

The Element at the End of the World: Chile's Green Hydrogen Strategy and the Global Energy Transition

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Abstract:

Chile is positioning itself as a leader in the transition to green energy, particularly through its National Green Hydrogen Strategy, which aims to make Chile one of the world's leading exporters of carbon-neutral hydrogen for energy and industrial applications. This thesis examines Chile's green hydrogen policy from a political ecology perspective, in the context of 1) the Chilean state's conception of green development; 2) hydrogen's political, economic, and ecological challenges to scale; and 3) the left-wing government's attempt to implement a socially and environmentally just environmental policy paradigm. By reviewing publicly available documents on Chile's hydrogen policy, the attempts by investors to implement the policy, and political debates around the scaling up of hydrogen in peripheral regions of the country, this thesis provides an early investigation into a novel political-ecological phenomenon. It finds several contradictions on the ground that will complicate the implementation of the Green Hydrogen Strategy, corresponding to the unreliability of the profit motive as a driver of the ecological transition, domestic core-periphery relations prompting local community resistance, and unrealistic assumptions of rapid scaling.

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“If Chile was the cradle of neoliberalism, it will also be its grave.”

- President Gabriel Boric¹

1. Introduction

1.1 Topic

Chile has long captured the imaginations of adventure seekers, agenda-setters, and activists across the world. This country at the tip of South America - scarcely 150 kilometers wide - stretches from the driest desert in the world to the wind-swept wastes of Patagonia, where colonial outposts set out to conquer this “uttermost part of the Earth” (Bridges 1947). In this place, centuries of imperial conquest played out across a kaleidoscope of rugged landscapes. Neoliberalism was born there 50 years ago, by an unholy alliance of a reactionary national military and a coterie of American capitalists. Today, a new president backed by a new generation of social activists promises to put it to death. Across this country, the sun burns through cloudless skies and relentless winds blow in from the vast, cold Pacific. This landscape means many things to many people, but for a growing coalition of political actors, that sun and those winds harken a renewable energy revolution that will free the world from fossil fuels. That abundant wind and solar power potential, in a land with a relatively low population density, offers a tantalizing prospect for the energy industry - the world’s cheapest green hydrogen.

Green hydrogen – that is, hydrogen for energy or industrial uses synthesized through renewable energy-powered electrolyzers – is becoming a core element of Chile’s environmental policy. In 2020, the Ministry of Energy –

¹ Quoted by Fabio Cambero, *Reuters* 2021.

with support from the omnipresent McKinsey & Co. – published the country’s National Green Hydrogen Strategy, which outlines an ambition to become a world leader in green hydrogen production and export. Powered by the relentless winds of Magallanes and the blistering sun of the Atacama Desert, abundant renewable energy (and, of course, a favorable foreign investment environment) will enable Chile to produce 25 GW of green hydrogen by 2030 (Ministry of Energy 2020, 8). If implemented, the Strategy will make this small country the largest hydrogen producer in Latin America. The applications are legion – in addition to the typical uses of hydrogen for agricultural fertilizers, cars, and trucks, Chile intends to synergize with its booming minerals sector by encouraging mines to establish green hydrogen plants onsite for internal use and export alike (Ibid). In both north and south, the Ministry of Energy hails hydrogen as an opportunity to create “a new productive identity” for Chile, with this emerging industry complementing its dominant role in mining the minerals needed for the green transition, cementing Chilean contributions to global green growth (Ministry of Energy 2020, 14). This energy boom comes to Chile in an era of political change, with implications that probe the structure of the global energy transition itself.

1.2 Aims

This thesis will assess the implications of the Republic of Chile’s National Green Hydrogen Strategy for the country’s ecological transition. The Strategy emerged within the context of pressure to decarbonize the capitalist economy, a preference for green development amongst the Chilean political class, and the regional revival of social-democratic governments across Latin America. In short, it entails a massive upscaling of a particular techno-fix in a relatively short amount of time – with impacts concentrated in a set of peripheral zones. This development model has been a source of contention around the world, from North

to South, that implicates fossil fuel and renewable energy projects alike. Since the first green hydrogen pilot plant in Magallanes only began operations in December 2022, there is an opportunity to examine an emerging case from the ground up. This thesis will be among the first academic publications on the impacts of Chile's Green Hydrogen Strategy, a case which has unique local dimensions but echoes numerous disputes over the path of green development unfolding around the world. These rich grounds for investigation offer insights into the scaling of green technology, local-global relations in a dynamic capitalist economy, and the paths by which left-wing governments navigate the thorny intersection between industrial policy and democracy.

