City Net Zero Profile: Antofagasta

With a metropolitan population of approximately 430,000, Antofagasta is the 5th largest city in Chile. It is the 74th largest in Latin and Central America and the Caribbean, and the 503rd largest city globally.[1]

Core City Population	370,000
Wider Metropolitan Area Population	430,000

This snapshot examines Antofagasta potential to accelerate towards 'net zero'. It assesses:

1. How enabling is the city's current endowment to decarbonise (inherited assets).
2. Ambition and strategy for a low carbon future.
3. Span of powers and influence to accelerate decarbonisation initiatives.
4. The platforms and projects underway that can support a lower carbon future.
5. The investment and business innovation environment to promote decarbonisation.

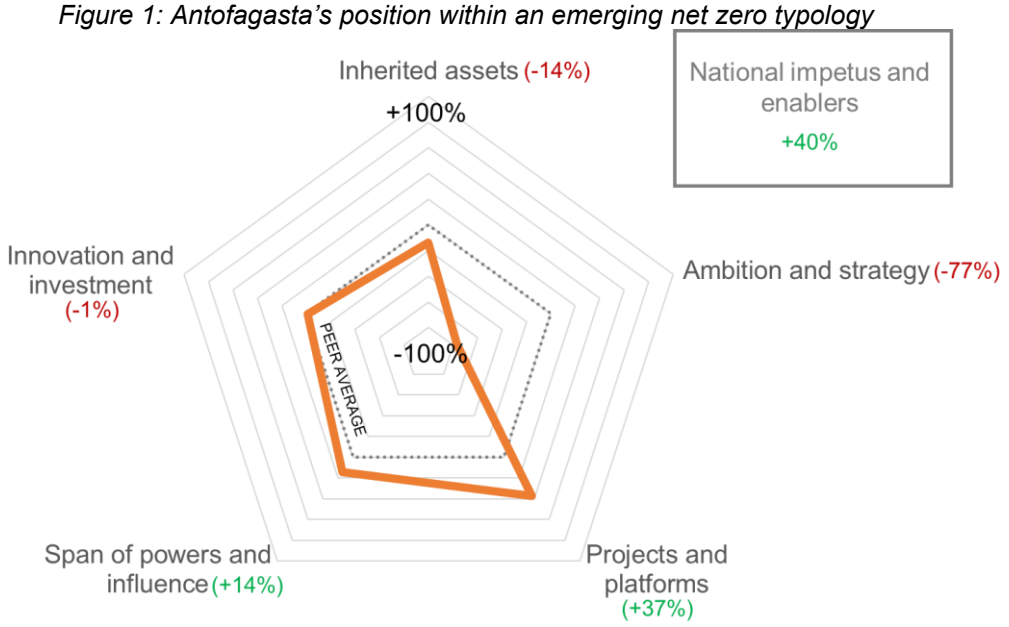
These 5 dimensions are explored in the summary statements below.

Summary and key findings

By global and regional standards, Antofagasta is:

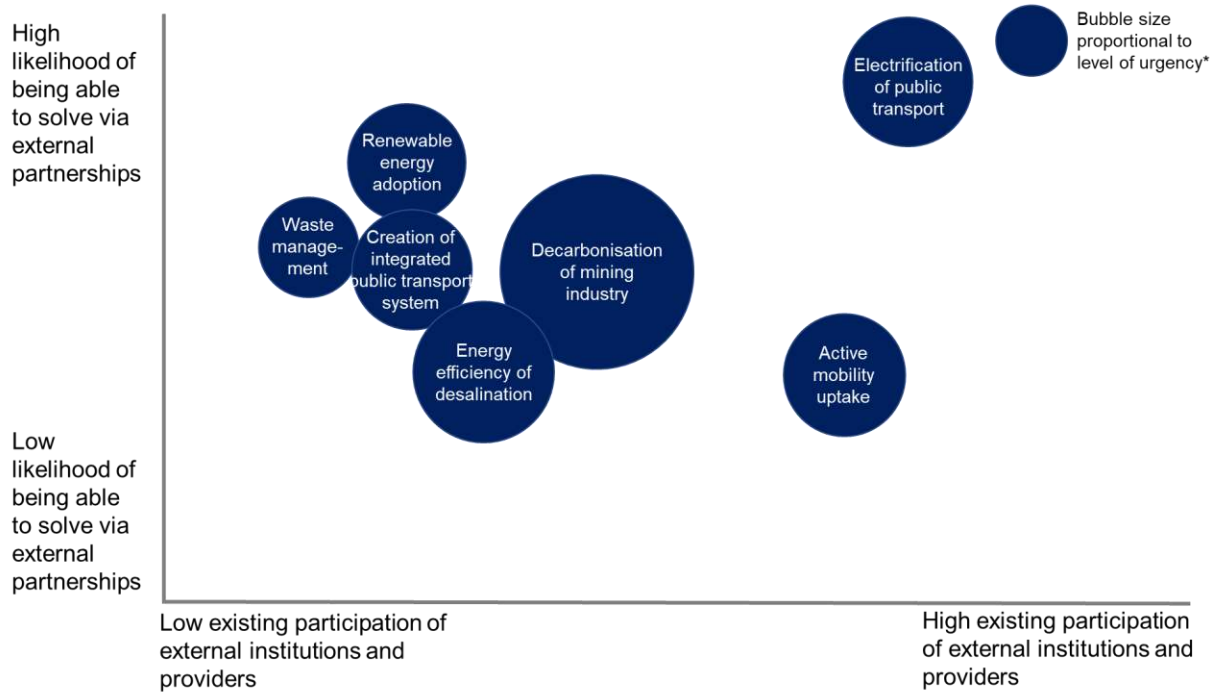
Assets	**A Net Zero Challenger**. The city inherits a more carbon-intensive economy and an urban form that requires bigger and bolder innovations for net zero restructuring.
Ambition	**Net Zero Championed**. In the absence of decisive net zero ambition from the city itself, internal and external champions raise the level of confidence citywide.
Powers	**A Net Zero Opportunist.** More distributed leadership to explore key opportunities to host and deliver innovations in the vacuum.
Projects	**A Net Zero Pathfinder:** Fast becoming an epicentre of scalable and potentially transformational projects in key sectors.
Innovation	**A Net Zero Experimenter.** Established relationships with multilateral development banks and some promising demonstration of private sector innovations to be built on in the next cycle.

