the economy, maintaining their maximum value through reuse, repair, reconditioning, and recycling. This way, we can extend products' useful life. When this is impossible, their components and materials are converted into new inputs, retaining their intrinsic value- avoiding waste generation and the need to extract new resources.

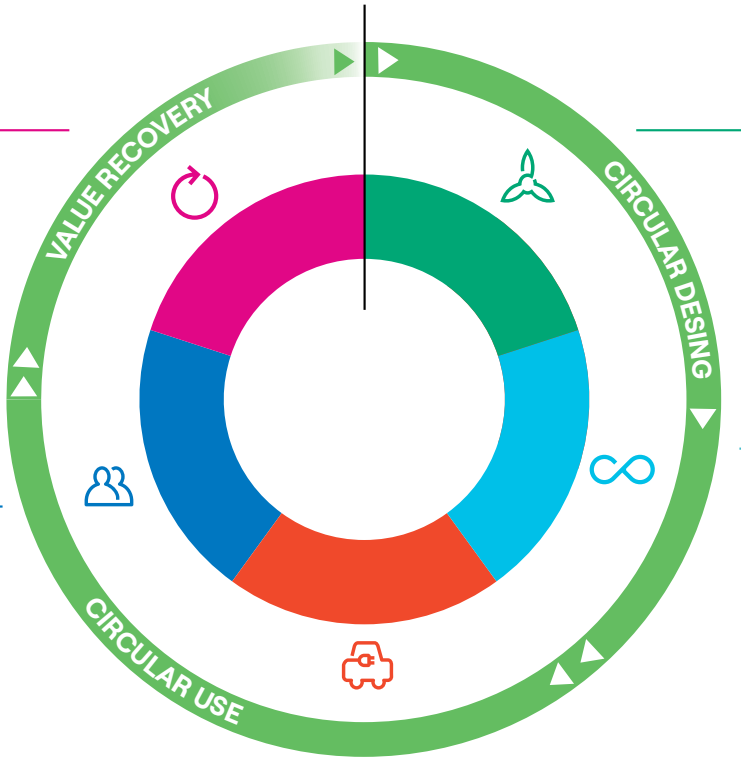
Regenerate nature

This principle proposes an active approach to the regeneration of natural capital, shifting from an extractive economy that degrades nature to one that helps restore soils, increase biodiversity, and return biological nutrients to the land.

New business models

A circular economy integrates different approaches. Along the entire value chain, they promote a new economic model based on sustainable inputs (renewable, reusable, and recyclable); maximizing the useful life of goods and products; extending the use factor (shared products and services), and the valorization of assets at the end of the first life cycle.

We structured the representation of this vision into five pillars[17]:



New life cycles

Every solution focuses on preserving the value of an asset by completing at the end of its life cycle by reusing, regeneration, upcycling, or recycling, in synergy with the other pillars.

Sharing platforms

Common management systems used by multiple users of products, assets, or competencies.

Circular input

Production and use model based on renewable input or previous life cycles (reuse and recycle).

Useful life extension

Approach to design and management of assets or products aimed at extending their useful life, e.g., through modular design, facilitated reparability, predictive maintenance, etc.

Product as a service

Business model in which the customer acquires a service for a limited period while the Company maintains ownership of the product, maximizing its utilization factor and useful life.

Benefits of a circular economy

Economical

Moving towards a circular economy implies that companies adopt new innovative business models that reduce their dependence on increasingly scarce resources. Resulting in new sources of revenue or cost savings and helps to mitigate risk exposure, with tangible advantages in terms of competitiveness. The Ellen MacArthur Foundation estimated that the European Union could save between 340 and 630 billion dollars in raw materials, especially for the vehicle, machinery, and equipment industry. At the Fast-Moving Consumer Goods (FMCG) level, the Foundation estimates a global value in circular opportunities that could achieve savings of $700 billion a year, especially in packaged food, apparel, and beverages. The latter represents 20% of raw material costs needed for their production[18]. According to Accenture, this new circular model could unlock some US$4.5 trillion in economic growth by 2030[14].

Sociales

New jobs will be required in research and development, metal reprocessing, maintenance, repair, sales, and other services that foster and strengthen customer and producer relationships. These measures will contribute to the development of shorter value chains and the closing of production cycles.

In this area, the Roadmap for a Circular Chile by 2040 defines a goal of 180 thousand new jobs for that year. On the other hand, the International Labor Organization (ILO) projects that the most significant growth will be in the service and waste treatment sectors, with 50 and 45 million jobs by 2030, respectively. This assumes a 5% annual increase in recycling rates for plastics, glass, cellulose, metals, and minerals and considers a 1% yearly growth in repair and leasing services. These measures would reduce the demand for new products and the extraction of raw materials[19].

Environmental

Circular economy principles are strictly linked to climate change relief by reducing emissions in value chains, retaining embodied energy in products, and sequestering carbon in the soil through regenerative practices.

According to Ellen MacArthur Foundation estimates, the circular economy has the potential to reduce 40% of GHG emissions by 2050 by applying its principles to the value chains of just four materials: cement, steel, plastic, and aluminum. If we consider circularity for the food industry, the reduction reaches 49%.

In addition to reducing emissions, this new model will help the resilience of cities by restricting the production of waste and air pollution[12].

Road to circular city

Although there are multiple ways to move towards a circular city, this study considers the concept of urban metabolism and the principles of a circular economy because they can easily measure the circularization of economic sectors' potential in an urban radius.

It is possible to analyze cities as an open system, which depends on flows of materials and energy with other subsystems, within and outside the urban boundary and between the different sectors of the economy[20]. In its functioning system, it is possible to identify supply flows -materials, energy, food, and water- and output flows -waste and emissions- whose behavior is determined by what has been called the urban metabolism of each city. This concept's definition states that it is the total sum of the technical and socioeconomic processes that occur in the city and result in growth, energy production, and waste disposal[21]. In a linear metabolism, material and energy resources come from outside, and most are disposed of outside. Ideally, cities can generate their resources in a circular metabolism, reducing external demand and connecting outputs with inputs[22].

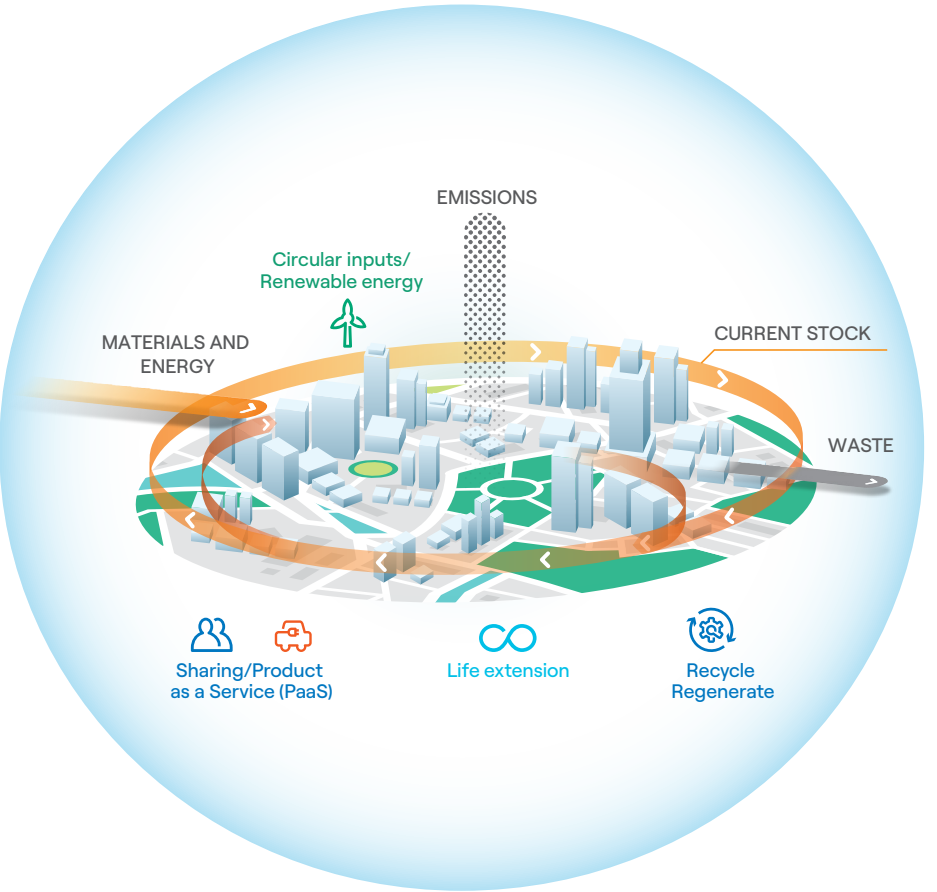
Cities are increasingly complex systems. As the population grows, so does the urban radius, meaning the demand for resources and services generates higher production levels, consumption, and waste[23].

Since urban centers are the source of a large part of the world's polluting emissions, they also could become the starting point for providing solutions and addressing the climate crisis.

The complement between circular economy and circular urban metabolism is convenient since both recognize the need to circularize processes to achieve sustainable development.

This form of development supplies energy demand from renewable sources. Products and materials circulating in the economy are valorized and extend their useful life, reducing pressure on natural systems through pollution and emissions. Innovation and technology also encourage the creation of new circular business models, the development of local markets, and industrial symbiosis processes in the city. It also rethinks the use of disused spaces to offer greater accessibility.

> In a circular metabolism, cities can generate their resources, reducing external demand and connecting outputs with inputs.



2.

A sectorial view

Where to focus efforts

Where to focus efforts

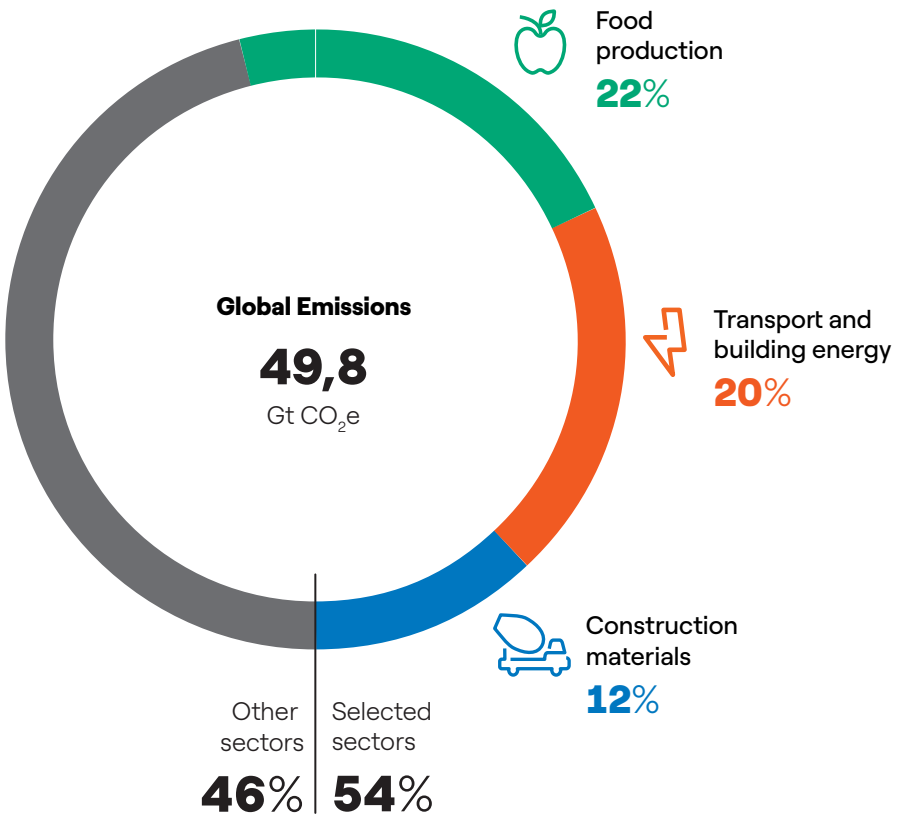
The vision of a circular city considers different key urban sectors to redefine the energy and material flows of the urban metabolism. The strong link between climate change and a circular economy generates the need to prioritize. Efforts in this study focused on three economic sectors that globally contribute significantly to GHG emissions in cities:

Energy use in transport and buildings is responsible for 20% of global emissions. These are emissions due to fossil fuel burning, either within cities – for example, in means of transport (Scope 1), outside cities for electricity production (Scope 2), or in the transportation of goods (Scope 3).

The production chain of four construction materials frequently demanded by cities (cement, steel, plastic, and aluminum) is responsible for 12% of global emissions, most of which are produced outside cities or even outside the country (Scope 3).

Food production, distribution processes, and organic waste disposal are responsible for 22% of global emissions (Scope 3).

Contribution to GHG emissions of selected sectors



Source: Compiled by the authors based on Ellen MacArthur Foundation, Completing the Picture: How the Circular Economy Tackles Climate Change (2019). Note: Construction materials: Cement, steel, plastic, and aluminum.

This chapter studies three Chilean sectors and their characteristics to delimit the areas of intervention most relevant to cities considering the main inputs and outputs of materials, energy, and waste. The analysis gathers pioneering cities' experiences in applying a circular economy of national and international expert entities and following current policies and programs.

Energy sector

As societies develop and prosper, they require more energy to function. Historically, global energy demand has increased in proportion to population growth[24].

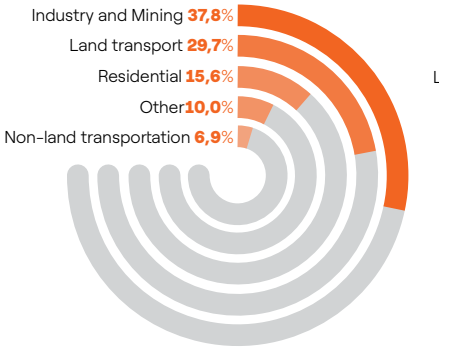
Chile has played a global role in accelerating its electricity generation matrix's decarbonization, promoting the installation of new renewable capacity. In addition, the electrification of final consumption will reduce impacts by adopting more efficient technologies and gradually abandoning fossil fuels.

Public programs and policies implemented in the last decade have depicted a clear and precise course toward emissions relief. The State's long-term commitment is reflected in the national Sustainable Mobility and Electromobility strategies, the Framework Law on Climate Change; the Energy Efficiency Law; the Distributed Generation programs through solar roofs, and the Home Energy Certification within the framework of the Energy Policy 2050. Adopting a circular vision in cities concentrating a large part of final energy consumption on transportation and home heating will allow the implementation of strategies to reduce fossil fuel consumption and benefit from potential local and renewable energy resources. The technological changes needed to carry out this transition should include requirements for a circular design that reduces value chain emissions and minimizes material supply risk exposure.

Dependence on fossil fuels

In Chile, the final energy consumption in 2019 was 301,629 Tcal[25], dominated by petroleum derivatives (57.5%). Fossil fuel burning activities for transportation and residential sectors are responsible for 38.5% of emissions[26] and 52.2% of use[27].

Final Energy Use (2019)



Source: Own elaboration based on the Ministry of Energy (2021). National Energy Balance Report (2019).

An ever-expanding vehicle industry

The private motor vehicle industry reached 5,147,227 units in 2019, with a steady increase in both the absolute number and the motorization rate. The latter went from 236 to 269 vehicles/1000 inhabitants between 2015 and 2019[28], caused by population expansion, higher purchasing power, and improved national road infrastructure.

The land transport sector consumed 89,556 Tcal in 2019, where 57% of final consumption was diesel oil, 42% gasoline, and only 0.3% corresponded to electricity. However, electromobility has been progressing rapidly. By April 2022, all regions of the country already had at least one recharging point, with a total capacity of more than 17 MW. Sales of electric vehicles have also grown significantly in recent years.

Challenges in the road to more efficient and electrified homes

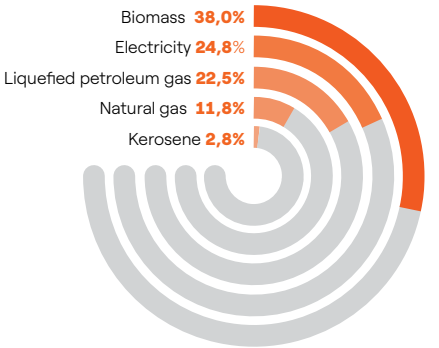
In 2019, the final energy consumption of the residential sector amounted to 46,557 Tcal. The composition of final use by energy source is dominated by biomass (38%), electricity (25%), and liquefied petroleum gas (23%). Air conditioning and domestic hot water (DHW) are the primary sources of annual energy consumption in dwellings, with 53% and 20%, respectively.