1.3 Research Questions

- 1. How does Chile's National Green Hydrogen Strategy position the country in the global environmental transition?*
- 2. What, if any, are the environmental and social drawbacks of the National Green Hydrogen Strategy?*

1.4 Structure/Roadmap

Following the above context-setting and delineation of the research question, this thesis will outline the theoretical and analytical framework of the study. I will take a political economy and political ecology approach, within a critical realist ontological framework, to investigate the research question. Key concepts to be employed include scale, green development, and Latin America's 'pink tide.' All these will be explained in the following section, with a brief review of relevant social science literature and a discussion of these terms in the

context of the case for each term. After these theoretical frames and concepts have been elaborated, I will also provide a literature review focusing on the engineering and economic challenges facing the green hydrogen industry in Chile and around the world.

After presenting this background material, I will explain the methodology and research instruments used to conduct this case study. Following this, the study's findings will be presented and analyzed. The findings and analysis are woven together in three subsections: the first summarizes the National Green Hydrogen Strategy and other national-level policy documents, the second discusses an enlightening case of hydrogen development in Patagonia, and the third speculates on the future of green hydrogen as the industry matures and expands across Chile. Finally, I present some concluding thoughts that place my findings in the broader regional and global context of Chile's nascent hydrogen boom.

2. Framework of study

2.1 Theoretical and Analytical Framework

Epistemology: Critical Realism

This thesis will apply an analytical framework of political ecology to its case. I do so within the epistemological tradition of critical realism, which posits the existence of an independent reality, albeit one that can never be fully discerned by the human mind, riddled as it is with political agendas, biases, and contradictions (Benton and Craib 2011; Guba and Lincoln 1994). Phenomena are emergent – that is, constituted by material and social relations that combine, often unpredictably, to form results that are more than the sum of their parts (Bhaskar, 1978). To critical realists, understanding the multifaceted mechanisms and circumstances that lead to a phenomenon is paramount (Bhaskar 2014; Vincent and O’Mahoney 2016). The lodestar of critical realism is the “practical adequacy” of the knowledge produced (Sayer 2000, 43). Though no scholar can credibly claim to be uncovering objective truths about the world, I aim for this work to be useful in the drive to understand the environmental politics of Chile and the world in this neoliberal age.

Theoretical framework

Approaching the development of green hydrogen in Chile as a political-ecological phenomenon highlights the interconnections between environmental change and political-economic transformation, demonstrating that the human activities often said to be divorced from nonhuman nature are in fact embedded within landscapes around the planet. The story of green hydrogen in Chile is one of global-local interaction, and as such must be approached with an understanding

of various theories of globalization. In this thesis, I was inspired by two schools of thought that are often seen – even by their own authors – as incompatible with each other. Anna Tsing’s notion of entanglement or *friction* articulates the sometimes-bizarre, often-horrific, and always-surprising results of the interactions across scales and geographies that constitute globalization. A more classical view, espoused by Alf Hornborg and drawing on Immanuel Wallerstein’s world-systems theory, highlights *ecologically unequal exchange*. For Hornborg, the political oppression and economic exploitation of peripheral regions by the planet’s imperial core are necessarily intertwined with environmental destruction in the Global South. These scholars may not appreciate being linked; indeed, the latter has been sharply critical of Tsing and the postmodern, posthumanist intellectual movement with which she is associated (Hornborg 2017). Even so, to set aside this debate for a moment and analyze both theories on their merits will reveal that both are necessary to comprehend the transformation that Chile is facing.

The notion of a unified “world-system” was first articulated by Immanuel Wallerstein in the 1970s, and has remained a mainstay of critical scholarship ever since (Wallerstein 2000). The world-system, in Wallerstein’s terms, is the “world-economy” a system consisting of a few “core” regions (Europe, North America, and Japan) that generate surplus wealth and power by exploiting “peripheral” regions, with a “semi-periphery” straddling the boundary between those two realms. “Unequal exchange” is the term ascribed to this system of exploitation. This is key background information, but it is Alf Hornborg’s corollary to the overarching theory that is of most interest for this work. Hornborg developed the term “ecologically unequal exchange” based on research demonstrating that the core imports embedded land and natural resources from the periphery as the basis

of its wealth-building project.² This reality prompts ecological devastation in poor countries, driven by and in service of the interests of the Global North.