Figure 1: Antofagasta's position within an emerging net zero typology



**Based on initial data. Scores subject to change contingent on final checks and weightings. **Peer average refers to average among all measured cities in Latin and Central America and the Caribbean, except for projects and platforms, where it refers to average among the 6 Chilean and Colombian cities. Full list of indicators for each theme provided in Appendix. Aggregate scores calculated using an ELO algorithm.*

Figure 2: The main challenges facing Antofagasta in the journey to net zero



**Based on a combination of external comparative data and level of urgency as identified in current strategies and plans and/or by industry practitioners during interviews carried out in early 2021.*

Based on the comparative data and observed insights from strategies and practitioners, among the key priority areas for Antofagasta to accelerate towards net zero appear to be:

1. Decarbonisation of the mining and water industries via renewable energy adoption
2. Electrification of public transport and the creation of an integrated public transport system in order to drive modal shift, strengthen intermodality and reduce transport emissions
3. Improving coordination across the region's multiple stakeholders and empowering them to make decisions that span systems and sectors and so can underpin bolder city-wide changes

Given these imperatives, the UK contribution has the potential to be most salient in the energy and transport sectors, especially in terms of:

1. Direct deployment of best-in-class solar design technologies to increase the efficiency of solar cells and help to harness any untapped potential of clean natural resources in the region
2. Market design, systems engineering and policy expertise on how to use policy and financial incentives to help shift to an output-based energy grid and decarbonise the electricity matrix
3. Assistance with the development of a regional sustainable transport plan, with clear business models and advice and support coordinating different stakeholders

How well set up is Antofagasta to go net zero?

Table 1: Antofagasta's aggregate scores in terms of current endowment to shift to net zero

	Score relative to Latin America leader* (max = 1)	Latin American leader	Latin American laggard	Rank among Latin American cities
Track record of compact development	0.51	Guayaquil	Tijuana	45th / 51
Transport systems efficiency	0.49	Santiago	Grande Sao Luis	41st / 52
Urban canopy coverage and protection	0.40	Toluca de Lerdo	Tijuana	22nd / 26

**Among all measured cities in Latin and Central America and the Caribbean. All indicators featured in each of the 3 main sub themes detailed in Appendix. Aggregate scores and ranks calculated using an ELO algorithm.*

Antofagasta is different from many other cities because, despite inheriting urban systems that are less conducive to decarbonisation, the presence of certain natural assets in the wider territorial region means the city may have a higher potential for progress in the next cycle. The urban systems underpinning the city today are not aligned with a strong decarbonisation agenda and the economic dynamics fuelling Antofagasta's urbanisation processes have up to now been largely concentrated in energy intensive-activities, such as copper mining. As a result, Antofagasta produces more CO_2 per person than any other Chilean city region.[2] However, the potential contributions of the city region's natural assets to the expansion of renewable energies are significant, and the strength of the regional economy means there are also many public and private initiatives that can help to foster urban transformation.

On one hand, the systems supporting Antofagasta's urbanisation have up until now not been conducive to decarbonisation. The city's transport system is highly reliant on fossil fuels, due mainly to a low penetration of e-mobility and urban cycling. Antofagasta's bike lanes cover less than 3 per cent of the urban road network, putting the city 8th among 13 measured Chilean cities.[3] At less than 50%, the sustainable mode share for the city is in the middle of the pack, but the all-round accessibility and efficiency of the public transport system remains behind (see Table 2).[4] Meanwhile, the recycling rate remains very low, and per capita waste generation remains nearly 25% higher than the standard set by National Urban Policy.[5] The treatment of waste for industrial activities in the region, including hazardous waste, is also a pressing challenge.

Antofagasta's inherited assets also pose more of a challenge to the journey to net zero. Antofagasta has inherited a relatively low density urban form, and has sprawled more rapidly than nearly all other Latin American cities in recent decades. Its built-up area has increased by nearly a quarter between 2000 and 2015, driving up emissions associated with commuting and transport.[6] Meanwhile, partly as a result of its desert geography, Antofagasta also has fewer 'green' assets and a much higher baseline of per capita electricity consumption, relative to other Latin American cities. In the absence of significant local opportunities for carbon sequestration, Antofagasta may have to prioritise other approaches to decarbonisation in the next cycle.

Antofagasta's energy distribution system is mainly based on non-renewable energy resources, and the adoption of solutions to reduce energy has so far been relatively limited. Additionally, the supply of water through seawater desalination plants for economic activities, as well as for human consumption, significantly impacts and increases energy demand.

On the other hand, Antofagasta's copper and lithium reserves, and its solar energy potential, make the city a potential platform for future decarbonisation efforts. As the main urban centre of a large desert that hosts one of the most important mining industries in Chile and Latin America, Antofagasta accounts for 54% of national copper mining production.[7] Antofagasta also hosts major projects for lithium production.[8] The presence of the mining industry has two important implications for the city. One the hand,

it means that Antofagasta's path towards net zero, regardless of the jurisdictional boundaries of the municipality, will be highly reliant on the progress of mining companies in reducing the emissions of their energy intensive 24/7 operations. Current estimates suggest that Antofagasta accounts for more than half of Chilean energy consumption associated with the copper mining industry.[9] On the other hand, the resources generated by this activity, and the strategic location of the city within the value chain of renewable energy production, means the city has a higher potential to structure and execute projects capable of reducing the environmental impact of its urban systems and dynamics. A key challenge for the next cycle will be incentivising a shift to renewable electricity production and delivering more efficient and sustainable mechanisms for energy storage.