Thirty-nine percent of households use firewood as central heating system energy, 19% use kerosene, and 21% choose liquefied gas. Natural gas and liquefied gas are the leading systems for DHW production and are used by 92% of households nationwide[29].

Although there was a slight decrease in energy use in housing between 2009 and 2018, 67% still do not have some measure of thermal insulation because most homes were built before 2001. Insulation requirements have since been introduced in the General Ordinance of Urbanism and Construction (OGUC). There is, therefore, a potential for reducing consumption, which poses interesting challenges for the construction sector.

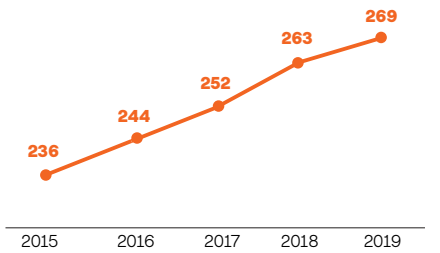
In the same period, 2009 -2018, electricity consumption increased to replace other energy sources. There was a jump from 1,692 kWh/household/year to 2,074 kWh/household/year, which shows a trend towards increasing electrification of consumption. By adopting efficient technologies, accompanied by the plan to decarbonize the electricity matrix, this trend will be critical to an effective reduction in fossil fuel use and, consequently, housing energy emissions.

Residential Sector Energy Sources (2019)



Source: Own elaboration based on Ministry of Energy (2021). National Energy Balance Report (2019). Biogas, which represents 0.01% of consumption, is not indicated.

Motorization rate (2019)
Vehicles /1.000 inhabitants



Source: Own elaboration based on INE (2019).

How to apply the principles of circularity in the energy sector?

From a circular urban metabolism perspective, the city will have to reduce fossil fuel consumption through energy efficiency to achieve the closure of resource cycles and reduce dependence on external resources. It should also implement modal shifts and use the urban territory's renewable energy resources, particularly solar radiation. Where possible, residual energy should be recovered from industry, waste, and wastewater, including opportunities to collaborate with other industries, including the food sector, given the energy potential of organic waste.

The electrification of land transportation will be the primary step contributing to city emissions and the dependence on fossil fuels. The first National Electromobility Strategy established long-term objectives to reach 40% of private vehicles and 100% of urban public transport by 2050. The Energy Route 2018-2022 aims to reach 2,430 electric vehicles by 2022, and the National Electromobility Strategy, launched in 2021, proposes that by 2035 the total of new additions to public transport and sales of light and medium vehicles should be zero emissions.

While the shift to cleaner mobility will bring benefits in terms of efficiency, noise, and emissions, to move towards a circular model, it is also necessary to promote innovative formulas that contribute to slowing down and reversing the increase in a vastly underutilized vehicle fleet. Estimations state that private cars spend 92% of their useful life parked[30]. In Santiago, the average occupancy today is 1.4 passengers per vehicle[31]. For example, a private vehicle with an internal combustion engine, occupied by 1.4 passengers, emits 174 g CO_2e/km per passenger. Switching to an electric car would reduce emissions to 123 g CO_2e/km[32], 30% less, considering Chile's current electricity matrix. Doubling the average occupancy rate would reduce emissions by 65% and halve the number of cars in circulation.

Therefore, technological transition with shared transport models, encouraging modal shifts towards active mobility (walking, cycling), creating conditions to reduce the need for travel (remote work) and a more capillary development of public transport, will bring additional benefits for decontamination, decongestion, and quality of life. The aspiration is a "15-minute city".

Regarding the motorization rate, the C40 network[33] recommends that large cities reach 190 vehicles/1000 inhabitants by 2030 and promote an ambitious goal of zero private vehicles[34].

This target is essential to consider the indirect emissions produced by product demand. For example, in the life cycle of a personal electric car, only 52% of emissions are due to energy use, while the rest are produced in its production cycle and infrastructure. These are generally not accounted for in national inventories, as production is mainly outside the country.

Regarding materiality and end-of-life, the National Electromobility Strategy regulates battery recycling within Law 20.920 on extended producer responsibility, including specific collection and recovery goals. The latter establishes incentives associated with reusing batteries extracted from different means of transport, generating a formal secondary market. Technological solutions for the second life of batteries will be studied and promoted to promote reuse in isolated and grid-connected electricity generation storage systems.

Further regulation is developing for Retrofitting, transforming combustion vehicles to electric vehicles, generating an industry that contemplates their particularities[35]. This is especially relevant if we consider how the application of circular principles can favor the development of a local sector dedicated to extending the useful life of the existing vehicle fleet, increasing its efficiency, and recovering its materials.

In the residential sphere, circularity measures aim firstly at avoiding or reducing the consumption of fossil resources in homes, particularly for heating and domestic hot water, which represent a large part of household spending. Improving the thermal performance of buildings should be a priority to reduce energy demand, especially in homes that still do not have any insulation measures. Although they require investment, they generate significant savings. They include, among others, insulation of walls 5 cm above the minimum required in the case of new housing or 10 cm in existing housing[29]. From a circular economy perspective, energy efficiency interventions must comply with circular design criteria, as will be seen in the section dedicated to the construction sector.

Since 2012, the Ministry of Housing and Urban Planning (Minvu) has been promoting a Housing Energy Rating instrument (CEV), which allows the energy requirements of homes to be evaluated in a standardized way. The CEV is materialized in a label that shows the savings with respect to the minimum requirements. As of December 31, 2021, more than 97 thousand evaluations had been carried out throughout the country, and 1,148 professionals had been accredited as energy evaluators[36]. Today this is a voluntary initiative, but the Energy Efficiency Law establishes that new buildings must have the label to obtain definitive municipal reception.

In addition, it must be displayed in all sales advertising. Technological change will accelerate the reduction in energy demand. Today there are technologies on the market, such as heat pumps, with a useful effect three times greater than conventional stoves –both electric and thermal– and with significant economic savings for families. They also entail a net reduction in the demand for fossil fuels.

The city offers ample potential to expand and encourage solar generation on the roofs of public and private buildings. Since 2015, more than eleven thousand photovoltaic installations have been connected in net-billing for a total of 114 MW37 and a potential greater than 7 GW in the most optimistic scenario[38].

Finally, the energy recovery potential should be assessed from industrial heat, waste or sewage. They could be inputs or inputs for other sectors, fulfilling an effective closure of the cycle of energy flows that are currently lost. An emblematic example is the recovery of biogas for residential use from the La Farfana water treatment plant, which produces some 24 million m3 of biogas per year for some 30,000 customers[39]. Another, on a smaller scale, is in the commune of La Pintana, which supplies 25% of fuel for waste collection through biodiesel made from used cooking oil[40].

Enel and its drive to Electromobility

Enel X leads Chile's energy transition of public transport through electromobility. By 2022, there will be more than 1,400 100% electric buses in circulation in the Metropolitan Region and more than twelve electro-charging terminals provided by Enel X Way. This measure has proven to be the right way for people to enjoy cities with a smaller carbon footprint and low noise and air pollution. This project includes more than 40 intelligent stops that accompany and make the travel experience safe by using this efficient electric public transport.

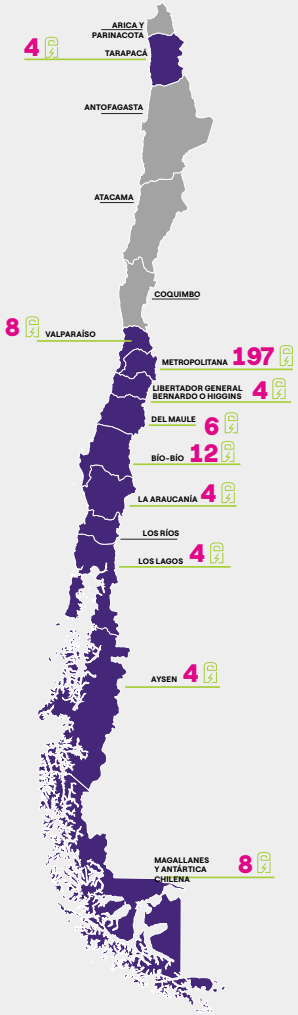
Enel X Way, the Group's new subsidiary, is making progress on the Enel Electro Route 2019-2025 infrastructure improvement project, aiming to install 1,200 charging points (both in public and private spaces), creating a network to further sustain electromobility development in Chile.

First electric service station in Latin America:

The construction of multi-use electric service stations seeks to optimize current facilities for a more circular urban ecosystem. With this, we strive to make all the intelligent charging infrastructure, efficiency, and amenities available to the citizens that facilitate this transition.

- Infrastructure Plan 2019-2025
- 1,200 charging stations throughout Chile
- Total: 251 stations opened to date

Electro route: established charging stations



Construction Sector

The construction sector is an essential driver of development and economic growth worldwide. Considering that people spend 87% of their time inside buildings[41] and share life moments there, the demand for better design, efficiency, and quality of building and infrastructure solutions is increasing.

In Chile, the Chilean Chamber of Construction estimates that the construction industry contributes 7.1% of the national GDP and generates 8.5% of jobs[42].

Historically, this sector has operated under a linear model, which consumes many low-cost and easily accessible resources and energy[43] causing enormous inefficiencies in using materials along the value chain[44]. One of the main consequences is the waste generation and loss of value of materials and externalities at each stage[42].

The construction sector is responsible for more than a third of global resource consumption, and the production of building materials consumes about 10% of global energy. By 2019, the International Energy Agency (IEA) estimated that the construction and operation of buildings were responsible for 38% of global emissions related to energy use[45].

This sector has experienced steady growth in emissions because the increase in a built-up area -65% between 2000 and 2020, has not been accompanied by adequate measures in terms of energy efficiency, as the average energy use per m^2 built fell by only 25%[46].

Concrete and Steel: two materials responsible for the impact of construction

Based on six case studies, the World Business Council for Sustainable Development (WBCSD) estimated emissions of a building average 1,800 kg CO_2e/m^2 over its life cycle.

Half of this is due to the building's operation, mainly through energy use, and the other half to embodied carbon, which derives from construction materials and processes. Steel and concrete, composed mainly of cement and aggregates, are the materials that contribute most to these emissions[47].

World demand for cement and steel for construction reached 1.98 and 0.52 Gt in 2015, respectively. Latin America contributed 35.5 and 10.6 Mt, respectively[46]. Cement alone will be responsible for 12% of global emissions by 2060[48]. In addition, 30 billion tons of sand are extracted every year for the manufacture of concrete, mainly from shores and beaches, which contributes to exacerbating the vulnerabilities of coastal regions[49]. Its demand, moreover, can easily lead to problems of illegal extraction. In Chile, an Aggregates Committee - formed under the auspices of the Chilean Construction Institute in 2010 - estimated a seven million cubic meters gap between the aggregate demand and the formal productive capacity that could result from illegal extraction[50]. This demonstrates the urgency of finding alternative sources of aggregate supply, for which Construction and Demolition Waste (CDW) could offer a solution, as seen below.

CDW, which contributes to about 30% of waste in developed countries[51], is a significant variety of

developed countries[51], is a significant variety of materials, including concrete, bricks, plaster, ceramics, glass, and metals. Some can be recycled, although currently only metals have good recovery rates due to their economic value.

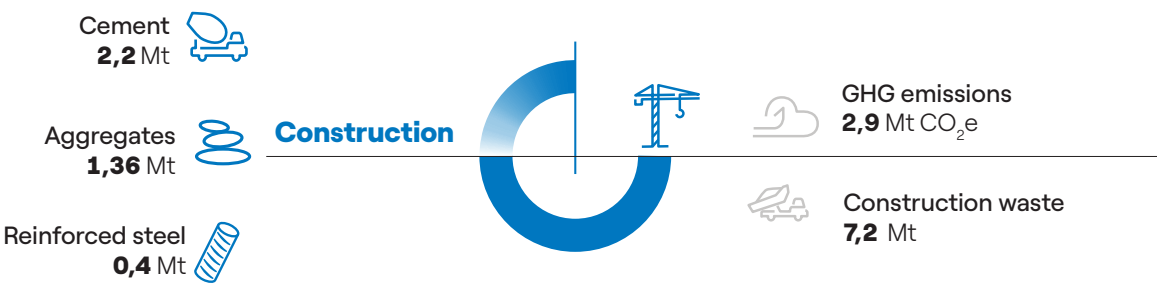
Estimated impacts in Chile

Given the little public information on the flow of construction materials in Chile, one of the alternatives for estimating the impacts is to analyze the trend regarding building permits and calculate material flows, waste, and emissions based on square meters built. According to public information, in 2019, 14 million m^2 were authorized for housing and almost 6 million m^2 for non-housing uses. This information helped with the material consumption analysis.

Sector's material consumption

Analysis of construction characteristics and materiality declared in the building permits, 57% of the constructions are made with reinforced concrete walls, a growing trend in the last ten years. This shows the relevance of the demand for this material in Chile.

In 2019, the Chilean Chamber of Construction reported 4,081,896 tons of domestically produced cement. This was in addition to 2,215,171 tons of imported cement. Domestic rebar shipments amounted to 551,085 tons, adding 151,483 tons of imported bars[52].



Source: Own elaboration based on INE and WBCSD data. For more information, see Methodological Notes.

Data from the WBCSD study estimates that about 0.67 m^3 of concrete would be required for each square meter of building constructed. This is equivalent to 201 kg of cement, 1228 kg of aggregates, and 34 kg of reinforcing steel bars.

About 0.17 m^3 of concrete would be required for extensions, equivalent to about 53 kg of cement, 323 kg of aggregates, and 21 kg of steel reinforcing bars. Thus, based on the permits authorized in 2019 for concrete constructions, 2.2 million tons of cement, 13.6 million tons of aggregates and 382 thousand tons of reinforcing steel would be required annually. This is clearly underestimated with respect to production and import figures, since it represents only a fraction of buildings and does not include infrastructure works, among others.

Emissions of the building sector

Regarding GHG emissions associated with the sector, the Chilean Chamber of Construction warns that the country does not have official figures that quantify this outflow. However, it made an estimate based on Chile's Third Biennial Update Report on Climate Change (2018)[53] and some assumptions that relate the construction sector to material production (cement, iron, steel, glass, and tar); cargo transportation and use of specialized machinery; and energy use in the commercial, public, and residential sectors. With these data, the Chamber concludes that this sector could potentially contribute 22.8% of the country's total GHG emissions[54].

Using the data from construction permits for concrete buildings and the life cycle emission factors proposed by Ecobase55, the contribution to GHG emissions due to the productive process of producing concrete and reinforcing steel has been estimated, and it is concluded that these are the main responsible for the sector's emissions. At the national level, concrete annually contributes 2.2 Mt CO_2e and reinforcing steel 0.7 Mt CO_2e, for a total of 2.9 Mt CO_2e. This constitutes a first approximation to determine the contribution to climate change of the demand for construction materials.

Waste generated by the building sector

Construction and Demolition Waste (RCD) comes from the construction of new projects; rehabilitation, repair and reconditioning of existing works; land preparation processes; demolition of works that have lost their value and/or demolitions due to catastrophe situations[56].

The only official source for the declaration of non-hazardous solid waste is the Pollutant Emissions and Transfer Register (RETC)[57] administered by the Ministry of the Environment (MMA). According to its latest report (2020), the construction sector in 2019 generated 735,243 tons of RCD. However, in the latest report on the State of the Environment[58], the MMA estimated a national production of more than 7 million tons of CDW per year for the Building subsector, one of the sources of CDW generation on which the country does not yet have accurate calculations. Likewise, the MMA encrypted 20 million tons derived from the affectation of homes by catastrophic events, such as the 2010 earthquake in the center-south zone. as the 2010 earthquake in the center-south zone.

How do we apply the principles of circularity to the construction sector?

According to the Ellen MacArthur Foundation, applying circular economy models to the built environment would imply reductions of 38% in emissions by the year 2050[12].

Following the principles of the circular economy, for the built environment, the strategies aim to reduce the use of materials and keep them in closed cycles of useful life extension, with reuse and recycling, among other measures. Technological innovation must provide enabling elements to choose materials with less impact, apply techniques to reduce manufacturing waste, and allow the efficient closure of life cycles, facilitating the disassembly and reuse of components.