Importantly, such a dynamic also masks the ecological destruction of the North's resource-intensive mode of living by offloading its ecological harms to the South – a phenomenon known as “environmental load displacement (Hornborg 2009, Hornborg & Martinez-Alier 2016). This body of work is essential to a systemic understanding of globalization, and offers valuable context behind the political ecology of the modern economy.

Given the extent to which Chile's economy is dependent on raw mineral exports, the concepts of ecologically unequal exchange and environmental load displacement carry political and emotional weight in the country. Many Chilean scholars have adopted the term “sacrifice zone” to describe the peripheral areas of their country that are consistently asked to sacrifice their environment and health at the altar of national and global development (Broto & Sanzana 2020, Valenzuela Pérez 2016, Vergara 2022).³ This dynamic has been entrenched for decades, and remains true in the energy transition facing the 2020s. It must be emphasized that decarbonization, while essential to the survival of humanity, does not inherently achieve social, economic, and environmental justice. A wave of scholars have applied the concept of unequal exchange and sacrifice zones to the unfolding energy transition, from the deleterious impacts of lithium mining to the displacement of communities in service of the wind energy industry (Dunlap & Arce 2021, Brock, Sovacool & Hook 2021, Scott & Smith 2017). These critics

² For an earlier exploration of similar themes, see Bunker (1985), *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State*.

³ “Sacrifice zone” was coined in the United States when a 1973 government study concluded that surface mining zones represented “national sacrifice areas” that could never fully recover (National Research Council 1973). Given the parallels between mining-exposed regions across the world, the term continues to resonate with affected communities in the U.S., Chile, and many other countries.

argue that, much like traditional extractive industries, renewable energy megaprojects seize land from Indigenous, rural, or otherwise marginalized communities in the interest of profit for corporations and energy security for wealthier, urban areas. These criticisms point to an example of David Harvey's (2005) notion of accumulation by dispossession, no different than the classic tale of industrial development except this time the carbon emissions removed. The underlying method of surplus value creation remains untouched.

The grand theory of ecologically unequal exchange as the basis of the capitalist world-system – and the critiques of capitalist renewable energy projects such a theory engenders – are essential contexts for scholars attempting to understand green development in Latin America. However, other theoretical interventions contribute more nuance to the discussion. The simple core-periphery heuristic no longer reflects the dynamic stratifications of the modern capitalist economy. For centuries, Europe and its North American settler colonies have been at the center of global commerce. Today, the weight of international trade is shifting to the Asia-Pacific axis, with much of the action happening between states that have been traditionally branded as part of the Global South (Wilkins 2010). Western states still have immense power to set the conditions of global politics, but governments in the Global South have long since emerged as agents of their own histories, not merely as colonial subjects to be acted upon. All the while post-colonial states, especially in Latin America, are emerging as agents in this new economic order. Martin Arboleda argues that resource extraction has taken on a planetary dimension, backed not only by brute colonial force, but also processes of technocratic governance that construct a transnational landscape of extraction (Arboleda 2020).⁴ Arboleda is careful to name this system as

⁴ For a brief description of Arboleda's notion of technocracy applied to the specific case of Chile, see the section entitled "Green development."

“planetary” rather than “global.” The dark side of the seamless cosmopolitanism imagined by neoliberal globalization, the notion of the planetary evokes Earth as “an unfamiliar place, riddled with eerie, destructive, and menacing forces,” a place marked equally by militarized borders for the poor and automated shipping infrastructure for raw materials and trade goods (ibid., 15-17). These dazzling and contradictory systems of wealth and poverty, movement and blockade, are latticed on top of each other. This is the defining trait of the modern world system: geographic complexity.

If the world system is defined by complexity and contradiction, then one might be tempted to throw up one’s hands and declare that it is utterly unpredictable. Before admitting defeat, though, some of Anna Tsing’s work merits a look. Her book *Friction: An Ethnography of Global Connection* (2004), draws upon ethnographic fieldwork in the extractive frontiers of Kalimantan, Indonesia in the 1990s. In this place being torn asunder by rapacious demand for commodities like gold, timber, and palm oil, global and local forces became entangled with one another. The results are difficult to encapsulate in a neatly-wrapped theory, with a diverse constellation of actors imposing a dynamic, inchoate environment on the rainforest frontiers of capitalist accumulation. This is what leads Tsing to mark “friction” as a core characteristic of globalization.