Antofagasta's regional solar energy potential is also unique. Due to the high levels of solar radiation, Antofagasta offers the highest potential for solar energy generation among all Chilean regions.[10] Installed solar power capacity is growing fast, and further expansion is expected, providing alternatives for reducing the carbon intensity of energy consumption in the city and in the industrial activities of the region, including mining.[11] The wider region is also already hosting wind power projects and there are local players actively exploring opportunities around green hydrogen.

Table 2: Antofagasta's performance versus Latin American cities across key net zero endowment metrics

		Antofagasta's performance	Average among Latin American cities*	Latin American leader	Latin American laggard	Rank
Track record of compact urban development	Built-up area expansion rate, 2000-2015[12]	+21%	+8%	+1.2% (Kingston)	+83.8% (Toluca de Lerdo)	63rd / 66
Urban forestry coverage and protection	Urban canopy coverage as share of metropolitan area[13]	0.1%	26%	82% (Santa Marta)	0% (Ciudad Juárez)	22nd / 23
	Change in urban canopy coverage as share of metropolitan area, 1992-2018[14]	-0.5% (0.6% to 0.1%)	-0.5%	+7.9% (Concepción)	-13.3% (Tijuana)	17th / 22

**Among all measured cities in Latin and Central America and the Caribbean.*

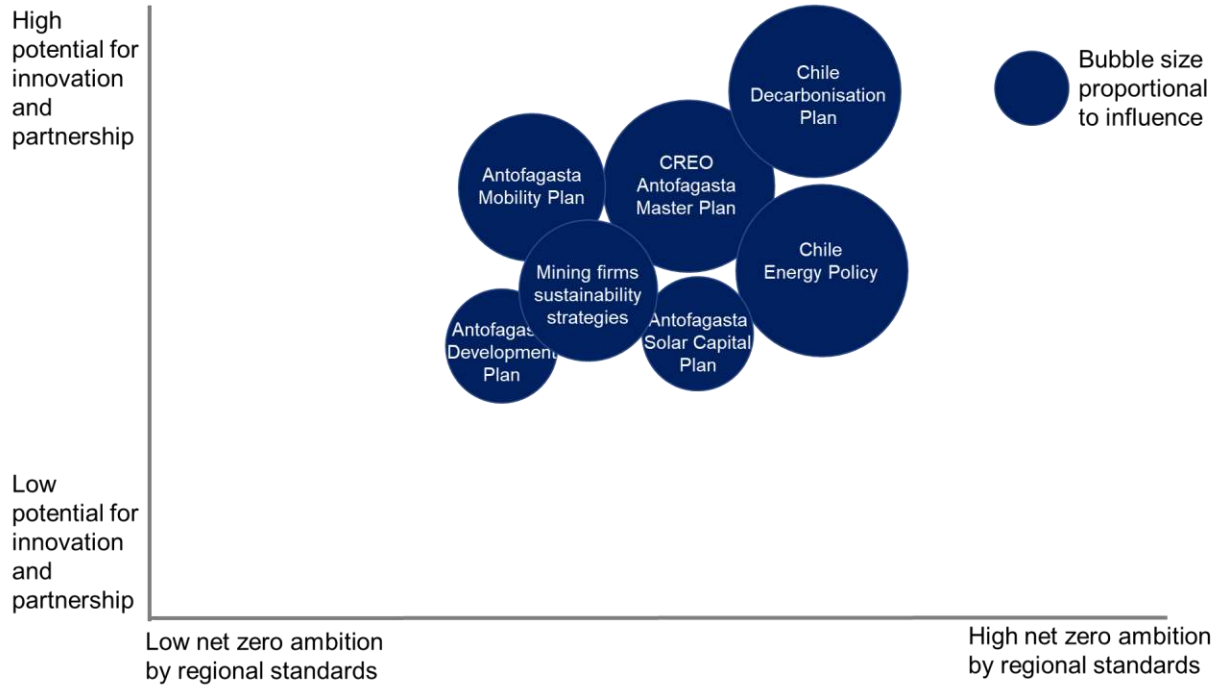
Table 3: Antofagasta's performance versus Chilean cities across key net zero endowment metrics[15]

		Rank among Chilean cities
Transport systems efficiency	Sustainable mode share	4th / 9
	Coverage of bicycle lanes	7th / 13
	Access to public transport	9th / 13
	All-round mobility systems efficiency[16]	8th / 11
Waste, water and electricity systems efficiency	Electricity consumption per capita	12th / 13

*All ranks apart from all-round mobility systems efficiency from SIDEU. Ranks calculated among 13 large Chilean cities for which data is available: Antofagasta, Calama, Concepcion, Iquique, La Serena-Coquimbo, Los Angeles-Nacimiento, Puerto Montt-Puerto Varas, Rancagua-Machali, Santiago, Talca, Temuco-Padre Las Casas, Valparaiso, Arica. *Where cities have more than one municipality, ranks calculated according to weighted average by population of all constituent municipalities within the metropolitan area.*

Ambition and strategy to become net zero: where might innovation and co-ordination be required?