It is essential to regulate the adoption of secondary and/or low-carbon materials, the design of prefabricated modular structures, and the development of procedures to certify the reuse of materials and components, among others45. Several of these matters are already being studied or proposed as goals in public policy59. And there are initiatives –such as those being developed by the Ministries of the Environment, Housing and Urban Planning, and Public Works – to include sustainability and circular economy criteria in the supply chain and develop better construction standards. In the short term, they must be overcome technical-normative and regulatory barriers, along with promoting and accelerating the adoption of circular business models.

To guide the application of the circular economy in this area, the Ellen MacArthur Foundation defined ten measures established under four principles: avoid new buildings; build to maintain value over the long term; increase efficiency in the use of materials and use sustainable materials60. Enel evaluated and expanded this proposal in conjunction with the MMA, adding a fifth principle on traceability and connectivity in the value chain.

Given the gaps in the demand for construction materials, the generation of CDW, and its poor traceability, Chile has a high potential to combine some of the five principles exposed through specific interventions that generate benefits from the design. Reduce the use of virgin raw materials. It would make it possible to supply part of the demand for material, particularly aggregates, which, as has been seen, present a significant gap between formal demand and supply. The Sustainable Construction Standards of the Ministry of Housing and Urbanism are directed in this direction, which codifies certain attributes of the materials used in work, prioritizing local, low-carbon, recycled, and low-waste design[61].

Incorporate, in the design phase, criteria of efficiency, durability, adaptability, and ease of disassembly they will reduce the annual demand for new materials and extend the useful life of buildings. Also, have materials suitable for a second life or recycling at the end of their useful life. It is necessary to move towards early collaboration in the supply chain, from formulating essential technical specifications to adding circular criteria.

The incorporation of efficiencies in the use of materials and the adoption of industrialized construction will reduce the amount of waste generated by the sector, which must be correctly separated and classified to ensure its reuse when possible. In this sense, the Sustainable Building Certification (CES) establishes that the company that handles waste or debris from work must certify the recovery of materials for recycling or reuse. The recycled material must represent at least 50%, by volume, of the total waste and/or debris removed[62].

Also, it is necessary to move towards better traceability of the flows of materials, waste, and emissions from the life cycle of buildings through, for example, the adoption of material passports in conjunction with BIM technologies. Finally, a collaboration among participants in the value chain will be key to establishing circular business models in construction and cooperation with other industrial sectors.

Circular economy measures in the construction sector

Avoid new buildings and urban land consumption	Design and build for long-term value	Build efficiently	Build with circular materials	Traceability and connectivity in the value chain
Evaluate new construction approvals	Design for longevity and heavy use	Reject unnecessary components	Reduce the use of virgin materials	Use of materials passport throughout the life cycle of components and buildings.
Recover disused constructions and take advantage of them through new ways of living.	Design for flexibility and adaptability over time	Increase efficiency in on-site materials and manage waste according to the waste management hierarchy and separation at source.	Use of low-carbon materials with valued and local content	Use of industrial symbiosis platforms.
Maintain and repair existing buildings	Design for dismantling, deconstruction, and selective demolition	Industrialize and prefabricate all or parts of the work	Replace the use of hazardous or polluting materials that have not been adequately specified in the design	Adoption of technologies such as BIM
	Modular design of construction systems.	Changes in logistics chains reduce storage demand.		
	Early collaboration with the supply chain for a circular technical specification.	Contracts encourage suppliers to reduce packaging and ensure waste return (voluntary REP schemes).		

Source: Adapted from the Ellen MacArthur Foundation by Enel and the Chilean Ministry of the Environment

Day Center for the Elderly, an example of sustainability in Punta Arenas

Within the collaboration agreement between the Ministry of Energy, the Ministry of Public Works, and the Construction Institute, the carbon footprint of the complete life cycle of a public building has been measured. This initiative, a pioneer in Chile, is the Day Center for the Elderly in Punta Arenas, a structure already certified by CES and recognized as the most sustainable in the country.

The results show the base case intensity of 1739 kg CO_2e/m^2. About 35% is due to materials and their transportation, construction, repair, and end-of-life. The rest comes from emissions in the operation phase, from the use of electricity and fuels.

The study modeled different scenarios, such as the extension of the useful life of the building or the incorporation of self-generation of energy, calculating the effect on the life cycle footprint.

Having measurements of this nature extended to more climatic zones in Chile will make it possible to know more rigorously the emissions produced directly using energy and those generated outside the city by the manufacture and transport of building materials (embodied carbon).

For more information, see here:

Source: Construction Institute (2022)

First concrete pole with circular design

Circular input

New life cycles

During Recycling Month, Enel Distribución implemented the first project to manufacture concrete poles with recycled aggregates. In 2022, the installation of 500 poles will materialize -at different points in the concession area- with the same capacity and durability as the traditional ones.

The concrete is converted into artificial aggregates with a determined granulometry and dosage thanks to the Department of Scientific and Technological Research of the Pontificia Universidad Católica de Chile (Dictuc), which conducted tests and analyses for the development of the project. Dictuc determined the quality of the materials and the correct proportion that could be used in manufacturing the recycled posts.

This innovative initiative is part of Enel's sustainability plan and its environmental performance, avoiding the final disposal of 5 thousand tons of concrete per year and reducing the consumption of virgin materials from quarries and rivers (considering that 77% of a pole corresponds to aggregates, such as gravel and sand). This contributes to reducing the demand for this material and CDW generation in the city, producing a local closure of the flow of construction materials.

For more information, see here:

Food Sector

One of the impacts of population concentration in urban centers is the strong demand for resources for the needs of cities. Among them is a basic one: food. As the world has urbanized, food consumption has focused on cities. And the trend continues in this direction. By 2050 it is projected that 80% of food will be consumed in cities[63]. Distances between production centers and consumption are increasing losses, almost 30% of what is produced, growing emissions from transport and packaging, plus the cost of food in cities[63].

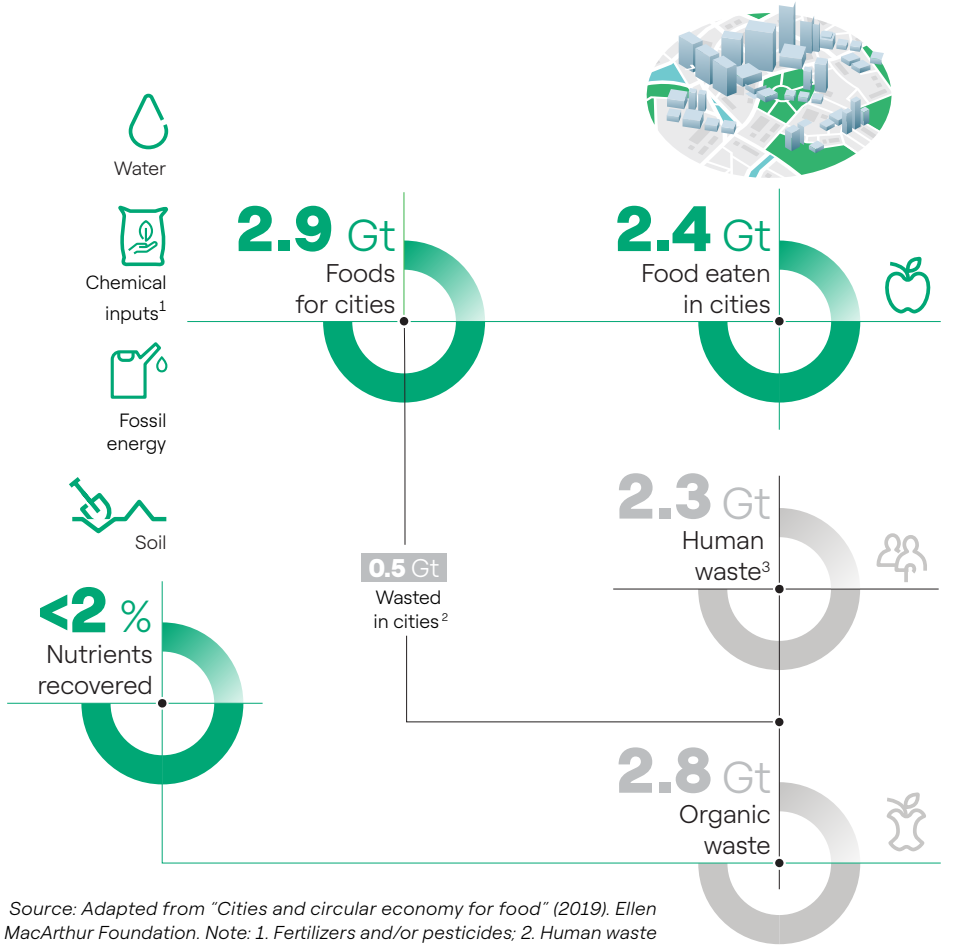
A vital sector for cities

The demand for food today is supplied by a system where a linear model predominates: food is produced in isolation from cities, and consumers are unaware of the process. But the sector's impact on the climate crisis is obvious. And it is also one of the main drivers of soil degradation, loss of biodiversity, and pollution of water, air, and soil due to the massive use of synthetic fertilizers[64].

Beyond the mark left by food production systems at the field level, today, we are witnessing that cities contribute to perpetuating this linear model by restricting the circular flow of resources that enter urban systems. According to the Ellen MacArthur Foundation, less than 2% of the global flow of organic waste produced in cities is effectively reintegrated into production systems.

These figures reveal the reality of an inefficient system in the use of resources and the lack of awareness about the waste of food that, if used, could be a water source, and generate nutrients and energy in a regenerative economy.

Scheme of the flow of organic nutrients in cities



Source: Adapted from "Cities and circular economy for food" (2019). Ellen MacArthur Foundation. Note: 1. Fertilizers and/or pesticides; 2. Human waste includes solid and liquid waste, expressed in wet mass; 3. Food waste in cities includes the distribution and consumption stages

Food systems challenges for Latin America and Chile

Understanding the complexity of the problem is key to sizing up the challenge of transitioning from a linear to a circular model. First, it is necessary to identify where and why inefficiencies occur along the food chain to focus efforts and investment in technological development to close these gaps.

The following figure from the Food and Agriculture Organization of the United Nations (FAO) shows the distribution of food waste in Latin America, starting with production in the field and continuing with storage, processing, and distribution, until consumption on our tables.

Chile is a country whose agricultural sector is the engine of integral development. It brings together an intense primary and secondary food supply activity and has a direct relationship with the people and the environment in which it operates[65]. The sector plays a leading role in the economy and today positions the country globally as an agrifood power. This is reflected in its contribution to the national GDP. It contributes 18% of GDP, 25% of exports, 20% of domestic market sales, 23% of employment, and 31% of companies[66].

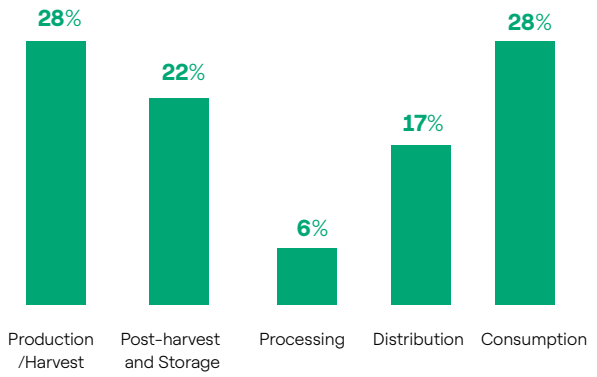
Among the main comparative advantages in forestry and livestock production, Chile stands out for its climate diversity, exceptional natural sanitary conditions, and high quality and safety standards.

Chilean agriculture has focused its development on international markets, and fruit growing has been one of the leading players in this take-off. More than 60% of the national fruit production is destined for export. The country is the biggest exporter of fresh fruit in the southern hemisphere and the world's largest exporter of table grapes, blueberries, and cherries.

Vegetable production is destined for fresh consumption and agroindustry (frozen, dehydrated, canned, and juices) for domestic and foreign markets. In this area, the role of Family Farmer Agriculture (AFC) stands out, which contributes to an essential part of the total production, particularly in dehydrated vegetable products, preserves, and juices, both for domestic and foreign markets. Regarding agrifood items, the AFC controls 54% of vegetable production. According to the 2017 Census, 73.4% of the farms are less than 20 hectares in size.

The forestry and livestock sector in the sustainability agenda stands out because it is carbon neutral and contributes to the capture of 60% of the country's emissions, making it a key player in mitigation. As Chile is a highly vulnerable country in the face of the climate crisis, the forestry and livestock sector is particularly affected since it depends directly on the weather. This poses relevant challenges in adaptation.

Food Waste and Loss (FWL) distribution in Latin America



Source: Own elaboration based on data from FAO (2017). Faculty of Agronomy Universidad de Concepción (2020) REFED Food Waste Map

In the context of a leading agrofood sector and the population's tendency to concentrate on cities, Chile has a double challenge to connect its food system with a society that is moving towards a circular model.

Must address, for example, the need to promote an agrofood chain and more sustainable practices to ensure the resilience of crops to climate change. And then, it must advance in the transition towards sustainable and smart cities through local strategies to promote responsible consumption, optimize distribution chains and efficiently reduce food and waste reduction.

How do we apply the principles of circularity in the food industry?

Cities combine many ingredients that make them an optimal environment for the emergence of solutions and innovations that accelerate the transition to circularity. As a first factor, they concentrate on the generation of waste and by-products with high recovery potential. The journey food takes from the field to our table produces 45% of the waste between distribution and consumption that, given the demographic concentration, occurs in urban centers.

As a second factor, purchasing power and consumer habits strongly influence the redesign of a more sustainable food offer with local solutions.

The third refers to the technological explosion and adoption of innovations in the logistics chain, which reduce inefficiencies and substantially impact waste prevention. Examples of this are intelligent solutions for monitoring the cold chain during transport and storage or using packaging and technologies that extend the shelf life of food.

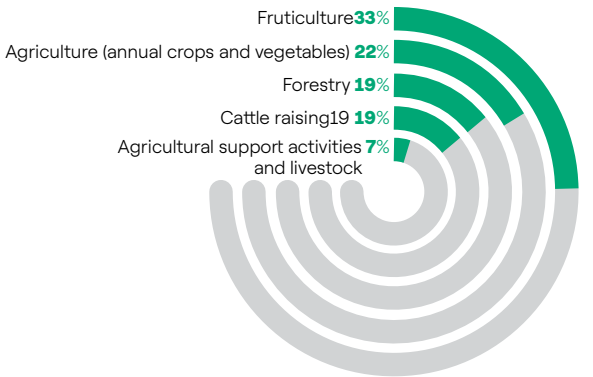
A fourth relevant factor is related to the proximity of actors, making ground towards positive collaboration: the proximity between citizens, distributors, and service providers foster the generation of networks for harnessing waste streams as inputs for a bio economy and the emergence of new circular business models.

A city under a circular economy model contributes to a food system that minimizes reliance on extracting finite resources improving resilience against vulnerability in the supply chain.

Under this vision, cities not only provide us with enormous benefits by reversing those negative externalities for the economy and the environment.

They also allow expanding the role of the food system in sustainable development. A circular city stands out for three fundamental pillars:

Relative contribution of items to Forestry and Agricultural GDP



Source: Prepared by PASO (2019) based on data from the Central Bank (2017). Note: Manufacturing GDP (wine, fruits, and processed meats) is not included.

Principles of a virtuous circular city

Promote local production and foods of systems of crop regenerative:

Cities must encourage urban and peri-urban production to strengthen the connection between production and cities and limit the journey from the field to the table. Adopting local production models strengthens a more sustainable supply chain. resilient.

Design and market healthier foods by promoting healthy eating habits.

Citizens develop healthy and responsible consumption habits, cities must carry out awareness initiatives and campaigns to install new habits and local capacities. Faced with this consumption trend, the food industry increases the availability of healthy and accessible foods for the population.

Making the most of food (and its waste) to develop a circular bioeconomy

Cities must enable solutions and infrastructure to take advantage of the chain of by-products, losses, and food waste to maintain its value over time, perpetuating itself in the production cycle, generating a sustainable secondary market.

Source: Adapted from "Cities and circular economy for food" (2019). Ellen MacArthur Foundation.

In Antofagasta food is not waste

FAO reveals that more than 30% of the food produced for human consumption is thrown out. In the mining region of Antofagasta, less than 5% of the food is produced locally, most coming from the north and center-south of the country. Food is transported for hundreds and even thousands of kilometers. Added to the minimum volumes of local production, the cost of food is considerably higher in this region than in the rest of the country, which threatens the food security of the population, especially the most vulnerable. It is imperative to make efficient use of them.