In the same volume, Tsing describes a case study that may be instructive for those seeking to understand commodity booms. In 1994, a hitherto-unknown Canadian gold prospecting company named Bre-X announced that it had struck the mother lode in the jungles of Kalimantan (Indonesian Borneo) – the largest untapped gold reserve in the world. A firestorm of media hype swept up retail investors and major corporations alike in a rush to invest, but after three years of chomping at the bit, independent investigators finally visited the area and discovered nothing but dirt. Bre-X had faked their test results. While this fraud

yielded nothing for the majority of its investors, it did enrich a few hucksters along the way; more importantly, it revalued land along Borneo's extractive frontier and prompted cronyist maneuvering among government functionaries looking to cash in on the final years of the neoliberal Suharto regime. Critical to this deception was the reach afforded to upstart companies by new technology (the Internet) and old marks (the gullible financial press). This enabled Bre-X to "conjure" vast amounts of capital from thin air (Ibid 55-59). Tsing names this process "spectacular accumulation" – accumulation by media spectacle and financial speculation – that drives profit on the frontier (Ibid, 55-59). Notably, this case demonstrates profit often comes before results.

When it comes to delivering the results that global corporations promise, however, the friction they encounter when moving against the landscape causes outcomes to diverge wildly from expectations. To mold the landscape to its needs, capital must divorce the land from its social and ecological context, turning it into a fungible element. Such a nonsocial landscape is, of course, a fiction; Tsing claims that the futility of this pursuit implies the "nonscalability" of capitalist world-making (Tsing 2012). These concepts of friction and nonscalability put words to the unpredictability of the modern world system, offering a surprising and useful complement to more traditional theories of globalization. In the endeavor that follows, such divergences between the imaginaries of the global economy and the reality of the energy transition will take center stage.

2.2 Key Concepts

Scale

The core objective of the National Green Hydrogen Strategy is the rapid deployment of a great number of industrial installations across the frontiers of

Chile in the coming decade. The state expects the small pilot projects currently operating in Magallanes and Antofagasta to proliferate across those regions, with a geographic extent and intensity transforming the landscape in a relatively short period of time. These operations will in turn feed a national and global market for hydrogen, plugging the regions into global networks of trade that will, in turn, make far-flung capital cities economically dependent on Chilean energy. Given the reordering of local and global relations implied, this necessitates a discussion of scale.

Popular discursive framings of this rather nebulous topic include “scaling up,” “scalar politics,” and even the concept of globalization itself. Scale itself has been defined as a socially constructed set of material relations across a particular geography (MacKinnon 2011). That definition comports with the sorts of scalar relations explored by this thesis – e.g., local-global, core-peripheral. Economic initiatives like hydrogen development require both conceptual and material reorganizations across those scales. The hydrogen strategy, in Chile as in other countries, is being implemented with the construction of initial pilot projects. The strategy document envisions these pilots seamlessly ratcheting up to a national scale, at which point a bevy of green hydrogen factories will feed into a national and global market – a market that the availability of cheap Chilean hydrogen will have in turn helped to create. As such, this is not a mere case of the global decarbonization consensus imposing its will onto a helpless Global South country. In one notable case, marginalized local communities in Latin America have also “scaled up” concepts like *sumaq kawsay/buen vivir* to shift norms in environmental policy at the global level (Kauffman and Martin 2014; Kauffman 2016). One can expect the same tendency to play out in the case of hydrogen. Local communities and national governments will certainly leave their own

imprint upon global policies and markets if and when green hydrogen morphs from a glimmer in the eye of investors to a global industry.

Assumptions about scalability from modelers and policymakers elide a complicated truth: as things scale, they change. A full-scale industrial region is not distinct from a pilot project only because it is bigger, but it is also qualitatively different due to the social, ecological, and economic relations transformed by the development. Scaling up requires the construction of what Anna Tsing calls “nonsocial landscape elements” or “nonsoels” (Tsing 2012, 508). There is no room in this model for historical contingency, local peculiarities, or “the way that contact across difference can produce new agendas” (Ibid 510). As hydrogen jumps from one frontier to another across Chile – southern fjords to northern deserts and, finally, to the more populous and contested regions in the country’s heartland – it will come into contact with unique local contexts, each of which could alter or even derail the industrial agenda.