Figure 3: Illustrative chart to show the landscape of Antofagasta's current net zero strategies



**Based on review of strategy content, comparative objectives, presence of innovation initiatives, and scope for partner delivery.*

Antofagasta does not yet have a local climate action plan and instead relies primarily on Chile's Plan de Acción Nacional de Cambio Climático.[17] In contrast to some other cities in Latin America, which have established firm local targets for net zero or have declared climate emergencies, Antofagasta does not yet have a robust city-wide monitoring system to track emissions and carbon footprints and does not yet disclose emissions data to CDP, a global not-for-profit charity running the world's biggest environmental disclosure system for investors, companies, cities, states and regions to better manage their environmental impacts.[18] Nonetheless, initiatives from different sources are raising the city's ambition to become a hub of forward-thinking decarbonisation projects that can accelerate the journey to net zero.

Current plans and projects to accelerate to net zero in Antofagasta are being promoted by both the public sector and the private sector, and are being encouraged by a number of international institutions. To modernise the underlying systems of the city and reduce the carbon footprint of Antofagasta's urbanisation, a civic programme – CREO Antofagasta – has been promoting the implementation of a 2035 Master Plan that comprises multiples areas of development.[19] Similarly, governmental stakeholders at different levels (local – regional - national) are conceiving a more sustainable urban future in Antofagasta through different mechanisms such as Antofagasta's Communal Development Plan 2013 – 2022, the design of Antofagasta's Sustainable Mobility Plan, Chile's decarbonisation plan and Chile's Energy Policy[20]. These initiatives reveal the city's critical decarbonisation priorities and challenges, including:

- The implementation of solar panels in homes, public infrastructure and other urban buildings – via CREO Antofagasta's Solar Capital Plan.[21]
- Fostering sustainable construction practices through providing financial incentives (green loans).

- Expanding bike lanes and creating a new system of publicly available bicycles to promote urban cycling.
- Improving public spaces and implementing an expanded pedestrian network to enhance walkability.
- Electrifying the public transport system of the city through new electric buses, a tram and a cable car.
- Promoting recycling and composting through selective waste collection and an integrated waste management centre.
- Improving the energy efficiency of the desalination plant supporting the city.
- Improving local research capabilities on renewable energies.
- Shutting down coal-fired thermoelectrical plants.

Antofagasta's industrial sector is also pushing to transform the region into a leading platform for the energy transition of Chile and Latin America and as a potential global partner of the renewables value chain. These efforts comprise initiatives by the mining sector, to expand copper and lithium production while reducing CO2 emissions in their operations, as well as by businesses from the energy sector that are exploiting the region's natural assets toto expand the share of renewables in Chile's energy matrix, including wind, green hydrogen and especially solar radiation.[22] The plans in these areas mainly focus on:

- The electrification of vehicles for industrial operations in the mining sector and increasing energy efficiency of the railway and seaport in order to more sustainably support the activities of this industry.
- Replacing contracts of energy supply to guarantee exclusive use of renewable sources in mining operations.[23]
- Improving energy efficiency of desalination plants supporting mining operations.
- Improving management of industrial waste through developing new integrated recycling plants.
- Harnessing the potential of renewable energies in the region – particularly solar energy through the execution of large-scale projects like large solar parks or concentrated solar power plants to distribute through the Chilean Great Northern Interconnected Grid.

Alongside a wider track record of UK engagement and partnership with Chile, Antofagasta benefits from several existing links with international networks, partnerships and institutions that can be built on in the next cycle, including with the UK. The city has long enjoyed a connection with the UK as a result of its railway and mining firms, but until relatively recently, the connection around urban planning has not been as visible.

In the next cycle, support from other countries may be required to accelerate progress on unlocking financing, establishing base line systems for emissions monitoring, creating more ambitious regional strategies, and improving carbon literacy. Some examples of current UK-Antofagasta partnership and collaboration include:

- **GIZ** and the **EU** are supporting the development of Antofagasta's Sustainable Mobility Plan.[24]
- **GIZ** is also supporting Chile's Energy Efficiency and Renewable Energies Programme, which includes initiatives in Antofagasta to improve energy efficiency in the mining sector and to foster projects on solar, wind and green hydrogen energy.[25]
- Development banks, such as the **Inter-American Development Bank** and **KFW**, are financing multiple renewable energy projects in Antofagasta's Region to harness the potential of wind and solar energy.[26]
- **The UK Prosperity Fund** supported CREO Antofagasta in the development of Antofagasta Solar Capital, a strategy for sustainable energy.[27]

What is Antofagasta's span of powers and influence to shift to net zero?

Table 4: Antofagasta's performance across key metrics relating to the city's span of net zero powers

	Score relative to Latin America leader* (max = 1)	Rank among Latin American cities
Metropolitan-level governance coordination	0.63	30th / 79
City-wide spending capability**	0.22	18th / 43

**Among all measured cities in Latin and Central America and the Caribbean. **Relative to city size. Full details of the individual metrics comprising each indicator provided in Appendix.*

In the current context, national government and regional government (GORE Antofagasta), and other public entities such as the Development Agency (CORFO) are the most influential public sector players in Antofagasta's decarbonisation journey. From April 2021, when it is expected that a regional governor will be democratically elected for the first time as part of decentralisation reforms, regional government may become an even more important agent in shaping local decarbonisation policies. Antofagasta's city leaders are also critical to the implementation of projects, although municipal resources are more limited than in some other cities.

Private firms responsible for the operation and maintenance of key urban systems, such as the owners of TransAntofagasta's buses or the operator of the city's main desalination plant, Aguas Antofagasta, are also essential allies. The actions of developers implementing commercial and residential projects in the city are strategic to transform the future of Antofagasta's built environment. The rapid expansion of the city makes the latter a critical challenge.