In the second half of 2020, a group of academics and professionals of various disciplines from the University of Antofagasta proposed to Corfo the execution of a project, Valora Alimentos, which would allow progress in matters of reduction of food waste in marketing centers in the region.

This proposal was joined by the Chilean Agency for Food Safety (Achipia), the Seremi of Agriculture and the Environment of the region, and the two main commercialization and distribution centers of food: the Central Vega of Antofagasta and the Agricultural Terminal of Calama.

It was necessary to leave the usual academic laboratories and meetings to learn about local realities, integrate the work of multidisciplinary teams, and articulate actions with public and private organizations. It has been very motivating to see the response of different people and organizations. Those participating are neighbors, social organizations, the gastronomic sector, students and university authorities, and regional companies, both locally and nationally, who have joined the work, each contributing from their personal and institutional possibilities. The results of Valora Alimentos include a specific management model for the associated premises, which will allow the recovery of food fit for consumption. Also included is a recipe book about recovered food, aimed at the entire population, and two opportunity banks, aimed at entrepreneurs.

made with recovered food, aimed at the entire population, and two opportunity banks, aimed at entrepreneurs. There, business lines based on a circular economy are proposed to generate products for food and non-food use, feasible to implement in the region, revaluing food discarded by consumers. The project is disseminating the results, seeking to contribute to reducing waste in the region and at the national level.

Promoting food recovery positively impacts economic, social, environmental, and health, including recovering nutrients of high biological value. I have focused and the team on contributing to society with a grain of sand. We dream of a near future when these initiatives are implemented and change how things are being done.

Each of us, in our professional and personal environment, can take small actions to reduce food waste and provide food security and a better quality of life in society. We invite you to join!

María José Larrazábal Fuentes,
Director of the Valora Alimentos project

3.

Circular cities

Urban radiographs and interventions

Chile's cities

Chile is one of the longest countries in the world and one of the narrowest. With 4,270 km. in length and an average width of 200 km, it has excellent contrasts given its geography, geomorphological, climatic, and biodiversity variability. This has shaped the cultural diversity and identity of the inhabitants of each territory.

The country has shown a sustained increase in population, mainly in the cities, regional capitals, and peripheral communes of the metropolitan areas, where Gran Santiago, Valparaíso, and Gran Concepción[68] stand out.

Chile does not have megalopolises, cities with more than 10 million inhabitants. The characteristics of urban development allow the country's cities to be classified as follows:

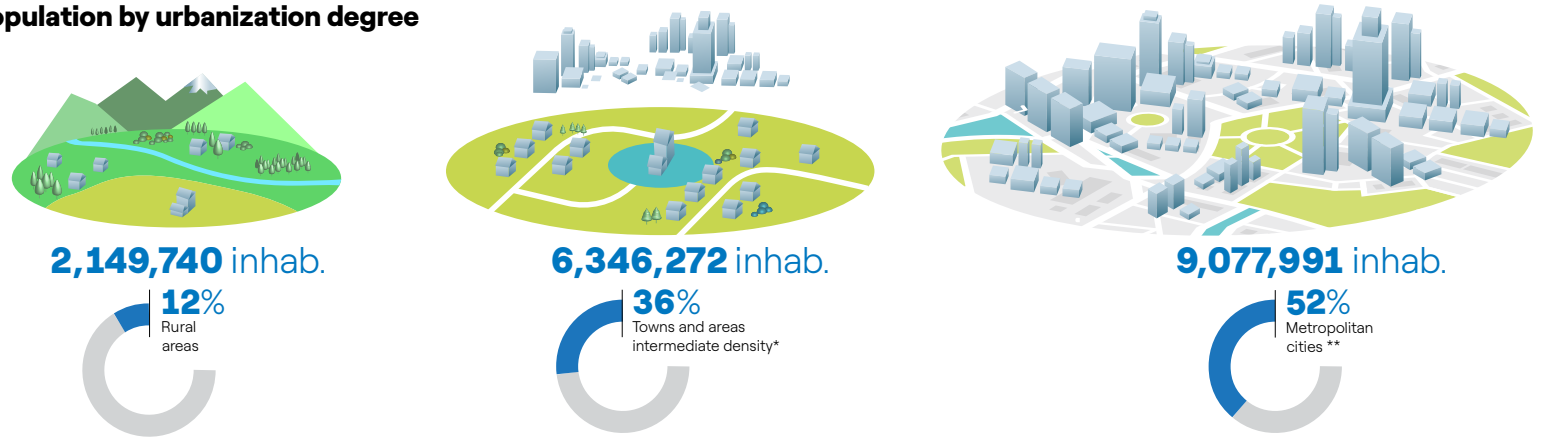
- Small cities: urban areas with between 5,000 and 20,000 inhabitants.
- Smaller intermediate cities: urban areas with between 20,000 and 100,000 inhabitants.
- Larger intermediate cities: urban areas with between 100,000 and 300,000 inhabitants.
- Metropolitan cities: urban areas on which 300,000 inhabitants.

The population of the national capital, the largest in Chile, is 6,103,852 inhabitants in urban areas. Of the country's total urban population, 58.9% (9,077,991 people) reside in metropolitan cities, while 41.1% is distributed among small, minor, and intermediate cities.

Chile's cities are remarkably diverse in structure, possessing political-administrative[69] and economic characteristics that reflect a highly centralized country that has increased around the extraction of raw materials. In addition, there are different development opportunities of geographical location, climatic conditions, and natural ecosystems.

Following the global trend of urbanization, the last national census from 2017 showed that 87.8% of the total population is concentrated in urban areas and only 12.2% in rural areas[67].

Population by urbanization degree



*Source: Own elaboration based on the 2017 Census (INE). Note: *Urban areas with less than 300,000 inhabitants, **Urban areas with more than 300,000 inhabitants.*

Due to its geomorphological characteristics, Chile is affected by seven of the nine vulnerability criteria[70] defined by the United Nations Framework Convention on Climate Change (UNFCCC)[71]. This means that it is more susceptible and loses its ability to adapt to the consequences of climate change[7]. With more than a decade of drought and many coastal cities that may be affected by rising sea levels, development plans must consider these factors. This way, the social, environmental, and economic risks from a linear model, unsustainable for the different natural ecosystems and human settlements, could be prevented.

Due to centralization, some of the gaps in the transition toward circularity are related to a lack of infrastructure and resources for developing R+D+i and local capacities. This is aggravated in the regions farthest from the capital and greater geographic isolation. But it is there where, precisely because of the size of their cities and because they have a less complex political-administrative distribution, urban environments have more potential to move more quickly towards circular practices. Promoting local ecosystems in them that create value circularly and sustainably is key.

Given the exposed context, **three cities have been chosen that are among the most populated in the country and that represent geographic diversity due to their location and cultural relevance:**

Antofagasta

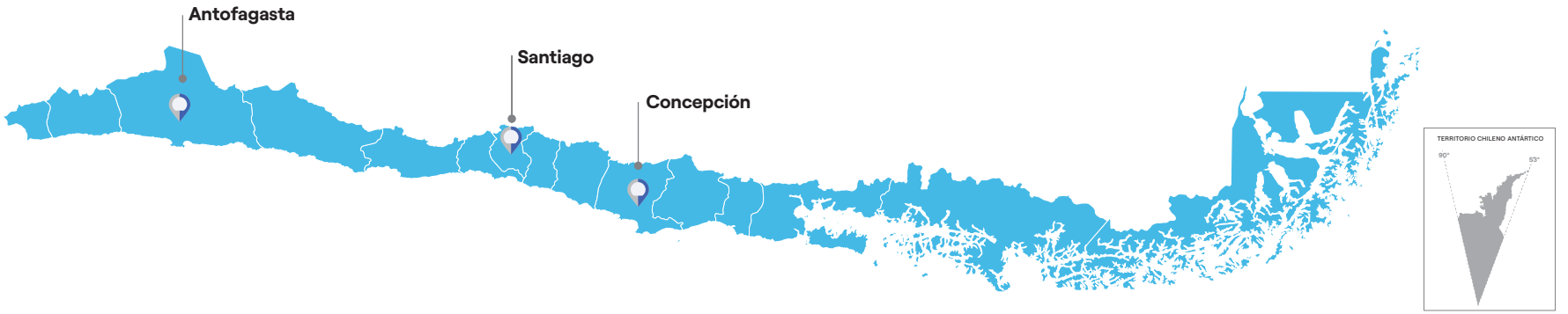
Regional capital, port city, mining center of the north and leader in the development of renewable energies.

Santiago

National capital, political-administrative, trade and service center, which is strongly intertwined with the cities in its immediate surroundings and is a pole of gravity at the national level.

Concepción

Regional capital, southern college town, it has a forestry, industrial and fishing vocation.



Antofagasta

Antofagasta is the regional capital, known as "The Pearl of the North". It is a city, port, and commune that has developed thanks to important port and industrial activities linked to large-scale copper and lithium mining. It is the civic center with the highest income per capita in Chile and, simultaneously, one of the most expensive cities to live in. According to the last Census of 201767, within the urban limits, 354,104 people inhabit, with a population density of 73 inhabitants/ha.

In its history, the region and commune of Antofagasta have had an economy based on the exploitation of minerals. In its first years, it was fertilizer and saltpeter; currently, copper and lithium. 54% of Chile's mining production is concentrated there, representing 16% of world copper production. According to data from the Central Bank, this region contributes approximately 11.63% of the national GDP, placing it second after the Metropolitan Region.

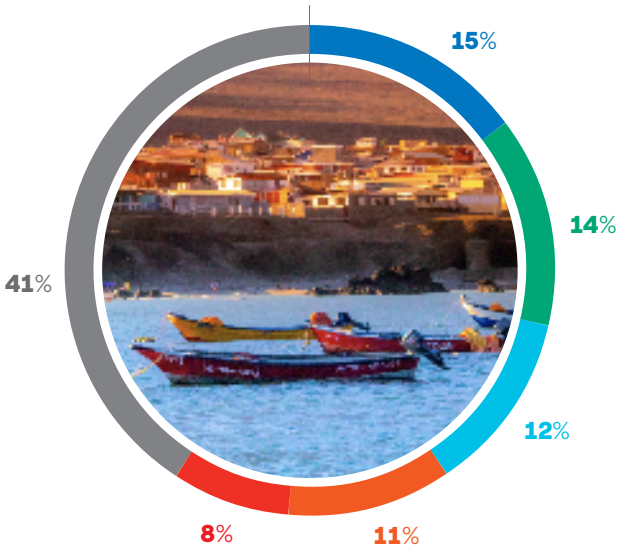
The solar wealth of the Atacama Desert gives this region an already perceptible economic potential with more than 3000 MW of installed renewable energy capacity. Antofagasta collaborates with the public, private and academic sectors for investment in research, development, and innovation of clean energies with benefits at a national and local scale.

From an urban perspective, the commune stands out for having very well-defined areas according to the socioeconomic level of its population. This situation, added to the high level of unemployment, has generated significant levels of segregation.

From an environmental perspective, the city faces important challenges. One of them is a large number of micro dumps, continuous garbage burning that affects air quality (La Chimba sector), high pollution in industrial areas (La Negra), and a coastline affected by hydrocarbon leaks[72].

The agricultural activity displays challenges due to climate conditions, soil characteristics, and the influence of the desert. The city has sought different mechanisms to provide itself with food. One of the fastest growing farming systems has been hydroponics, which represents a highly efficient methodology in water use, adjusted to the climatic reality, and operates close to consumers. The strengthening of these innovative farming systems has been possible thanks to the water supply from desalination plants. Today, Antofagasta's commune has the highest hydroponic crop concentration in the region. This scenario represents a local production model that supplies urban consumption with a smaller water footprint.

Antofagasta
Main economic items



- Construction
- Teaching
- Administrative and support service activities
- Wholesale and Retail; repair of motor vehicles and motorcycles
- Manufacturing industry
- Others

Urban data and demographic

Consolidated urban area
4,874 ha

Urban population
354.104 Inhabitants

Population density
73 inhabitants/ha

Urban households
105,521

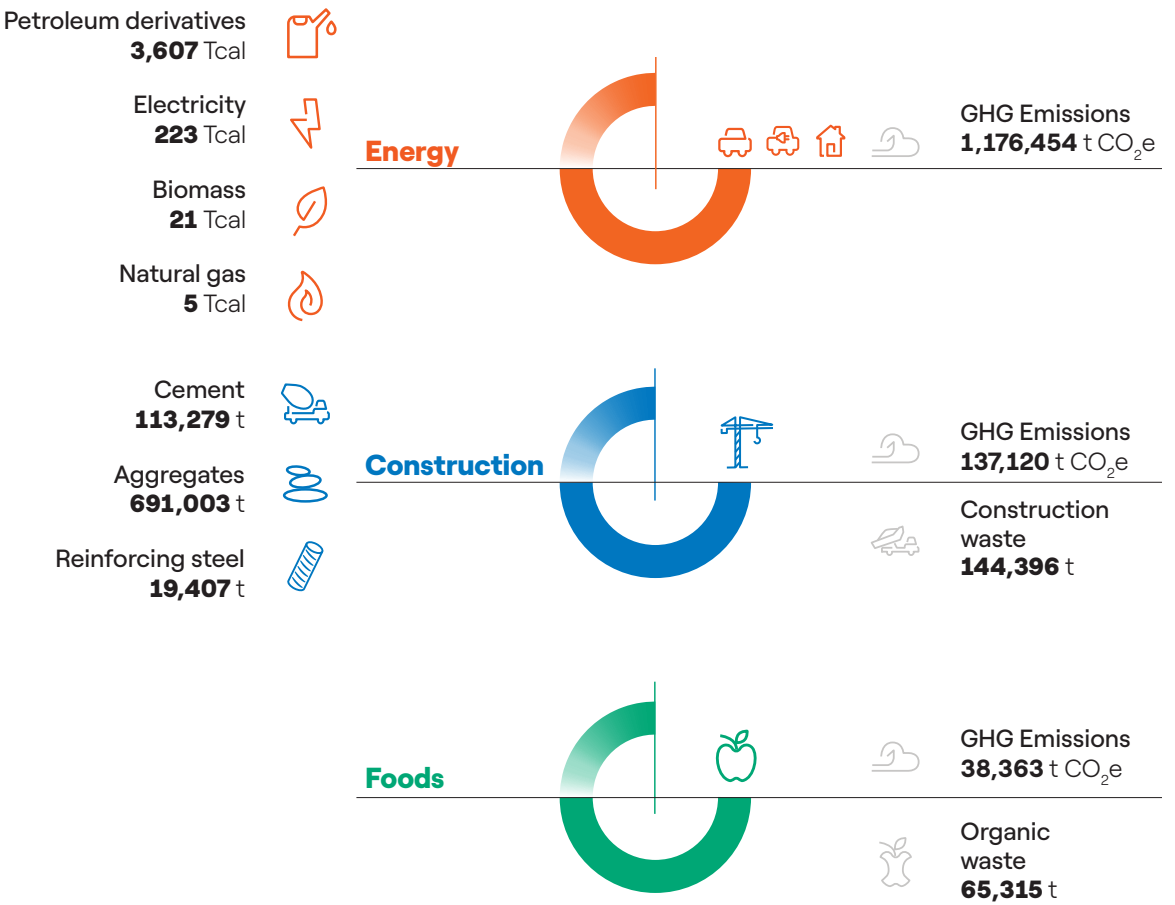
People per household
3.4

Source: Own elaboration based on SII data, by number of workers registered in the companies by commune[73], Census 2017, open data from the Center for Sustainable Urban Development (Cedeus)[74]

Antofagasta radiograph

Flows of energy, materials, waste, and emissions (scope 1, 2, and 3)

Among the sectors considered in this analysis, Antofagasta contributes to the consumption of 823 thousand tons of building materials; 3,857 Tcal of energy; it produces 220 thousand tons of construction waste and 65 thousand tons of organic waste. The emissions generated by the three sectors reach 1.35 Mt CO_2e. Land transport is the leading issuer.



Source: Own elaboration. For more information consult Methodological Notes Note: 1 Tcal = 1012calories

Antofagasta
Main urban indicators

Due to its geographical location, Antofagasta has a high potential for distributed photovoltaic generation, which is currently being used with just over 500 kW of installed capacity. If this potential is developed, it could reach 45% of the city's energy demand. A private motorization rate of 216 vehicles/1,000 inhabitants is surveyed, which is lower than the national average (269 vehicles/1,000 inhabitants) but is accompanied by a high percentage of trips by private means of transport (37%).