The ‘Pink Tide’

In the late 1990s and early 2000s, an ascendant electoral left emerged in Latin America that challenged the longstanding dominance of neoliberalism in the region’s affairs. The years of the so-called Washington Consensus – free market economies driven by foreign investment and backed by close political alignment with the United States – had left Latin America plagued by corruption, political instability, and the worst income inequality in the world. Beginning with Hugo Chavez’s 1999 ascent to power in Venezuela, the left claimed electoral victory in countries including Argentina, Nicaragua, Ecuador, Bolivia, Uruguay, Chile, and Brazil. This ‘pink tide’ became one of the watershed events of Latin American history, but many of these governments left complicated legacies that continue to be the subject of fierce debate among activists and scholars. Making sense of that

legacy is critical to this research because the pink tide may be rising within Latin America once again. Most of the aforementioned countries, including Chile, have once again elected left-wing or center-left governments in the last five years. In many cases, these governments are led by the very same figures on the vanguard of the original pink tide.⁵ This includes the election of social democrat Gabriel Boric after an epochal wave of protests struck Chile in 2019. Although Chile was not a primary center of the original pink tide, Boric's election indicates the Chilean left's ambitions to be placed at the crest of this next wave. Given the left's resurgence, the case of Chilean hydrogen is interesting precisely because it represents an opportunity to see how a neo-pink tide government adapts its country's industrial policy to serve the interests of its progressive base – precisely the challenge faced by the original leaders of the Latin American left.

The pink tide governments were not (and are not) monolithic. Their divergence on core issues spawned numerous attempts at sub-categorization, including a pedestrian “good-bad” binary emerging from many foreign policy thinkers in Washington. The paradigmatic example is Castañeda (2009): “there is not one Latin American left today; there are two. One is modern, open-minded, reformist, and internationalist...the other, born of the great tradition of Latin American populism, is nationalist, strident, and close-minded [sic].” Conveniently, the “nationalist, strident, and close-minded” countries are those who took a more openly confrontational tack against the United States (Cameron 2010). More nuanced analyses suggest that researchers should seek to understand the unique social conditions that spawned each country's government rather than dichotomizing the left into social-democratic and populist camps (Ibid).

⁵ The reelection of Brazil's Luis Inacio Lula da Silva, and the long-awaited presidential ascendancy of Andres Manuel Lopez-Obrador in Mexico, are notable examples.

Despite the obvious flaws of foreigners' attempts to define the pink tide, these schools of thought do stumble into an uncomfortable truth – some pink tide governments had a complex relationship with democracy and human rights, and their record at addressing the problems they were elected to solve is mixed. In *The Impasse of the Latin American Left* (2022), Gaudichaud, Mondonessi, and Weber refer to the pink tide as a set of Gramscian “passive revolutions” that ameliorated the worst excesses of the region’s wealth inequality but did not fundamentally reorder the economic system; instead, they merely “absorb[ed] and de-escalate[d] class struggle from below (Ibid, 8).” There were genuine reductions in economic inequality and poverty, but crucially, this economic progress was contingent upon profits from natural resource extraction. Because these governments failed to diversify their economies, when commodity prices fell in the early 2010s, working-class living standards, and often the governments themselves, fell with them (Ibid., 75-87). This would ignite a period of struggle that splintered the left, pitting left-wing administrations against the progressive and environmentalist movements that had first put them into office. Often, these struggles revolved around the question of extractivism.

Given the economic volatility spawned by reliance on commodity extraction, the issue was bound to be contentious. However, debates over extraction in Latin America during the pink tide era became the locus of a much more visceral struggle – a struggle over the obligations of a left government and the nature of democracy itself. In *Resource Radicals* (2020), Thea Riofrancos chronicles this process in Ecuador, where left-wing president Rafael Correa attempted to chart a course towards prosperity for all through the rough terrain of petro-politics and resource extraction. Correa positioned extractivism as a necessity to enrich the working-class population that had elected him, but Indigenous peoples and environmental movements rallied to prevent their

cherished territories from turning into sacrifice zones at the expense of this broader project. Riofrancos identifies these ideological camps as “resource nationalists” and “anti-extractivists,” respectively. The anti-extractivists articulated a more radical vision of democracy constituted not only through national elections but also citizens’ assemblies, local consultations, and protest, asking a provocative question: who is the ‘demos’ in “democracy?” (Ibid., 115-137). This also connects to the questions of “scaling up” raised earlier in this work; as anti-extractive movements show, the pink tide had a mixed record because concentrating all decision-making in the hands of the state cannot fully achieve the left’s emancipatory ends (Mann 2022). With the left once again ascendant in Chile and elsewhere, these governments must navigate the gulf between their economic imperatives and the demand for local autonomy and sustainability anew.