The industrial sector, in particular mining companies and energy firms, are leading many of the most ambitious projects focused on energy transition. The largest investments on renewable energies and clean technologies are fuelled by these sectors that operate beyond the urban boundaries of Antofagasta's municipality but are the engines of the city's economy. The Energy Cluster of Antofagasta, an initiative supported by CORFO, is coordinating cross-sectorial actions to accelerate the momentum of renewables.[28] Companies associated to the mining operations, such as the tyre manufacturing company Michelin, are also advancing initiatives to reduce the carbon footprint of the industry through circular economy projects.[29]

In Antofagasta the relative lack of a private company to run the city's buses means that decarbonising the transport sector may be more of a challenge compared to other cities. Despite attempts to build a single regional organisation to own and manage buses, there is at present a high level of fragmentation, with many different small-to-medium-sized owners. The relative lack of an integrated bus and transport system also makes it more challenging to convene stakeholders in support of electrifying the transport system, and evidence suggests that it may be beneficial to introduce a new administration or management structure to ease the implementation of electric bus chargers, for example by creating an organisation to own buses and then lease them off.

CP: Current Performance (1 =poor, 2 = limited, 3 = modest, 4 = promising, 5 = good)
*AI: Ability to influence (1 = low, 2 = limited, 3 = moderate, 4 = higher, 5 = very high)**

	CP	AI	Key notes	Key local stakeholders**	Current and potential UK contributions
Transport	2	3	The low financial capacity and the fragmentation of the private owners of buses that support TransAntofagasta may be detrimental to ambitions for electric and multimodal urban transport. Political decentralisation and election of new regional governor may impact the dynamics shaping the policies and priorities in the transport sector. Mining companies looking to use electric vehicles in their operations to accelerate the transition towards low carbon. Euroclima and GIZ have an ongoing project to strengthen city-level focus on sustainable mobility and develop a mobility master plan.[30] GORE, CREO, Antofagasta Municipality and Chile Foundation supported a design competition to incentivise construction of pedestrian networks in the city.[31]	GORE Antofagasta Antofagasta Municipality CREO Antofagasta TransAntofagasta Mining companies Antofagasta and Bolivia Railway company FACB Antofagasta PLC Antofagasta's Seaport Company EPA	Urban services firms-led expertise in sustainable mobility master plan. Expertise on EV charging infrastructure for citywide electric buses
Energy	2	4	Chile's National Energy Policy aims for 70% renewable electricity by 2050. It considers solar energy as the main driver of this transition. Antofagasta has the largest natural potential to support this ambition.[32] In the mining sector, Chile's government is influential through regulation and through the state-owned copper mining company Codelco. Investments in the energy sector supported by private, public and multi-lateral efforts. Local Energy Strategy plans for Antofagasta to become the solar capital of Chile and Latin America by 2025.[33] Antofagasta's copper and lithium reserves support the strategic role of this region in the global energy transition.	GORE Mining companies[34] Energy companies[35] Antofagasta's Regional Energy Cluster Local Universities CORFO	SME and energy provider-led solar design to increase efficiency of solar cells Network providers' expertise on connecting solar and wind farms to grid infrastructure. Systems engineering expertise to bring together siloed systems.
Building	3	2	Regional Energy Cluster convenes and supports local businesses working on small or medium scale projects relating to energy efficiency of the city's building stock.[36] CREO Antofagasta has promoted the implementation of Green Loans to incentivise energy efficiency in the construction industry. Both initiatives are supported by Chilean Chamber of Construction.	Chilean Chamber of Construction – Antofagasta Office	Expertise in meeting international sustainable certifications. Building Information Modelling (BIM) software and digital twin technology for new building stock. Financial tools and platforms to demystify and mobilise green loans.
Waste	3	2	New landfill "Chaqueta Blanca", operated by a private firm, was opened in 2018. Features an Integrated Waste Management Centre.[37] The tyre manufacturing company Michellin is constructing its first tyre recycling plant via a partnership with Sweden group Enviro.[38]	Consortium Santa Marta Michellin Chile	Sustainability target setting for new landfill.
Water	3	2	Aguas Antofagasta is constructing a new phase of its desalination plant to cover 100% of Antofagasta's city demand (up from 85%).[39]	Aguas Antofagasta Mining companies	Green construction and civil engineering techniques.

**Based on insights from desk research and interviews. **In addition to the City Government.*

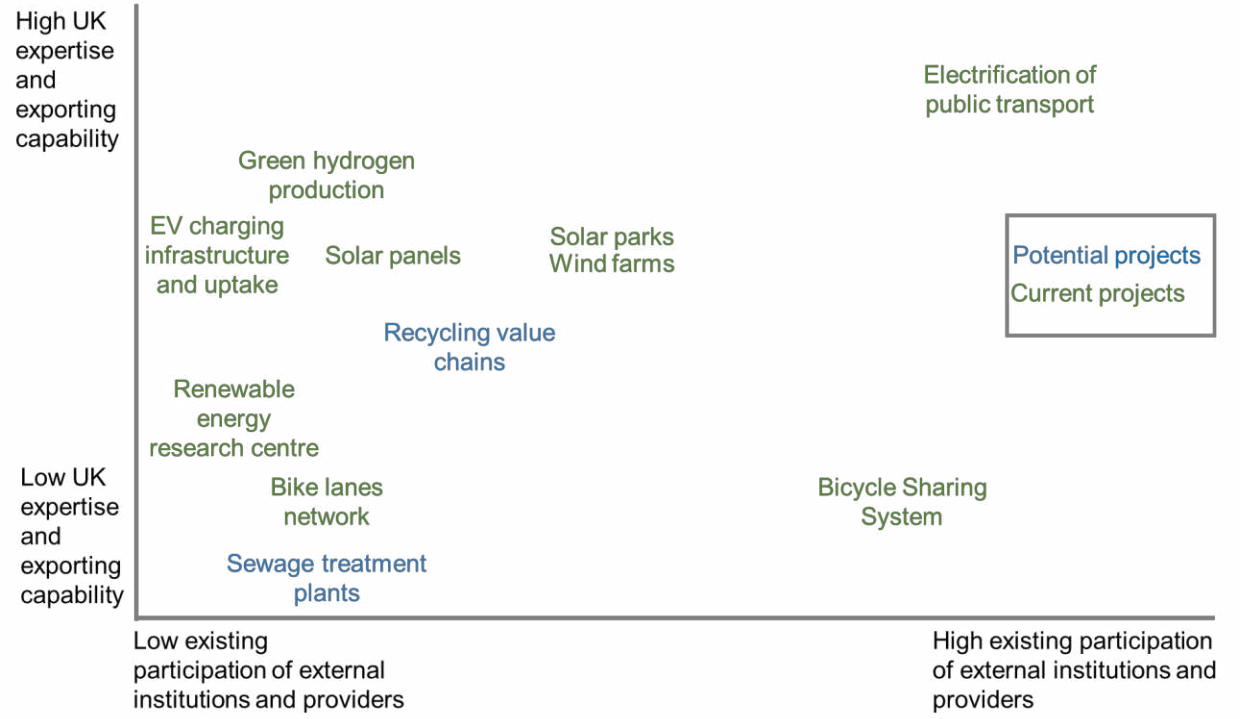
What are the platforms and projects to catalyse net zero? Who are the potential investment and innovation partners?