It presents greater electric flow in homes compared to other Chilean cities (49%) and a better level of thermal insulation (44% of homes with wall insulation). There is still a low or null recovery of construction and demolition waste and organic waste, critical aspects to address given the growing population.

Energy

Motorization rate	Private transportation trips	Public chargers
216 vehicles/1,000 inhab.	**37** %	**220** kW

Photovoltaic systems under net billing scheme	Houses with termal insulation (thermal zone 1)	Electrification in households
531 kW	**44** %	**49** %

Construction

Building permits (2019)	Recovered CDW declared (2019)	Public investment (2021-2022 budget)
627,808 m^2	**0** t	**53,511** MCLP

Foods

RSD production per capita	RSD valued (2017)	RSD sent to composting and vermiculture (2017)
1.36 kg/inhab/d	**0** t	**0** t

Source: Own elaboration. For more information see Methodological Notes

Antofagasta circular interventions

In the first place, circular economy measures should promote the recovery of construction materials to avoid the accumulation of CDW, generating local virtuous cycles.

Food rescue initiatives have been prioritized in the food sector to reduce waste and recover nutrients for bioenergy.

In the energy sector, progress must be made towards forms of more sustainable mobility, promoting modal changes, the electrification of consumption, and taking advantage of the local potential for distributed generation.

CE Prinicples	Measure	Description	Expected benefits
	Electrification and energy efficiency	Encourage the adoption of distributed generation technologies and air conditioning by heat pumps	E R V S
	Electric public transport	Promote the electrification of public transport, including the conversion of the existing fleet	E R V S
	Modal changes	Encourage remote work to reduce the need for travel and shared transport and expand the bike lane network.	E R V S

CE Prinicples	Measure	Description	Expected benefits
	Reduce current supplies	Incorporate local, circular, low-carbon materials and adopt, where possible, Sustainable Construction Standards	E R V S
	Circular desing	Encourage the reconversion of disused spaces. Incorporate efficiency, durability, adaptability, and ease of disassembly criteria in the design phase	E R V S
	Construction site efficiency	Adopt industrialized construction techniques and locally valorize CDW in the production of recycled aggregates	E R V S

CE Prinicples	Measure	Description	Expected benefits
	Redistribute	Promote distributor-consumer direct sales platforms for products close to the expiration date or defective products, generating secondary markets.	E R V S
	Nutrient recycling: development of new foods	Promote food waste rescue programs from free fairs to developing food. Promote entrepreneurship ecosystem and new circular business models.	E R V S
	Nutrient recycling: anaerobic digestion	Implement municipal programs for the management and recovery of organic waste through low-scale bioenergy systems generating energy and biofertilizers to promote a local economy	E R V S

Circular Economy Principles (CE)

- Eliminate waste and pollution
- Circulate products and materials
- Regenerate nature

Benefits

- E Reduction of GHG emissions (climate change)
- R Reduction of demand for virgin resources (decoupling)
- V Valorization of resources
- S Potential social impact and quality of life

Grand Santiago

Founded in 1541, Santiago, or Greater Santiago, is the country's capital. It is located in the Metropolitan Region (RM) and comprises 34 communes of the conurbation[75], nestled in the Maipo basin and surrounded by mountain ranges. According to the 2017 Census[67], it has 6,103,852 inhabitants in the urban area, which represents 34.7% of the national population, with a density of 77.3 inhabitants/ha.

Santiago is also the country's main economic engine and one of the most relevant in Latin America. The Chilean capital, considered the most innovative and sustainable city in Latin America according to IESE Cities in Motion Index (CIMI) 202076, stands out in the economy, human capital, and technology dimensions and concentrates on the main political and administrative institutions and financial and of business. According to figures from the Central Bank of 2020, the GDP of the Metropolitan Region is equivalent to 43% of the National GDP, driven by the economic, financial, and business services and trade sectors.

The urban area at the edge of Santiago has a relevant food production, which represents 12.2% of the national GDP. It is distributed in the production of fruit trees 45%, vegetables 21%, cereals 13% and vineyards 10%. The production of vegetables in the RM represents 25% of the national production and is mainly consumed in the local market.

Like most large cities, it is not exempt from urban challenges. This is indicated by its lower performance in the environment, urban planning, mobility, and transportation dimensions of the CIMI 2022, whose deficiencies are manifested in multiple areas: air quality; social segregation characterized by lack of access to quality health and education; low connectivity; an excessive car fleet that generates congestion; high levels of stress among citizens; lack of resilience associated with poor planning, among others. In addition, the effects of climate change and the 13 years of drought (2010-2022)[77] in the central zone have strongly impacted Santiago, its population, and its development.

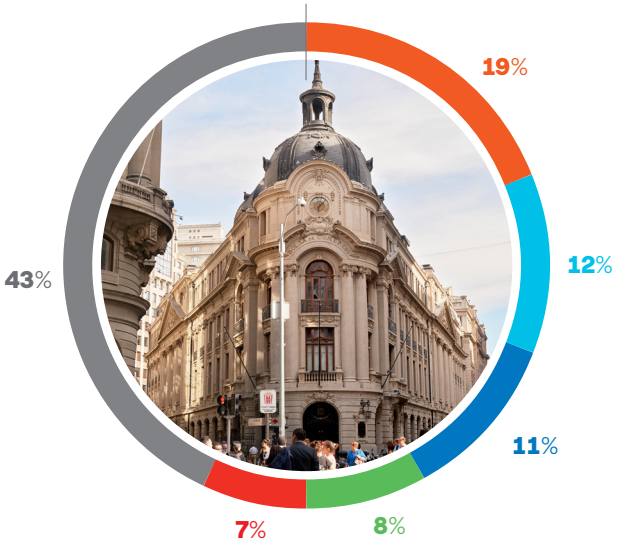
From the urban point of view, it has been consolidating as an extensive, dispersed, and fragmented city. Due to these characteristics and the environmental challenges, the recently elected Regional Government has promoted the initiative "Resilience Santiago", whose pillars are safety, urban mobility, environment, risk management, economic development, connectivity, and social equity. In addition, it created the Coordination of Environment, Biodiversity, and Climate Action, along with two Advisory Councils formed with representatives from academia, civil society, the public sector, and non-governmental organizations (NGOs). It also organized a public-private technical roundtable on the circular economy.

Together with the region's main cities, within the framework of COP26, Santiago adhered to the Declaration of Circular Cities of Latin America and the Caribbean promoted by the Economic Commission for Latin America and the Caribbean, ECLAC, and the International Italo-Latin American Organization, IILA.

Santiago joined the Declaration of Circular Cities by adopting voluntary commitments that promote and accelerate the transition to circular cities.

For more information see here

Santiago
Main economic items:



- Wholesale and Retail; repair of motor vehicles and motorcycles
- Administrative and support service activities
- Building
- Professional, scientific, and technical activities
- Manufacturing industry
- Others

Urban data and demographic

Consolidated urban area
78,914 ha

Urban population
6,103,852 Inhabitants

Population density
77,3 inhabitants/ha

Urban households
1,941,375

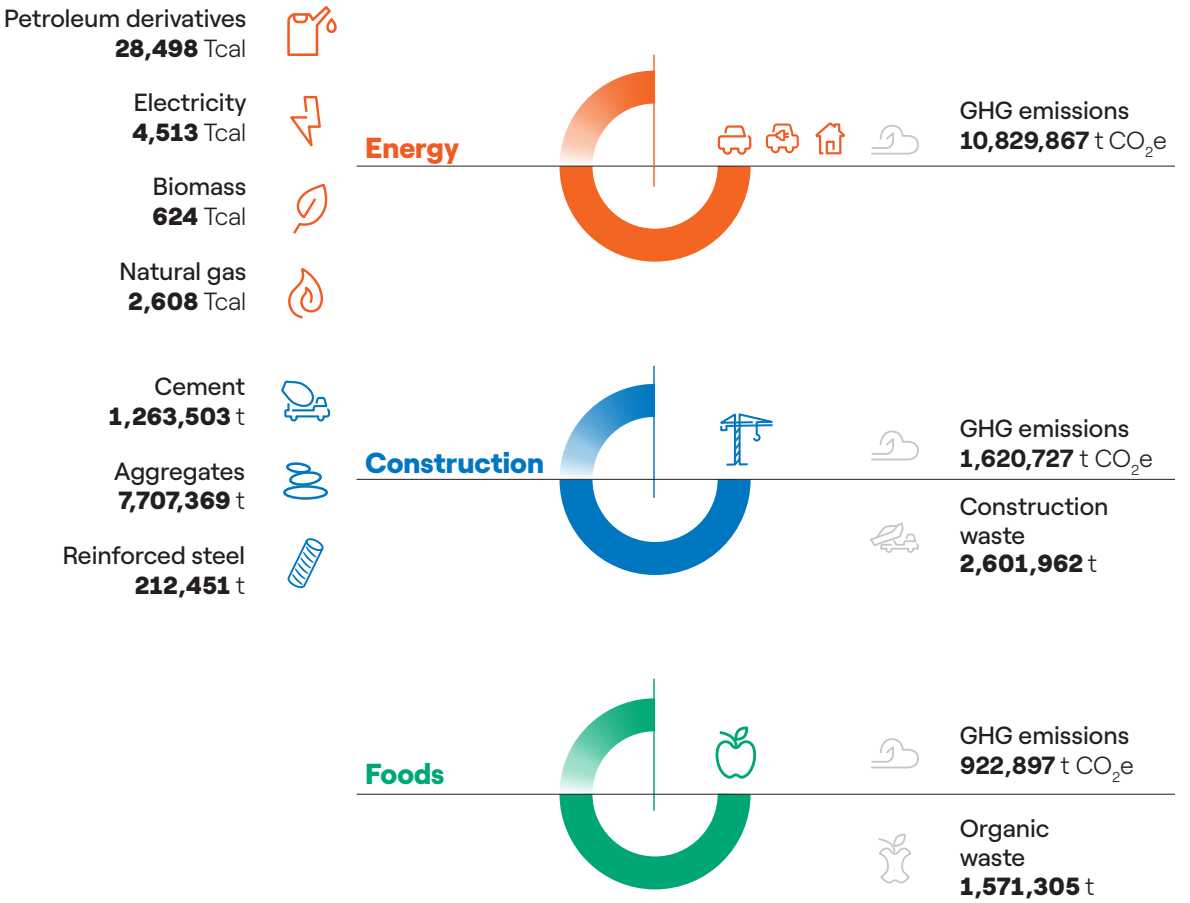
People per household
3.1

Source: Own elaboration based on SII data, by number of workers registered in the companies by commune73, Census 2017, open data from the Center for Sustainable Urban Development (Cedeus)[74]

Santiago radiograph

Flows of energy, materials, waste, and emissions (scope 1, 2 and 3)

Among the sectors considered in this analysis, Santiago contributes with the consumption of 9.2 million tons of construction materials, 36,243 Tcal of energy, produces 2.6 million tons of construction waste, and 1.6 million tons of organic waste. Emissions generated by the three sectors reach 13.4 Mt CO_2e, and land transport is the leading emitter.



Source: Own elaboration. For more information see Methodological Notes

Santiago
Main urban indicators

As the most significant urban center in the country, Santiago has a high potential for distributed photovoltaic generation through solar roofs, which currently use more than 18 MW of installed capacity.

The private motorization rate is 255 vehicles/1000 inhabitants, close to the national average, with a lower percentage of trips in private transport than in Antofagasta (28%). Still, we could improve this by promoting more sustainable modes of transport and opening the opportunity for new business models.

Electricity going into houses is higher than the national average (37%), but the level of thermal insulation is deficient (16% of homes with wall insulation). Activities for the recovery of construction and demolition waste and organic waste are minimal, although there are initiatives with good results in some municipalities.

Energy

Motorization rate	Private transportation trips	Public chargers
255 vehicles/1,000 inhab	**28** %	**76,419** kW

IInstallations photovoltaic in net billing	Insulated homes thermal (thermal zone 1)	Electrification households
18,268 kW	**16** %	**37** %

Construction

Permissions building (2019)	Recovered CDW declared (2019)	Public investment (2021-2022 budget)
7,201,884 m^2	**208,119** t	**383,806** MCLP

Foods

RSD productionper capita	RSD valued (2017)	RSD sent to composting and vermiculture (2017)
1.22 kg/inhab/d	**76,582** t	**1,580** t

Source: Own elaboration. For more information see Methodological Notes

Santiago
Circular intervention

In Santiago, circular economy measures should focus on more sustainable mobility models as a priority. This could reduce the rate of motorization, encouraging modal shifts and reducing the need for travel through, for example, policies that encourage remote work. In the food sector, it is imperative to move towards a greater valorization of organic waste, generating local virtuous cycles of consumer awareness and urban agriculture. Given the low insulation of housing, it is also a priority to encourage the improvement of thermal envelopes, the adoption of efficient air conditioning technologies, and the adoption of construction standards that incorporate circular economy criteria.

CE Principles	Measure	Description	Expected benefits
	Electrification and energy efficiency	Encourage the adoption of distributed generation technologies and air conditioning by heat pumps	E R V S
	Electric public transport	Continue strengthening the progressive electrification of public transport, including the conversion of the existing fleet	E R V S
	Modal changes	Encourage remote work to reduce the need for travel, shared transport and expand the bike lane network	E R V S

CE Principles	Measure	Description	Expected benefits
	Reduce current supplies	Incorporate local, circular, low-carbon materials and adopt, where possible, Sustainable Construction Standards	E R V S
	Circular design	Encourage the reconversion of disused spaces. Incorporate efficiency, durability, adaptability, and ease of disassembly criteria in the design phase	E R V S
	Construction site efficiency	Adopt industrialized construction techniques and locally valorize CDW in the production of recycled aggregates	E R V S

CE Principles	Measure	Description	Expected benefits
	Urban agriculture and food safety	Promote community urban gardens for the local supply of vegetables in the face of rising food costs. Opportunity to promote circular consumption habits	E R V S
	Recycling and citizen culture	Promote greater adoption of municipal programs for the management of household organic waste, promoting management solutions at the family, neighborhood, and city levels	E R V S
	Prevention and awareness	Development of local public policies and social marketing campaigns to raise public awareness and encourage responsible consumption habits	E R V S

Circular Economy Principles (CE)

- Eliminate waste and pollution
- Circulate products and materials
- Regenerate nature

Benefits

- E Reduction of GHG emissions (climate change)
- R Reduction of demand for virgin resources (decoupling)
- V Valorization of resources
- S Potential social impact and quality of life

Circular Communities: A master plan for a circular neighborhood

"Circular Communities" is an urban project of the Sembra Association, which seeks to encourage its future inhabitants to be active and responsible users in relationships and actions with their environment

Based on a circular design and construction, the master plan proposes promoting social cohesion through the generation of community spaces that meet the needs of leisure, sports, business, and meeting.

Inside the houses, shared space takes on greater relevance in surface, location, and relationship with interior courtyards and public squares, visually and in terms of circulation. Community spaces allow the development of the economy and local trades.

The master plan includes different areas whose cycles integrate: water management, mobility, energy, social cohesion, economy, food, and housing.

The houses are designed sustainably in terms of materials, construction systems, and energy consumption.

It considers a bioclimatic design that takes advantage of the orientation, natural ventilation, and the installation of on-grid photovoltaic systems, the reuse of gray water, and multiple technologies that minimize the environmental impact of the building throughout its useful life.

Each family's space's design and construction process cannot be carried out without it. An essential part of the project's sustainability is the community's participation in each space's design and construction processes.

The challenge of the Sembra Association is to materialize and make this model of the Circular Neighborhood a reality. It is socially sustainable and will allow families a better quality of life, pleasant internal and external spaces, promote and strengthen neighborhood life, and access to high social conditions.

More information about this project here:

New facade for Solar Building

Circular input

Shared Platform

The materials that make up the facades of significant buildings have begun to be rethought to take advantage of their surface. The installation of solar panels is an option that adds economic, social, energy, and environmental benefits, helping to reduce the city's demand for fossil fuels.

Solar facades integrate photovoltaic cells, which become a sustainable energy alternative. The electricity generated is used for consumption in the building and can also be directly fed into the network for sale to large distributors.

The Nueva Córdova building has almost half a thousand mono-crystal photovoltaic modules. It is the first in South America of this scale to implement solar photovoltaic facades to generate electricity and shared platforms for recharging cars, electric bicycles, and more.recharging cars, electric bicycles, and more.