Green development

In this thesis, I argue that Chile, under both left- and right-leaning administrations, is a green developmentalist state, and that its hydrogen policy must be understood in that context.⁶ Hydrogen is seen as an opportunity to profit from the transition to renewable energy, but it is also part of a larger agenda to position Chile as a leader in that transition by linking hydrogen to other industries, especially the mining sector. This model of development falls somewhere on the middle of Riofrancos’ spectrum between resource nationalism and anti-extractivism, given its attempt to address the climate crisis without abandoning extractive and capitalist models of development. Discourses on (green) development are wide-ranging enough that to attempt an exhaustive summary would consume this project entirely, but one Latin American scholar worth noting

⁶ This thesis considers “green development” and “sustainable development” to be synonymous – for a more precise definition and discussion of these terms, see Adams (2019).

is Eduardo Gudynas. Gudynas critiques development as such, arguing that the notion is “growth-aligned, and therefore anti-environmental” whether pursued under capitalism or ecosocialism (Gudynas 2017). This critique animates much of the vociferous criticism levied against pink tide governments’ extractive policies, but one could imagine such governments retorting that there is an undeniable need to increase the material standard of living in the Global South. Might green hydrogen – not a primary commodity like copper or oil, but still an export-oriented industry dependent on intensified production in certain landscapes – represent a middle path between anti-developmentalism and resource nationalism?

Both the staunchest boosters and fiercest critics of green development would likely agree that Chile represents an emblematic case of that political-economic strategy. Chile, with its 4,000 kilometers of territory stretching from the world’s driest desert to the subantarctic fjords of Tierra del Fuego⁷, has long struggled with the conundrum of how to balance socio-economic advancement and the protection of its variegated ecosystems. A key element of this struggle is the dominance of the Santiago metropolitan region, home to 7 out of Chile’s 18 million inhabitants and all of its major civic institutions, and the peripheral regions of the country. Patagonia, in particular, has been the locus of an ongoing centuries-long struggle against colonialism that predates the Chilean state itself.

In the modern manifestation of the conflict in Patagonia, scholars have identified a “Patagonian imaginary” that casts the region as a *tabula rasa* for Chile’s green developmentalist dreams (Mendoza et al 2017). When capital turns its gaze South, it sees in Patagonia’s rushing rivers the potential for mega-dams to electrify Santiago, despite the fierce resistance of Indigenous Peoples and

⁷ If its internationally-unrecognized claims to the Chilean Antarctic Territory are to be taken at face value, Chile in fact stretches all the way to the South Pole.

environmentalists (Silva 2016). In Patagonia's starkly beautiful vistas, capital sees sites for luxury eco-lodges to separate international tourists from their cash. Now, when capital feels Patagonian wind buffeting its face, it sees green hydrogen. This represents the continuity of a regional imaginary of green development that serves the interests of the Chilean state as a whole, erasing the presence of local communities who demand autonomy and sovereignty amidst the unfolding narrative of Patagonia's transformation.

Alongside the construction of peripheral zones for green industry, the development of Chile is also informed by the country's close historical relationship to neoliberalism and technocracy. Among scholars of the history of capitalism and neoliberalism, Chile is notorious for its close relationship to the set of economists known as the "Chicago Boys," who were empowered to rewrite Chile's regulatory regime after a 1973 U.S.-backed coup installed right-wing dictator Augusto Pinochet (Fischer 2015). This made Chile a test case for the neoliberal Washington Consensus across Latin America, a history which echoes to the present day; most of Pinochet's authoritarian constitution and devastating economic reforms are still in place today (Arboleda 2020). Moreover, there is a long tendency towards technocratic management in the Chilean public policy landscape that significantly predates Pinochet. Since the 1920s, expertise has been vaunted in Chilean statecraft, a tendency which created the conditions for the overwhelming power of the Chicago Boys and to this day lends an "antipartisan bent" to Chilean politics, leading to remarkable continuity in policy and institutional structure despite the transition to democracy (Ibid., 140-174, Huneus 2000). Neoliberalism and technocracy cast a long shadow over Chile's approach to the environmental transition.