In the next cycle, Antofagasta's progress will depend on its ability to convene and unite multiple types of stakeholder across the many different types of project that are underway. The endeavour of the mining sector to reduce the carbon footprint of its operations while supporting the global value chain of renewable energies, as well as the investments of the energy sector in renewables (research and generation) can help to transform this territory into a regional decarbonisation champion. The synergies that initial leadership around the energy transition will inevitably trigger can then help to unlock more rapid improvement Antofagasta's urban systems in order to further mitigate CO2 emissions.

Relative to other cities in Latin America, Antofagasta stands out as a city with more observable large, high profile and potentially transformational projects that can accelerate the journey to net zero. There are more multi-million-dollar investments currently underway in the city, and more of an observable track record of establishing support from a broader range of entities, including businesses, multi-national development banks and research institutions.[40] This means there are more potential pathways for overseas organisations to contribute to Antofagasta's decarbonisation.

The projects mapped in the table on page 11 and in the conceptual diagram below have different levels of participation among external institutions and providers, and different levels of suitability for UK expertise and exporting capability (see diagram below).

Figure 4: Map of current and potential net zero projects in Antofagasta



Antofagasta is also unique among Latin American cities for its stronger track record of engaging civic organisations to take the lead on decarbonisation efforts. In CREO Antofagasta, the city finds a stakeholder that provides city-wide thinking and thought leadership on issues relating to decarbonisation in a way that is not present in other cities in Latin America. Created in 2013 and financed primarily by local mining companies, the organisation acts as a catalyst of private-public efforts in this space, coordinating actions and policy proposals for the city of Antofagasta, governmental organisations, private companies,

academic institutions and community groups. Other non-governmental platforms also seem to be more active in promoting decarbonisation.[41] These include:

- **Antofagasta University**: is Antofagasta's leading public educational institution and has a research centre focused on energy development.[42] This centre has a project dedicated to renewable energies. In this context, the University has fostered dialogue and initiative to unlock the region's potential in solar energy.

- **Industrial Association of Antofagasta**: the association is one of the most influential local institutions within the private sector and supports initiative relating to industrial transformation, innovation and climate change. The association is supported by the main firms of the mining and the energy sector and therefore it is a critical ally to connect companies shaping the path to Antofagasta's decarbonisation.

- **Chile Foundation**: as one of the most prominent NGOs in Chile, the Foundation is a strategic ally to raise awareness and foster projects to accelerate to net zero in both the private sector and the public sector. The organisation has an initiative focused on the use of natural resources that encourages dialogue and actions to transform the mining industry and advance toward sustainable development practices.[43] This entity is also influential in policy making processes.

- **Fraunhofer Chile**: a foundation leading research in Chile that works with the aim of developing the solar energy industry in the country based on the methodologies of the German Fraunhofer Institute. It is a key stakeholder to understand the contributions, challenges and opportunities of Chile's (and Antofagasta's) renewable energies sector in the journey to net zero.

- **Solar Energy Research Centre**: a research centre producing specialised knowledge on Chile's potential in solar power with the support of local stakeholders, including Antofagasta's University and Fraunhofer Chile.

- **Mining Council**: a private national NGO that convenes the most important mining companies of Chile, including the key players in Antofagasta's industry, Codelco, BHP and Antofagasta Mineral. It is therefore a potential partner to encourage bold actions in the sector to accelerate to net zero.

- **Generadoras de Chile**: a private national NGO that convenes the leading companies of the energy generation sector in Chile, including ENEL, ENGIE and AES Gener, all of which are investing in the Antofagasta region. This association can help to provide a crucial link with some of the key investors in the energy transition in Chile and Antofagasta.

- **ACERA Chilean Association of Renewable Energies**: a private association of more than 140 businesses working on renewable energy in Chile, in different areas of the industry's value chain. It is a key platform to connect current and potential investors in order to leverage Antofagasta's natural assets in the journey to net zero.