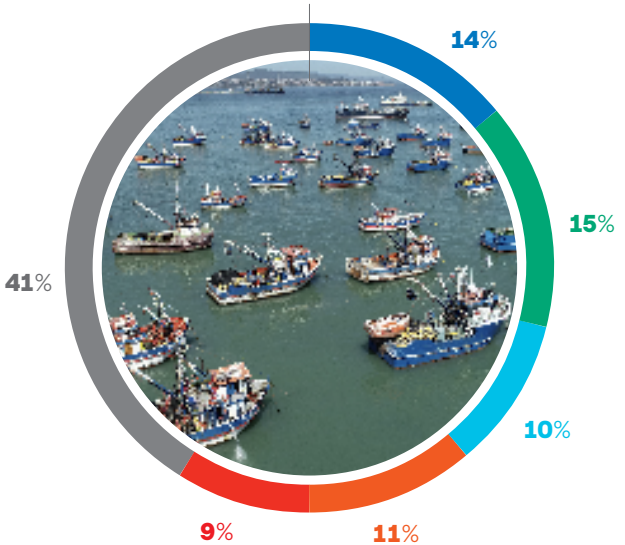
Great Concepción

Located in the Biobío Region, on the banks of the river with the same name, Concepción or Greater Concepción has ten communes[79] and is one of the urban centers with the highest level of industrialization in the country. The city was founded by Pedro de Valdivia in 1550 and is currently the most populous after Santiago, with 951,739 inhabitants and a population density of 44 inhabitants/ha.

Concepción concentrates its economic activity in the services area and functions as the region's financial center. Historically, the city has had a strong presence in the manufacturing and logistics industries. It is known for being a university city and having important cultural and historical centers. In the national context, the Biobío Region is in fourth place in GDP participation, with 7.9%.

Like any metropolitan area, it has significantly deteriorated air quality. The intensive use of wood-fired heating –generally from wet firewood – and the presence of industries in the middle of the city have increased the levels of particulate matter and the consequent respiratory diseases, especially in children and the elderly. In August 2015, it was declared a saturated zone, with the highest contamination levels concentrated in Concepción, Coronel, and Talcahuano communes.

Concepción
Main economic topics:



- Construction
- Teaching
- Administrative and support service activities
- Wholesale and Retail; repair of motor vehicles and motorcycles
- Manufacturing industry
- Others

Urban data and demographic

Consolidated urban area
21,709 ha

Urban population
951,379 Inhabitants

Population density
44 inhabitants/ha

Urban households
309,297

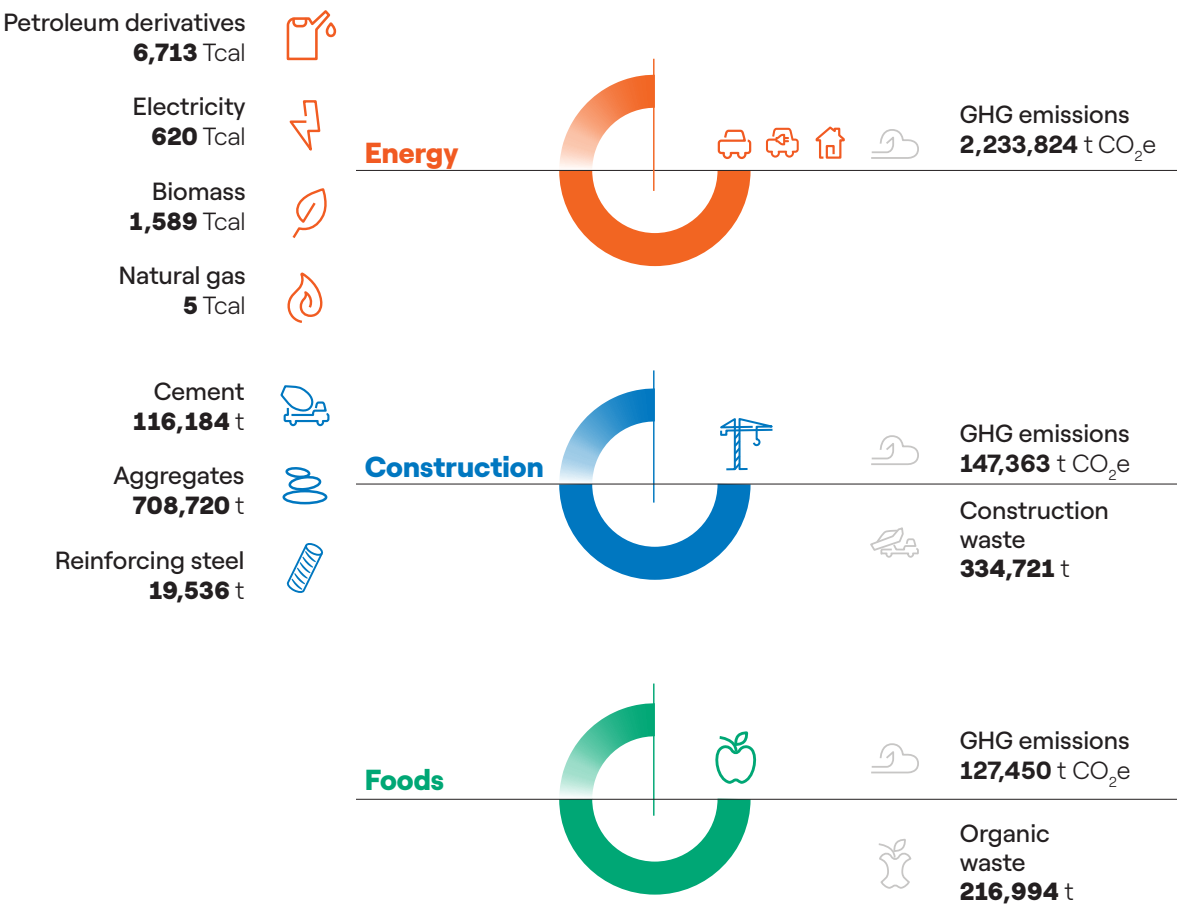
People per household
3.1

Source: Own elaboration based on SII data, by number of workers registered in the companies by commune[73], Census 2017, open data from the Center for Sustainable Urban Development (Cedeus)[74]

Concepción radiograph

Flows of energy, materials, waste, and emissions (scope 1, 2, and 3)

Among the sectors considered in this analysis, the city contributes with the consumption of 844 thousand tons of construction materials; 8,927 Tcal of energy; it produces 335 thousand tons of construction waste and 217 thousand tons of organic waste. The emissions generated by the three sectors reach 2.5 Mt CO_2e, and land transport is the leading emitter.



Source: Own elaboration. For more information see Methodological Notes Note: 1 Tcal = 10^{12}calories

Concepción
Main urban indicators

Concepción presents the highest private motorization rate among the cities analyzed (257 vehicles/1000 inhabitants). However, lower means of personal transport (24%) highlight the relevance of public transport and the potential to increase its electrification.

It presents the lowest electricity use in homes compared to other cities (22%), lower than the national average of 25%, with biomass being the most used energy source to supply a greater demand for heating. The level of thermal insulation can still be improved: only 21% of homes have wall insulation, which is a priority in this city because it is located in a colder thermal zone. With a low or null recovery of construction, demolition, and organic waste, Concepción is aligned with the rest of the country in this area.

Energy	Motorization rate **257** vehicles/1,000 inhab.	Private transportation trips **24** %	Public chargers **506** kW
	Photovoltaic installations in net scheme **1,316** kW	Houses with thermal insulation (thermal zone 1) **21** %	Electrification of homes **22** %
Construction	Building permits (2019) **932,884** m^2	Recovered CDW declared (2019) **0** t	Public investment (2021-2022 budget) **147,363** MCLP
Foods	RSD production per capita **1.02** kg/inhab/d	RSD valued (2017) **2,234** t	RSD sent to composting and vermiculture (2017) **37** t

Source: Own elaboration. For more information, see Methodological Notes

Coronel: the heat stays home

"Here in Coronel and the south, there is the firewood culture; all the houses have the fireplace burning all year round, and in autumn and winter, it is worse. Walking the streets at night can even bother your eyes because of the smoke, or it can hurt your nose and everything. So we told ourselves that something had to be done.

We have had a family business with aluminum for a long time. First, they were structures, and one day they asked us for a window. And I noticed that it was excellent, with attention to detail: it is not cutting, come and install it. We started with the thermo-panel ones. We began to find out how they were made, find the distributors of the products we needed, and so on.

My grandson Benjamín, my niece's son, has always been concerned about the environment, but I call him that. He participated in fairs and projects, won contests, and everything. The idea of bringing to market a product that improves the thermal envelope of homes was born from him. And since the main point of heat leakage is the windows, we told ourselves there was an opportunity. People would consume less firewood or could use another type of heating.less firewood or could use another type of heating.

He now studies medicine in Buenos Aires and is one more in the factory every vacation he comes. He always gives us ideas. He inspires me and encourages us all. My grandson is the head, and we are his hands.

It was Benjamín who helped me apply for Enel's "Coronel Emprende" fund and won. Thanks to that, we could buy a piece of equipment called the "dream machine." With one movement, the structure is ready! Before, everything had to be done by hand and with much effort.

Everything changed, even increased our production. People look for us because we do everything. We remove the original window, level it, and then install our thermo-panel one. We even recover the previous one, we reuse, improving what they have. If it is in good condition, we take advantage of everything and lower the cost to the client.

Our business is called Shalum Aluminum, which is a play on words that comes from the nickname of Gonzalo, Benjamin's father. We started spreading it through social networks, which has gone well for us. They highly recommend us. We moved to another house because we used the first one as a workshop due to the need for space, which allowed the business to grow. We work from Monday to Monday, and we support each other. I am excited to see all that is coming for our family.

Here in Coronel, people like our thermo-panel windows, but the main issue is money, so they prefer to use a cheaper one. In addition, we do not talk about this enough. There is a lack of education about it.

On the other hand, the State spends a lot of money to treat diseases related to breathing air with PM 2.5 and PM 10, mainly from the combustion of wood in home stoves. Therefore, along with educating, public policies must also go hand in hand to improve home heating systems. An environmental recovery plan was recently entered[80], which allocates resources to improve the air quality and the houses' heating system, in addition to demands of regularized constructions so that they use this type of windows.

First, we are ready for that, and I see a bright future if we continue to move forward so that it takes another turn for the Coronel community and others. If we all had these windows, we would trap the lost heat. It is a saving, in addition to improving the health of the people here."

María Isabel Faúndez
Owner of Shalum Aluminum
Winner of the Entrepreneur Fund 2021

Concepción's circular interventions

Given its location and the still low insulation of homes in Concepción, circular economy measures should aim to encourage the improvement of the thermal envelope and the adoption of efficient technologies. The possibility of recovering industrial heat for heating should also be explored district and adopt construction standards with circular economy criteria.

Like all big cities, it is essential to move forwards towards sustainable mobility, aiming at reducing private vehicle's and trips.

In the food sector, there is potential to articulate short chains and promote urban gardens, together with new business models for the valorization of nutrients.

CE Principles	Measure	Description	Expected benefits
	Electrification and energy efficiency	Encourage the improvement of the thermal envelope of new and existing buildings, and encourage the adoption of air conditioning technologies by heat pumps.	E R V S
	Industrial heat recovery	Study the feasibility of recovering industrial surplus for district heating	E R V S
	Electric public transport	Strengthen the electrification of public transport, including the conversion of the existing fleet	E R V S
	Modal changes	Promote remote work to reduce the need for trips and shared transport and continue expanding the bike lane network	E R V S

CE Principles	Measure	Description	Expected benefits
	Reducing raw supplies	Incorporate local, circular, low-carbon materials and adopt, where possible, Sustainable Construction Standards	E R V S
	Circular design	Encourage the reconversion of disused spaces. Incorporate efficiency, durability, adaptability, and ease of disassembly criteria in the design phase	E R V S
	Construction site efficiency	Adopt industrialized construction techniques and locally valorize CDW in the production of recycled aggregates	E R V S

CE Principles	Measure	Description	Expected benefits
	Articulate short chains and take advantage of waste and agricultural by-products.	Promote direct sales platforms for producers in peri-urban areas, offering losses or overstock of retail sales channels. Connect with consumer demand, restaurants, casinos, etc.	E R V S
	Food safety and citizen culture	Promote urban community gardens for the local supply of vegetables in the face of increased food costs. Opportunity to promote circular consumption habits	E R V S
	Nutrient recycling	Promote entrepreneurial ecosystem, new circular business models for biorefinery solutions (ingredients, biomaterials)	E R V S

Circular Economy Principles (CE)

- Eliminate waste and pollution
- Circulate products and materials
- Regenerate nature

Benefits

- E Reduction of GHG emissions (climate change)
- R Reduction of demand for virgin resources (decoupling)
- V Valorization of resources
- S Potential social impact and quality of life

Resilience and quality of life

The proposed measures seek to inspire the transition of cities in the north, center, and south of the country towards a circular city model. The latter can bring positive effects in terms of socio-ecological resilience and the ability of urban ecosystems to absorb impacts and maintain their original and stable autonomous organization[81].

For example, renewable or closed-loop inputs can shorten value chains and promote local supply, thereby improving resilience to external disturbances. Adopting urban plans with more green and cultivable areas can reduce the effects of extreme weather events, such as heat islands, provide fresh food to communities, improve air quality, reduce noise pollution, and support native urban species. On the other hand, the reconversion of underused or disused buildings and spaces in neighborhoods can bring people closer to services, job opportunities, and recreation areas, benefiting the quality of life.

Reimagining cities and putting into practice the circular measures proposed for Antofagasta, Santiago, and Concepción is configured as a step towards more equitable, diverse, prosperous, livable, resilient cities and aimed at a safe and healthy environment where people develop, live and enjoy in the community.

Using renewable or closed-cycle materials can shorten value supply chains and promote local supply, thereby improving resilience against external disturbances

Santiago on a bike

"During the year 2020, the commune of Santiago registered a 62.5% increase in the use of bicycles. In the United States, sales grew by 75% and in Italy by 60%. In Quito, the rise was 700%. The pandemic has generated a spontaneous movement for sustainable mobility.

It is no mystery that global warming has affected us all in one way or another. For this reason, many people have decided to return to their roots and cultivate a simpler life. Sustainable mobility is one aspect of this transformation.

More than 15 years ago, I decided to live my life more sustainably, which has served as a springboard to get to know different initiatives and experience the city from another perspective. It is also true that the various situations we have experienced in Chile have helped many people take the path toward a lifestyle that cares more about the environment and the cities. The pandemic was a determining cause of this life choice since it affected us all equally. Many people have had to reinvent themselves and open the doors to new opportunities, such as the circular economy. The appreciation of local commerce, life in the neighborhood, and the importance of social networks as the primary means of connection have been one of the effects of the health contingency.

In this context, I feel that using the bicycle has fulfilled a fundamental role, either as a means of transportation or specific services in a delivery format.

The bicycle has helped us as an escape route because, due to the pandemic, going out was a complex issue and limited to schedules and permits. This forced us to go out only near our neighborhoods.

One of the advantages of using this means of transport is the point of view it offers us. By bicycle, you can see the landscape and get to know the surroundings. This incredible experience highlights elements of the city that are close to us and that, with other means of mobility, become imperceptible: local businesses, trees, recycling points, our neighbors and their own realities, and even their enterprises.

Slowly networks began to be created in which the logic is: I help you, you help me; I support you, you support me. A kind of territory appropriation was generated, which we had lost a lot with the issue of the digital revolution. So, it wasn't weird anymore to receive purchases from the market by bicycle or from entrepreneurs offering their services at the door of your house. Cycling is a lifestyle that facilitates relationships between people, values the local economy.
It even creates jobs! It also generates ideas, such as recovering materials from giving them a new use.

Retrieve means to add value to an object in disuse. I have seen that with the same bicycle tubes, it is possible to do backpacks, earrings, and even wallets, and I also saw again that newspaper is used to wrap purchases. Therefore, it does not seem at all strange to me that, in the future, large companies and even small ones will use these concepts of recovery. It would be wonderful to give the planet a break.

This transformation that has led us to use the bicycle more also requires an adaptation of the cities. More interconnected bike lanes are needed, especially for new cyclists with less experience on the routes. Along with this, there is a need to have better driver education for all cyclists and non-cyclists to mitigate the risk of repeated accidents.