PROJECTS TO CATALYSE net zero	Size	Timeframe	POTENTIAL INVESTMENT AND INNOVATION PARTNERS
RENEWABLE ENERGY			
Solar parks 20% of commercial, public and residential electricity consumption to be supplied through PV solar by 2025. Multiple projects ongoing in region.[44]	Large	Ongoing	Ministry of Energy Antofagasta's mining companies Antofagasta's energy companies CREO Antofagasta
Wind farms Multiple projects ongoing in region.[45]	Large	Ongoing	Ministry of Energy Antofagasta's energy companies
Green Hydrogen plants HyEx project by Engie and Enaexs. 2000MW solar farm and hydrogen electrolysis plant to produce 124,0000 tonnes of green hydrogen per year.[46]	Large	Ongoing	Ministry of Energy Antofagasta's mining companies Antofagasta's energy companies
Solar panels Multiple projects ongoing in region	Medium	Ongoing	CORFO Antofagasta Municipality Chilean Chamber of Construction
New Renewable Energies Research Centre at the Chilean Institute of Clean Technologies USD 265million over 10 years.[47]	Large	Ongoing	CORFO Associated Universities INC AUI Antofagasta's mining/energy companies
ELECTRIFICATION OF TRANSPORT			
Electric mobility - Electric vehicles/equipment for the industrial operations (mining sector – logistics).	Large	Ongoing	Mining Companies Mining Council
Electric buses Pilot project launched in 2019 by BYD, Enel X and regional government to research suitability.	Medium	Short	BYD Enel X GORE Antofagasta Antofagasta Municipality Ministry of Transport Chile GIZ EU Euroclima Programme
Tram Total investment of USD 62million proposal for 2 tram lines with 14 stations. Postponed until 2023.[48]	Medium	Long	
Cable car USD 173million proposal. 12.9km.[49]	Medium	Long	
ACTIVE TRANSPORT AND MOBILITY			
Expansion of bike lanes network[50]	Medium	Ongoing	GORE Antofagasta Antofagasta Municipality Ministry of Transport Chile GIZ EU Euroclima Programme CREO Antofagasta
New system of public bicycles[51]	Small	Ongoing	
Pedestrian networks Cerro Mar La Chimba - Ascotan, Cerro Mar Barrio Estación – Villa Codelco, Cerro Mar Maipú – Mall Plaza Pilot project: Maipu Caminable	Medium/Small	Long/ Ongoing	
WATER TREATMENT			
Newly improved desalination plants: Phase II of Antofagasta's North desalination plant USD 80million (construction between 2021 and 2023).[52]	Large	Ongoing	Aguas Antofagasta Mining companies
WASTE			
Recycling value chain development New recycling and composting centre.[53] (USD 6.7million) Michellin and Enviro tyre recycling plant: Investment of USD 30million.[54] (construction between 2021 and 2023)	Small/Medium	Ongoing/ Short	Santa Marta Consortium Michellin and Enviro GORE Antofagasta Antofagasta Municipality

Project Size: Small: <USD 10million, Medium: USD 10 – 50million, Large: >USD 50million. Project time frame: Short: 1 – 2 years, Medium: 2 – 5 years, Long: > 5 years

Appendix

Net Zero Typology – Terms and Criteria

	Assets	
	Impaired	Strongly negative score (<-20%) or limited evidence of efforts to diversify/improve systems
	Challenger	Negative score for assets, but evidence of efforts to diversify economy and invest in underlying systems
	Reformist	Marginal score for assets, no other defining features
	Guardian	Marginal score for assets, presence of natural assets is defining feature
	Equipped	Positive score, evidence of leadership on one of the agendas (e.g. public transport/density etc.)
	Ambitions	
	Constrained	Negative score for ambition and strategy, limited ambition of public sector ambition plus limited evidence of role of civic leaders, platforms and others in supporting ambitions
	Championed	Negative score for ambition and strategy, but strong evidence of role of civic leaders, platforms and others in supporting ambitions
	Cautious	Negative score for ambition and strategy, but some evidence of emerging public sector ambition.
	Enthusiast	-15% to +15% for ambition and strategy, plus evidence of willingness to accelerate in next cycle.
	Trailblazer	Highly positive score for ambition and strategy.
	Powers	
	Reliant	Marginal score overall, plus evidence of strength in integration measures but majority of projects/systems overseen by private sector actors
	Opportunist	Positive score for powers and influence, evidence of civic leadership and/or non-gov platforms to build on
	Functional	Negative score for powers and influence, no real signs of strength for governance integration or financial/fiscal powers
	Change-maker	Positive score for powers and influence, not as strong for governance integration (outside top 25%) but strong for financial/fiscal powers
	Commander	Positive score for powers and influence, top 25% for governance integration
	Projects	
	Steady	More projects in pipeline than underway, strongly negative score (e.g. -20% or lower) for projects and platforms.
	Standby	Moderately negative score for projects and platforms (-10 to -20%), platforms stronger than projects.
	Accelerator	More projects in pipeline than currently underway, signs of acceleration, marginal score (-5% to +5%) for projects and platforms.
	Purposeful	Positive score (+5% to +15%) for projects and platforms, without transformational scale or impact.
	Pathfinder	Very positive score (>25% or higher) for projects + platforms, demonstrative of pace of change and appetite to deliver.
	Innovation	
	Unsigned	Strongly negative score for innovation and investment, limited and sporadic observable relationships with MNDBs or other partners and platforms.
	Cushioned	Strongly negative score for innovation and investment, yet some evidence of observable relationships with capital suppliers and other civic or business enablers to fall back on.
	Experimenter	Marginal score for innovation and investment, with strong evidence of leverageable relationships with big capital and other actors and appetite to pilot & demonstrate.
	Invested	Positive score. Stronger evidence of multi-sector leadership, more established track record of scaling pilots.
	Pioneer	Strongly positive score. Established track record of scaling city-wide projects, supportive universities, dynamic green innovation ecosystem.

The list of indicators for summary Spidergram (indicators in red are national datasets) is provided below. NOTE: not all cities are included in all indicators. Final scores are calculated according to an aggregate of each city's position across all measures, using an ELO algorithm. The Business of Cities' ELO algorithm computes the overall performance of each city relative to all other cities on aggregate across multiple benchmarks and datasets. The Elo algorithm rates cities or regions by comparing their performance in every possible permutation against a list of other cities/regions. The system produces the most accurate comparative assessment of city/region performance, as it accounts for the fact that some cities/regions appear in more benchmarks and datasets than do others, and that each dataset measures a different number of cities.

Systems and Assets

Track record of compact development

- Core urban area population density (Demographia)
- Built-up area expansion rate, 2000-2015 (OECD)
- Per capita built-up area expansion rate, 2000-2015 (OECD)
- Weighted population density (ITDP)

Urban canopy coverage and protection

- Urban green coverage as share of metropolitan area (OECD)
- Change in urban green coverage as share of metropolitan area, 1992-2018 (OECD)

Transport and infrastructure systems efficiency

- % of population living within 500m of frequent public transport service (ITDP)
- % of population living within walking distance of healthcare and education services (ITDP)
- % of population living within 500m of a car-free zone (ITDP)
- Per capita length of high-capacity public transport: BRT, light rail/tram and metro/subway (multiple sources)
- Aggregate score across all publicly available global benchmarks of public transport systems performance (multiple sources)
- Size of electric vehicle fleet (C40)
- Sustainable modal share (C40)
- Per capita public transport uptake (University of Rosario)
- Sewer coverage (University of Rosario)
- Electric power coverage (University of Rosario)
- UN Habitat Colombian Urban Connectivity Index

Span of Powers and Influence

- No. of municipalities per 100,000 people in the metropolitan area (OECD)
- Size of core city vs. metropolitan area (multiple sources)
- Extent of metropolitan level government coordination (multiple sources)
- City level spending capability: absolute capital budget of city government plus per capita capital budget (multiple sources)
- No. of modes of transport the main transport authority has authority over (multiple sources)
- % of modes of transport the main transport authority has authority over, relative to the number of modes of transport that exist within the city (multiple sources)
- Transport authority spending capability: absolute budget of main transport authority plus per capita budget (multiple sources)
- Level of fiscal autonomy (University of Rosario)
- Local budgetary collection capacity (University of Rosario)
- Municipal risk management index (University of Rosario)

Innovation and Investment Environment

- No. and % of local tech-enabled firm HQs specialising in sectors directly allied to net zero (Crunchbase)
- No. and % of local tech-enabled firm HQs specialising in sectors indirectly allied to net zero (Crunchbase)
- Presence, extent and maturity of open data platform (multiple sources)
- Presence of universities capable of leading the charge on the urban SDGs (Times Higher Education Impact Rankings 2021):
    - Affordable and clean energy
    - Industry, innovation and infrastructure
    - Climate action
    - Sustainable production and consumption

Ambition and Strategy

- Presence, scale and timespan of climate action plan (multiple sources)
- Presence and scale of climate emergency declaration (multiple sources)
- Scope of planned climate actions (multi sector vs. single sector) (multiple sources)
- Presence and timespan of city-level target for net zero (multiple sources)
- Implied carbon reduction momentum (multiple sources)
- Presence and maturity of standardised emissions reporting mechanism and carbon emissions disclosure practices (CDP)
- Consistency of current targets with Paris Agreement goals (C40)

Projects and platforms

- Aggregate project size and status (according to size of investment and current status: plan/ambition, pilot, project, or city-wide scaled project)
- Average number of sources of leadership in decarbonisation projects in the city (city/regional government, national government, business, multi-national organisations, universities and civic groups)
- Number of pilot and demonstration projects with high potential to scale
- Presence of independent civic organisation for city and track record of thought leadership or activity on issues relating to decarbonisation
- Number and visibility of non-governmental platforms:
    - Visibility on social media websites
    - Visibility in global media sources
    - Number of mentions in relation to decarbonisation

National level impetus and enablers

- Presence and timespan of national net zero ambition / target (World Economic Forum)
- Climate Change Performance Index score (New Climate Foundation)
- KPMG Climate Change Readiness Report 2019:
    - Enterprise capability
    - Government capability
    - Societal capability
- Presence, scope and timespan of national emissions reduction target (multiple sources)
- Implied carbon reduction momentum (multiple sources)
- National renewable energy share for electricity output (World Bank)
- National level CO2 emissions per capita (World Bank)
- National level GDP per capita (World Bank)

Indicators used to calculate metropolitan-level governance coordination score (p. 6): no. of municipalities per 100,000 people in the metropolitan area; size of core city vs. metropolitan area; extent of metropolitan-level government coordination
Indicators used to calculate city-wide spending capability score (p. 6): absolute capital budget of city government plus per capita capital budget

References and endnotes

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- 925MW park in northern Antofagasta, by Chilean power generator Colbún. USD 788million Inti Pacha solar park.
- Andes Solar II-B project- 180MW and 112MW lithium battery storage system. Largest BSS in Latin America. Construction began 2020. By AES Corporation
- Domeyko solar park 204MW by Power Chile/Enel Chile. Investment USD 164million. Construction
- Plans for Parque Fotovoltaico Estepa Solar, USD 350million by Atlas Renewable Energy. 577MW.

- Engie- 82 MW Capricornio Solar Park.
- Pampa Tigre solar PV farm by Mainstream Renewable Power- 100MW (65km SW of city)- 934mil

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- Horizonte Wind farm, Antofagasta USD 700million by Colbun
- 162MW wind farm by Engie- 36 wind turbines of 4.5MW each plan.
- Antofagasta wind farm- project entails 128 wind turbines.
- Enel Green Power- Tatal wind farm - 33 wind turbines. USD 190million under construction
- Engie Chile- 353MW project with 57 wind turbines – USD 424million. Has secured project site.
- Llandos el Viento wind farm – USD 400million, 42 wind turbines with 222.6MW

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