The electric bike is not a very popular option due to the high price they still have. I'm still a pedaling romantic and don't consider having an electric one. However, it understands that it could be a solution for those who work daily in delivery if it were economically accessible."

Hernán Torres
Neighbor of Independencia
Collaborator of Indepecleta and
Muévete Collective

4.

Public politics and governance

The elaboration of public policies is essential for the development of any country since it expresses the mandate or will of governments to respond to relevant problems of society82. Building a public agenda that prioritizes the issues perceived by the different actors and citizens becomes necessary to achieve good governability and governance.

Chile has implemented various instruments and mechanisms to collect the priorities of the actors and citizens. They can be identified as public policies, strategies, plans, and programs applicable at the national, sectoral, administrative, and/or operational scale, as well as laws and decrees. Its objectives aim to define guidelines, courses of action, initiatives, measures, and financing systems[83].

Multiple public policies act transversally and specifically for the different sectors: climate change, energy, construction, food, and water, among others. What evidences the State's commitment to addressing the climate crisis and advance in energy, economic, environmental, and social sustainability,

In recent years, the concept of circular economy has become increasingly present in national and sectoral strategies. Linked to the development of new business models; improvement in material productivity; energy efficiency; reduction of GHG emissions; use of resources that are considered waste; promotion of local production. And the creation of job sources, among others.

Notable instruments, which lay the foundations for the transition to this new circular economy model, are the Circular Economy Roadmap for Chile to 2040 (2020); the RCD Roadmap: Circular economy in the construction sector (2021); the Circular Economy Strategy in Construction (private initiative, 2021) and the National Organic Waste Strategy (2021).

The Circular Economy Roadmap for Chile to 2040 suggests territories must address local challenges by diagnosing their specificities, needs, and potentialities. In a decentralizing challenge, the Roadmap also proposes considering that the territories' communities influence their development and decision-making.

Record of advances in policies and governance

Sector	Politics
Climate change	Climate Change Framework Law 2022 (LMCC) **Long Term Climate Strategy 2021 (ECLP)** Nationally Determined Contributions 2020 (NDC) National Climate Change Action Plan 2017-2022 (PANCC) National Strategy for Climate Change and Vegetation Resources 2017-2025 (ENCCRV)
Energy	National Energy Policy 2050 (PEN) **National Energy Efficiency Plan 2022-2026 (PNEE)** **National Electromobility Strategy 2021 (ENEM)** National Sustainable Mobility Strategy 2021 (ENMS) **National Strategy for Heat and Cold 2021 (ENCF)**
Building	**RCD Roadmap: Circular Economy in Construction 2035** National Sustainable Construction Strategy 2013 (ENCS) Climate Change Adaptation Plan for Cities 2018-2022 (PACCC) Circular Economy Strategy for the Construction Sector 2021*
Foods	**National Organic Waste Strategy Chile 2040 (ENRO)** Agrifood Sustainability Strategy 2021 (ESA) Organic Recycling Program (2017) **Sheet of Route Covenant Chilean of the plastics 2020**

[84] This cadastre was prepared to consider various sources. It does not consider all national policies and those that have goals related to cities have been highlighted in bold. We have defined acronyms for the different policies to facilitate their understanding and follow-up in this document.

In the debates and political practices of the last decades, the term governance has acquired great significance. Although its meaning is not yet agreed upon -due to the close relationship with the culture and the way of seeing the development of each society – it can be affirmed that good governance is aimed at achieving sustainable development and implementation of the circular economy associated with human well-being.

The principles that characterize good governance are the participation of all actors in society, information transparency; integrity; legality; sound policies; accountability; response capacity, and, the absence of corruption and crime in decision-making[85].

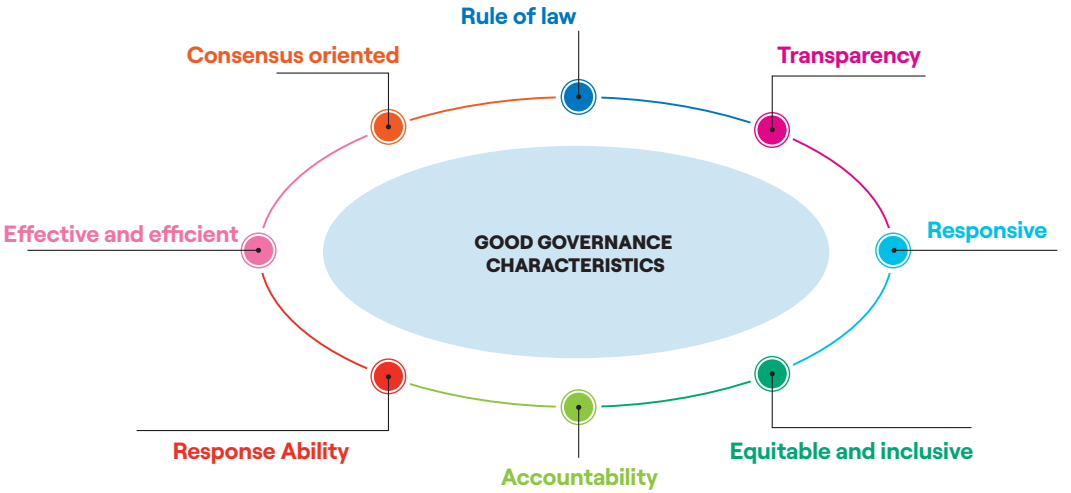
These principles are essential to generate flows of information, instances of dialogue, feedback, and deliberation that allow, jointly, to improve decision-making, develop public policies and coordinate the development of strategies in various areas. In the circular economy, these principles are vital and allow for the development of the country with a view to long-term sustainability beyond the interests of a particular government.

Goals for Chilean Cities

	2025	2030	2035	2050
Energy		**100%** of cities (>50,000 inhabitants) will have Mobility Plans to reduce emissions of atmospheric pollutants **(ECLP)**	**100%** of new additions to urban public transport are zero emissions **(ENEM)** **100%** of light vehicles sold are zero emissions **(ENEM)**	**30%** reduction of GHG emissions from urban mobile sources derived from the implementation of Mobility Plans **(ECLP)**
	100% of new buildings have an energy rating **(PNEE)**		**70%** new appliances are energy efficient **(PNEE)**	**75%** of homes generate heat and cold in a sustainable way **(ENCF)** **50%** savings in thermal energy demand (new buildings) **(ENCF)**
Construction		**>50%** of the volume of the reused or recycled RCD to manufacture new products **(ECLP)**	**>30%** of the materials and construction systems have certification of circular attributes. **(HDR RCD)**	**100%** of traceability of construction waste and national demolition. **(ECLP)** **100%** of the new constructions certify zero waste in their processes. **(ECLP)**
Foods	**1** Food Waste Prevention and Reduction Plan (PDA) that considers emission reduction measures **(ECLP)** **25%** of recycled material is included in plastic containers and packaging. **(HDR Chilean Plastics Pact)**	**30%** of organic waste is recovered **(ENRO)** **50%** reduction in FLW **(ENRO)**		**66%** of organic waste is recovered **(ENRO)**. Goal to 2040

Thus, for an effective transition towards a circular economy, the appropriate economic, legal, and governmental policies and instruments must be in place. And it will not be successful except through public-private collaboration and especially with citizen participation in the definition and implementation of public affairs aimed at implementing public policies in a decentralized, democratic, and inclusive manner.

Other characteristics of good governance are in the recently published comparative study on effective governance for the circular economy in the Journal of Cleaner Production. It presents four paths to developing the circular economy in various socio-cultural and political contexts[86]. These are its main results:



Accelerators for effective governance in circular economy [86]

1. Breaking through the silo mentality in Government	Governance for a CI should not be limited to environmental policy. Rather, it should focus on a comprehensive policy mechanism with a national strategy or legislation that defines the roles and responsibilities of public agencies, the private sector, and other stakeholders throughout the life cycle of materials.
2. Long-term orientation of Government	The necessary processes to develop and advance towards a collaborative economy must be government projects executed with a long-term perspective and transcending a specific government.
3. Inclusion of external costs in the price of products	To internalize the environmental and social costs of products during their life cycle, political instruments such as extended producer responsibility, new production costs, and taxes must be implemented. These changes are necessary to foster new business models that stimulate the circular economy.
4. Willingness to build public-private partnerships	Implementing a sharing economy requires partnerships between companies within and across supply chains and between Government and industry. That is public-private collaboration. Implementing a sharing economy requires partnerships between companies within and across supply chains and between government and industry. That is, public-private collaboration.

A word from Regional Governors

Ricardo Díaz

Regional Governor of Antofagasta

"The Antofagasta region is a territory that is at the forefront of major issues of the future. Without going too far, our region plays a fundamental role in global technological development. A large part of the copper and lithium that is essential is exported from here. For the new technology industry, however, producing it brings with it a high cost in carbon dioxide emissions and different types of waste, such as household solids and construction and demolition waste.

The challenge of learning and teaching how to manage our waste is key when starting to develop cities circular, but above all resilient, where multisectoral work is prioritized, where Regional Governments must articulate the various actors such as public and private services, academia, and highlighting citizen participation since we are the people who live in the region, which we must decide the type of cities in which we want to live.

In our region, we are already working on different initiatives that promote the construction of circular cities. Some of these initiatives consider the recycling of wastewater for the irrigation of green areas, electromobility plans, transition to productive matrices such as the production of green hydrogen, among others.

Circular cities are a paradigm shift that we want to promote in our territories and there the energy, road and productive development challenges are very important. That is why this Study is a valuable input that will make all the actors aware of the importance of working together to obtain more and better results, in such a way that, without losing our identity and historical vocations, we take a leap towards modernity and a circular economy."

Claudio Orrego

Regional Governor of Santiago

"We know that a harmonious development of the region is not possible without territorial equity, and above all, without social and environmental justice. One of the first measures I took as governor-elect was to declare a Climate Emergency in the Metropolitan Region, creating advisory councils with representatives from the public-private world, civil society, academia, and international organizations. The purpose of the call was to address issues of the environment, climate change, and land use planning that help us face the problems in these matters.

One of the most devastating effects of the climate crisis is the drought that we have experienced in the last 13 years. For this reason, we created the Regional Water Emergency Table that seeks, among other things, circularity, protection, and sustainable use of water. The same for the case of waste: we hope to generate a revolution, changing the current linear management model towards a circular model, targeting incentives for the reuse and recycling of waste, use of the organic fraction, and ensuring the equitable implementation of the Extended Producer Responsibility Law, REP.

In terms of climate change, we formed an alliance between the regional Government and the Adrianne Arsh-Rockefeller Foundation Resilience Center to promote projects that mitigate the effects of climate change. Here I highlight the pilot project of green roofs for the city, the urban planting program, and the formulation of an action protocol in periods of extreme heat whose purpose will be to save lives.

Regarding sustainable mobility, we have made a tremendous effort to have a transport policy that can address the challenges of building an integrated network of bike lanes, promoting electromobility, repaving sidewalks, and generating new mobility strategies in coordination with the Ministry of Transport and Telecommunications."

Rodrigo Díaz

Regional Governor of Biobío

Within the framework of the 2022 Circular Economy Meeting held on March 3, the regional governor of Biobío, Rodrigo Díaz Wörner, mentions that "we are a region where the metalworking, woodworking and fishing industry stands out, and that over time has developed a strong vocation in services, engineering, logistics, and technological development," adding "that in recent years we have had growth in terms of food exports."

Regarding the challenges that his territory presents, he warns, "the challenge is how to combine the generation of economic activity that gives employment to the people who live in our region, with the need to look beyond our regional boundaries and how we take care of the planet to reduce the risk that climate change means".

In this context, he indicates "in the region decisions that seek to maximize collaboration spaces between all the agents that intervene in the processes, reaffirming the commitment with the sustainable development objectives. Faced with that, he details "We are convinced that cooperation with the business world, academia, social world, public bodies, and learning from other countries that have traveled a path before us, we can extract applicable knowledge on the territories."

The governor emphasizes that "Biobío is an industrial region. It is a region where design, knowledge and the arts also shine.

We are very interested in being able to learn and in the circular economy we will find a way to combine the production of goods and services that we must produce to provide sustenance to our people".

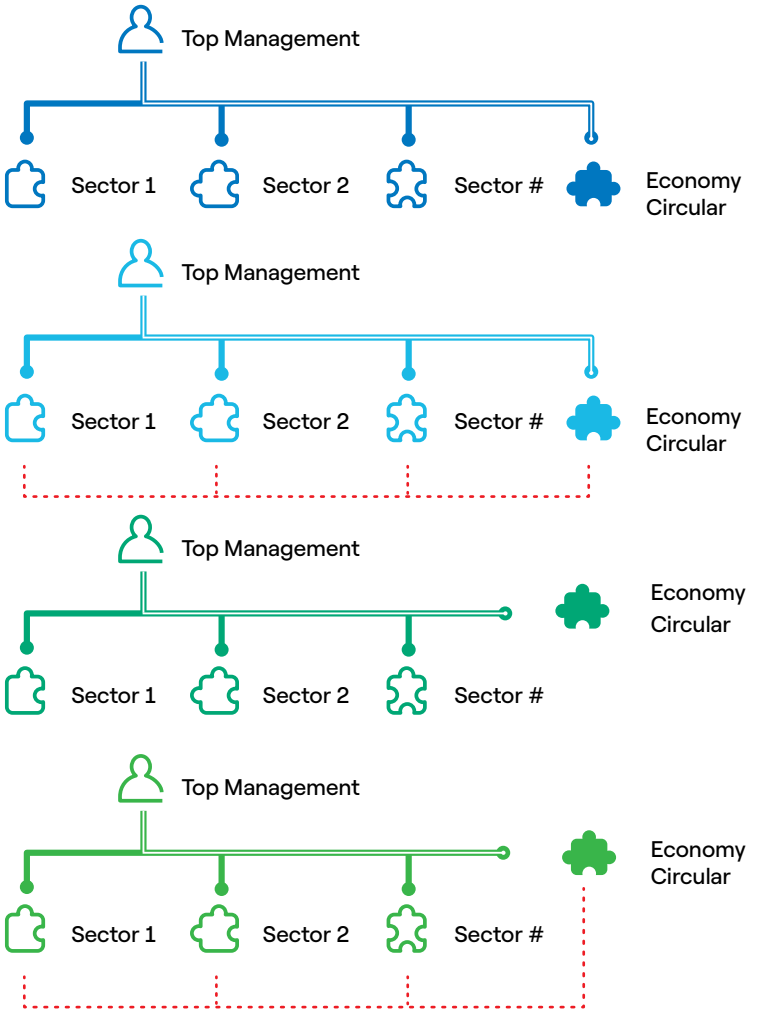
Where do we locate the governance?

The economy remains open. The decision of where to position governance for the direction of the circular economy remains open. But it must be transversal to all sectors: institutional, business, academic, etc. For this reason, assigning a relative responsibility to a specific industry or a specific ministry would severely limit their benefits.

In Chile, decentralization aimed at strengthening regionalization represents a particular opportunity for a circular economy to be part of the vision of a new institutional design strongly anchored to the territory. Until now, the efforts have transferred resources and powers from the central level to the regional levels expressed in the regional governments (created in 2021 and democratically elected) and the municipalities. In the future, innovative and effective ways of coordination are required to apply policies, plans, and programs that allow articulating local actions in the circular economy.

Given the international experience, countries should begin to recognize a multilevel dimension in policy formulation. Specifically in Chile, the regional governments take on a significant role in formulating development policies and entrust local execution in this area to the municipalities. Undoubtedly, the main challenge lies in improving inter-institutional and inter-sectorial coordination, where the collaboration of the public sector, the private sector, and society is essential.

Circular economy governance



Scene 1
Assignment of responsibility to sectors.
A purely sectorial vision could limit the scope of a more global solution.

Scene 2
Assignment of responsibilities to the sectors considering the interrelation with other areas.
Compared to the previous scenario, this scenario could contribute to the development of more comprehensive and effective circular policies.

Scene 3
Creation of a control room that repositions institutionality.
With this scenario, a possible problem of transversality and overall vision is overcome, but it can be critical in terms of centralization and the response to the needs of each sector.

Scene 4
Mixed solutions.
It is considered a control room that relies on the institutionality, and in turn, proposes a transversal relationship with the sectors involved, to favor the strategies that are defined at the central level.

5.

Tools and the International Experience

Each city is unique, and therefore, the strategies and solutions must be specific to each case. Promote a culture of collaboration within the city and between cities will be key to accelerating the transition to circular models.

This section summarizes success stories in various cities around the world, with a declared commitment to circularity. In addition, a toolbox is presented that can help cities in the effective incorporation of the principles of the circular economy, from the identification of opportunities to the evaluation of performance.

Initiatives successful in the cities of world

City	Description
Bogota, Colombia	**Circularize Program.** It summons 35 companies from Bogotá from six clusters related to the development of innovative circular products, processes, or services. The program has six stages for the beneficiaries, which include: training in the circular economy, modeling a new line of business, development of the business plan, and preparation for a business roundtable and/or investment round that allows them to scale. **Know more→**
Sao Paulo, Brazil	**Urban future ability project:** Through the application of industry 4.0 technologies, Enel, in partnership with the government and the National Electric Energy Agency, is developing the first network digital twin (digital twin of the network) in Villa Olimpia. Using 3D technology, the project models a replica of the local electrical infrastructure and its behavior. The simulation is possible thanks to the installation of more than 5,000 sensors that communicate information in real-time both to the energy distributor and to the various local stakeholders. The initiative seeks to be a laboratory that allows testing of new technologies – such as electric vehicles and smart lighting – to improve urban planning, use energy more efficiently and incorporate recycled materials as input in works. **Know more→**
Amsterdam, countries low	**Amsterdam Circular Strategy 2020-2025.** Aligned with the policies of the European Community, Amsterdam is considered a pioneer city in a circular economy. In its strategy, it aims to significantly reduce the use of virgin materials by 2030 and move towards a completely circular city by 2050. It involves three value chains: food and organic waste, consumer goods, and the built environment, and uses the Donut Model, developed by economist Kate Raworth, who describes how societies and businesses can contribute to economic development while respecting planetary boundaries. **Know more→**
Copenhagen, Denmark	**Circular Copenhagen – Resource, and Waste Plan 2024 (RAP24).** The city aspires to be the first carbon-neutral capital by 2025, and the RAP initiative incorporates this vision. The promotion of sustainable mobility plays a key role. One of its main promoters has been the urban planner Michael Colville-Andersen, who, in 12 graphics, represented the potential of bicycles to transform the world's cities. **Know more→**
Austin, USA	**Austin Material Marketplace** is an online platform that allows businesses and organizations to connect and find reuse and recycling solutions for waste materials and by-products. The program aims to create a closed-loop collaborative network of companies, organizations, and entrepreneurs, where one organization's hard-to-recycle waste and by-products become another organization's raw material. In addition to diverting materials from landfills, these reclamation activities generate business, significant cost savings, energy savings, and create new jobs. **Know more→**
Guelph-Wellington, Canada	**Food for Future** aims to create Canada's first circular food economy. It is developing a food system in which everyone has access to nutritious food, nothing is wasted, and the impact on the environment is minimal. Through an ambitious program that integrates innovation, development of metrics, challenges, and events, it is driving a movement in the city that aspires to achieve a 50% increase in access to affordable and nutritious food; 50 new circular food businesses, in collaborations and social enterprises; and a 50% increase in economic benefit by unlocking the value of waste. **Know more→**
Tainan, Taiwan	**TaiSugar Circular Village** It is the first residential project that integrates the circular economy from the design. It is a "village" made up of three "Circular Blocks" where the "Circular Field" houses are located. It has a "House-C," a "House-E," and a "Farm-C." The C-House functions as the town's living room, E-House as the kitchen, and C-Farm is the garden where the food is produced. Modularization was crucial in this urban development. The design stage considered assembly in construction and deconstruction after use. Some of the materials used include recycled and ecological components, in addition to choosing those that allow reducing of emissions. A pioneering project of its kind that has been recognized internationally. **Know more→**

Tools to accelerate and monitor the circular transition

Cupply chains and traceability

Santiago Chamber of Commerce – Sustainable Supply Chain guide

A tool that seeks to develop a sustainable management approach based on continuous improvement, producing positive environmental, social, and governance (ESG) impacts that allow optimizing processes and managing resources efficiently, innovatively, and with a long-term vision. The term is based on best local and international practices, combining the ten principles of the global compact and the 17 SDGs.

It focuses on incorporating sustainability criteria from the definition of needs and accompanies them with indicators for effective monitoring throughout the relationship between client and supplier.

Pass and materials

Document that records and classifies all construction materials according to their composition, origin, location, economic value, and recovery paths for their end of life, turning cities into banks of materials to be extracted in the future.

This tool makes it possible to generate knowledge about the materials used in the city and fill the monitoring tools with data for decision-making on the application of circular business models.

Integrate models circular business

Sharing the city - Seoul

The city of Seoul has become a pioneer in promoting shared activities. The initiative has certified 50 projects that offer people alternatives to owning property, from the platform for the shared use of cars or the exchange of items between neighbors to the opening of almost 800 disused public buildings to organize meetings and events.

The initiative makes it possible to generate benefits by improving the usefulness of existing resources, creating jobs, and increasing the sense of community and trust among citizens while reducing environmental impacts by reducing the demand for resources.

Circle City ScanTool

It is a tool to aid municipalities, consultants, or project developers in analyzing cities and their circularity and, formulating an action plan for a circular economy, detecting opportunities.

It is based on data on employment, emissions, material flows, and economic value, guiding the user for its proper collection. Once the focus of the analysis has been specified, according to what is most affecting the city, recommendations are obtained on the strategies to be adopted, and case studies can be consulted to make informed decisions.

Monitoring

Enel X - Circular city index

It is a circularity indicator for cities that is based on open data available at the national level in four areas: digitization, environment and energy, mobility, and waste.

For each one, scores are attributed that evaluate the degree of implementation of policies and infrastructures that help the territory in a transition process in an urban circularity perspective.

It includes all the communes of Italy and allows public administrations to identify successful cases, compare them with their own reality and thus replicate solutions that have already been shown to be effective.

Amsterdam circular display

In order to know the progress toward a circular economy, the city of Amsterdam monitors the consumption of raw materials, the impact on emissions of food and organic waste, consumer goods, and the built environment, thus allowing to identify the areas where to prioritize efforts and estimate the feasibility of meeting the goal of halving the use of raw materials by 2030 and becoming a 100% circular city by 2050.

Sustainable Supply Chain Guide, CCS

The Management Guide for a Sustainable Supply Chain, developed by the Santiago Chamber of Commerce with the support of the UC Innovation Center, is an interactive platform that seeks to make visible and promote best practices in commercial relations between clients and suppliers.

This document offers guidelines for building a long-term relationship in the supply chain based on understanding and identifying the stages that make up the relationship, the role of the principal and supplier, and the risks, opportunities, and performance indicators suggested to be applied.

It also proposes integrating possible social and environmental impacts into the supply chain in an environment of transparency and business ethics through a gradual application of six levels of practices in sustainable development that are following the 10 Principles of the Global Compact. United Nations and the 17 Sustainable Development Goals:

1. Compliance with current legislation
2. Extra-legal commitments and compliance.
3. International request or affiliation.
4. Mechanisms of assurance, efficiency, and operational management.
5. Methodology of work with the supplier, ASG operational management.
6. Collaborative/integrated work methods.

Know more→

Conclusions

Although Chile only contributes 0.25% of the global emissions of greenhouse gases, according to the United Nations Organization, it has seven of the nine criteria of vulnerability to climate change. According to other studies, it is among the ten countries most affected by the increase in global temperature, with the consequent risks for the territories and their population. Inaction will have a high cost.

This document shares with other studies that it is essential to step on the accelerator and change how we inhabit and relate to natural ecosystems, particularly in our cities, where 87.8% of the national population lives.

The State has become aware and, according to the information gathered for this document, in the last 10 years, substantial progress has been made in terms of public policies, plans, and programs for mitigation and adaptation, which establish ambitious sectoral goals. Our preliminary survey detected at least 17 goals aimed at the sustainability and circularity of cities. Awareness of the climate crisis has also increased in the various productive sectors and society, probably because the effects of climate change are already evident.

This report shows that these advances are a starting point and that it is already possible to take the next step:

A paradigm shift incorporates the circular economy and applies its principles in cities.

The geographical characteristics of the country's political-administrative centralization present significant challenges for cities, which are exacerbated by the enormous difference in size, productive vocation, and economic development. The implementation of circularity in Chile requires collaboration between several types of cities to align and extend to the entire country the goals established so far by the State and the productive sectors. The challenge, as evidenced in this document, is to find a way to incorporate the local reality, summoning all the actors, especially the citizenry, to implement those measures that allow taking advantage of the potential of the existing strategies, plans, and programs.

Like other studies that Enel has carried out, this document gathers the reality of three cities, Antofagasta, Greater Santiago, and Greater Concepción. It concludes that it is possible to apply the principles of a circular economy there. This is possible by taking advantage of the progress of pioneering practices and innovating business models that provide economic, social, and environmental benefits.

This work collects public data from three key sectors for a circular urban metabolism: energy for mobility and residential buildings, construction materials and waste, and food and organic waste. Sectors that contribute worldwide

By more than 50% to Greenhouse Gas (GHG) emissions and are strategic for the functioning of cities.

The available data and indicators allowed build a first approximation of the urban metabolism of the study cities and guide circular measures in the selected sectors, highlighting, among them: the electrification of public transport, the improvement of energy efficiency standards, and the recovery of surplus heat; the reconversion of disused spaces and the incorporation of sustainable construction standards; the promotion of sustainable consumption habits for the prevention of food waste, the rescue of food and the recycling of nutrients for bioenergy. The proposed measures were selected for their contribution to reducing GHG, valorizing resources, reducing the demand for virgin resources, and reducing the social and quality of life impact.

The challenge is to rethink cities from a comprehensive perspective, transfer new capabilities and take advantage of the potential for creating joint value, through intersectoral collaboration.

At Enel we believe that it is possible to reimagine cities. We hope this report will serve towards designing cities towards circularity, through the redefinition of energy flows and materials of the urban metabolism, prioritizing those sectors with the greatest impact on climate change.

Glossary

Acronyms

IDB: Banco Interamericano de Desarrollo

BIM: Builing Information Technology

CDT: Technological Development Corporation

CEDEUS: Center for Sustainable Urban Development – Catholic University

CES: Certification Sustainable Building

CChC: Cámara Chilena de la Construcción

CMNUCC: United Nations Framework Convention on Climate Change

CIMI: Cities in Motion Index

EMF: Ellen MacArthur Foundation

FAO: Food and Agriculture Organization of the United Nations

GEI: Greenhouse gas effect

Gt: Gigatons, 10^9 tons

IEA: International Energy Agency

INE: National Statistics Institute

IPCC: Intergovernmental Panel of Experts on Climate Change

IRP: International Resource Panel

MCLP: Millions of Chilean pesos

MINAGRI: Ministry of Agriculture

MINERGIA: Ministry of Energy

MINVU: Ministry of housing and urbanism

MMA: Ministry of Environment

Mt: Megatons, 10^6 tons

PASO: Office of Agrifood Studies and Policies

OGUC: General Urban Planning and Construction Ordinance

UN: United Nations

GDP: Gross domestic product

RCD: Construction and demolition waste

RSD: Collection of Domestic Solid Waste

UNEP: United Nations Environment Program

LULUCF: Land use, land use change, and forestry

WBCSD: World Business Council for Sustainable Development

WEF: World Economic Forum

Change Climate

Adaptation: Concept applicable to human and natural systems. It corresponds to the adjustment process to the actual or projected climate and its effects to moderate the damage or take advantage of the beneficial opportunities.

Climate change (CC): Change in climate, attributed directly or indirectly to human activity. It alters the composition of the global atmosphere, which adds to natural climate variability observed over comparable time periods.

Incorporated carbon: It is included in the manufacture of construction products, the construction of buildings, the replacement of materials, and the end of useful life. During the design and procurement stage, designers and contractors can prioritize lower carbon footprint products.

Carbon neutrality: It consists of creating a balance equal to 0 between the country's GHG emissions and captures in terms of CO_2e.

CO_2 equivalent (CO_2e): It is a universal metric used to express in terms of CO_2 the level of global warming that other GHGs have.

Decarbonization: Process through which countries, people, or other entities seek to achieve an existence without the consumption of carbon of fossil origin. Reference is mainly made to the reduction of carbon emissions associated with generating electricity, industry, and transport.

Renewable energy: Supply sources of energy that are considered inexhaustible. Among them are considered hydraulic, solar, wind, and tidal. Similarly, depending on their mode of exploitation, those from biomass, geothermal energy, and biofuels can also be considered as renewable.

GHG: Greenhouse gases are gaseous components of the atmosphere, of natural or anthropogenic origin, that absorb and emit terrestrial radiation produced by the surface of the Earth, atmosphere, and clouds. This property is what causes the greenhouse effect.

- **Anthropogenic gases:** In addition to CO_2, NO_2 and CH_4, and other fluorinated substances such as sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

- **Gases of natural origin:** water vapor, carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3).

Carbon footprint: Set of GHG emissions produced by people, organizations, products, events, or geographic regions in terms of CO_2 equivalents. From an industrial point of view, it serves as a control and management tool to understand and improve environmental performance.

INGEI: The National Inventory of Greenhouse Gases is a document that supports and makes transparent information related to the emission and absorption of GHG in the country during the period 1990-2018.

Planetary limits: There are nine key processes for the stability of the biosphere and the development of life safely. The list goes as follows: climate change, chemical pollution, depletion of the ozone layer, aerosols, ocean acidification, biogeochemical cycles, freshwater consumption, and changes in land use and biodiversity.

Mitigation: Human intervention aimed at reducing the sources or enhancing the sinks of greenhouse gases.

Actions and Concepts

Circular bioeconomy: It is a process that aims to transform the linear production model by promoting new methods that encourage the conversion of biological resources and waste and nutrient flows into products with added value, such as food, natural products, and bioenergy.

Biogas: Gas produced by the decomposition of organic matter.

C40: It is a network of some megacities of the world that commit to facing climate change through collaboration and knowledge transfer that promote significant, tangible, and sustainable measures.

Supply chain: Corresponds to the sequence of processes involved in producing and distributing a commodity or product.

The value chain is the process or activities with which a company adds value to an item, including production, marketing, and provision of services.

Lifecycle: Progressive stages a product or service has in the market, from obtaining raw materials to the end of its useful life. This considers all processes, threads, inputs, and outputs of matter and energy.

City in 15 minutes: It is a form of development in which cities provide all the necessary services at shorter distances. This strategy is based on the decentralization of the economy so that each neighborhood has the following aspects of urban life: workspaces, commerce, leisure, green areas, and housing.

Thermal comfort: Physical concept describes when people do not experience a sensation of heat or cold in an infrastructure. Namely, when the conditions of humidity, temperature, and air movement are pleasant and adequate.

Sustainable development: Type of development that satisfies present needs without compromising the ability of future generations to meet theirs. It is based on balancing the economic, social, and environmental pillars.

Ecosystem: is a functional unit consisting of living organisms and their nonliving environment and interactions.

Green Jobs: Jobs related to providing environmental goods and services that contribute to environmental protection and the sustainable use of resources.

Synthetic fertilizer: Fertilizer manufactured throughout industrial processes.

Industry 4.0: It refers to the fourth industrial revolution, driven by digital technology and data processing.

Urban metabolism: It analyzes the flows of matter, energy, and information established between urban settlements and their geographical context. Its study is helpful to measure the total demand for raw materials and electricity consumption (inputs) and the impact that we can have on the environment due to emissions and the lack of recovery of "waste" (outputs).

Net billing: It is a distributed generation system for self-consumption. Clients are given the right to install self-generation systems (with NCRE and a limit of 300 kW of installed capacity) and sell their surpluses to the distribution network at a regulated price.

Organic waste: They are biodegradable waste from gardens and parks, food and kitchen waste from homes, offices, shops, hotels, restaurants, cafeterias, canteens, and retail consumption establishments.

Industrial symbiosis: It is the association between companies to make use of and take advantage of the resources, materials, water, energy, and by-products derived from the production process of a product or service. This symbiotic relationship makes it possible to reduce environmental impacts and contribute to closing material and energy cycles.

Agri-food system: The set of activities that contribute to the formation and distribution of agri-food products and, consequently, to the fulfillment of the function of human nutrition in a society.

Just energy transition: Transition from fossil sources to renewable sources for power generation. It is produced with attention to jobs, the security of energy supplies, and a fair distribution of the costs associated with the transition.

Valorization: Actions aimed to value, recover, and recirculate materials and energy wasted because they are considered waste within the production chain.

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