2.3 Literature Review: The Hydrogen Economy

In recent years, green hydrogen has been anointed as a critical input for the transition away from fossil fuels. Already used in the production of critical commodities such as fertilizer and steel, this simple element has become the cornerstone in a “hydrogen economy” proposed by many researchers as a means to fuel the green transition in sectors that renewable energy cannot decarbonize alone. Sectors for which green hydrogen has been proposed as a climate solution span nearly the entire spectrum of industrial activity, from steelmaking to fertilizers to long-haul shipping, with varying degrees of ecological and economic feasibility. The purpose of this thesis is to understand the political-ecological implications of one country’s commitment to make hydrogen the basis of its green economy, not to assess the technical utility of green hydrogen as an engineering solution. However, a brief discussion of the economic and technical challenges that green hydrogen faces will enhance the reader’s understanding of the former problem.

One fact that animates the background of this research is the material footprint of green hydrogen. Hydrogen is by far the most common element in the universe, but it almost always appears on Earth bound to other elements. Traditional methods of hydrogen production, termed “black,” “brown,” or “gray” hydrogen, separate the hydrogen and carbon atoms in coal or methane, respectively, by burning those fuels. These carbon-intensive processes account for the overwhelming majority of all hydrogen produced today.⁸ This thesis is concerned with an alternative method known as electrolysis, which separates hydrogen atoms from the oxygen atoms in water by running the water over an

⁸ There is a veritable rainbow of other methods of hydrogen production; the most notable besides gray, and green is “blue” hydrogen, which combines traditional fossil-derived hydrogen with carbon capture

electric current. If powered by renewable energy, electrolysis produces no direct carbon emissions; as such, the industry has labeled renewable energy-powered electrolysis as “green hydrogen.” Electrolysis-produced hydrogen accounts for only 1% of hydrogen production globally and must scale to an unprecedented degree if global climate commitments are to be met (IRENA 2022).

To create hydrogen fuels used to power vehicles (as in one of the primary cases examined in this thesis), the hydrogen atoms can be combined with carbon molecules captured from the atmosphere to yield hydrocarbons that are chemically analogous to gasoline, diesel, or other transportation fuels. Therefore, it can be tempting – not to mention clever marketing – to claim that hydrogen-based fuels are literally pulled from thin air. As is the case with every other commodity, this is not true. Hydrogen demands material inputs and produces waste products like any other industry. If green hydrogen is utilized to its full potential for decarbonization in the United States, one recent study finds, the industry will demand 15% of the country’s current water consumption by 2050 (Grubert 2023). In the Chilean case, demands on water, energy, and materials will be even higher given the country’s plans for dense hydrogen development that far outpaces domestic demand (CASA 2022). Despite the clear environmental benefits of green hydrogen over its fossil fuel-derived counterpart, there still exist material entanglements with the landscape that could become the locus of political disputes.

Another challenge to the scaling up of green hydrogen is that the sector must overcome significant engineering barriers to be cost-competitive with gray hydrogen. For all potential markets, green hydrogen currently commands a massive price premium over conventional energy sources – two to three times more than average fossil fuel prices as of 2022 (IRENA 2022). For instance, aviation – envisaged as a key sector to decarbonize using green hydrogen – would

see operating costs more than double if the sector switched to green hydrogen fuels (Hoelzen et al 2022). In addition to higher production costs, green hydrogen also faces massive logistical challenges due to the complicated nature of shipping hydrogen. The latest research considers overseas shipping to be economically infeasible, with local production or pipelines being a far more realistic way of delivering hydrogen to customers (Moritz et al 2023). Hydrogen pipelines, the cheapest method of long-term shipping, are still 10-50% more expensive than fossil fuel pipelines (IRENA 2022). Shipping the product overseas, as envisioned by the Chilean strategy, requires dedicated port infrastructure, which only 20 ports worldwide either possess or are immediately ready to construct – none of which are in Chile (Chen et al 2023). Thus, green hydrogen will require significant engineering and infrastructure developments if it is able to scale; even with technological advancements, the logistics of production and shipping remain serious concerns. Chile's green hydrogen agenda, as this thesis will soon demonstrate, bets on the industry's ability to greatly reduce these price and shipping constraints in the short to medium term.

3. Methodology

3.1 Research Methods

This thesis is a case study of the Chilean Green Hydrogen Strategy and the industrial development emerging across the country as a result. I selected this case because it is a novel event in the history of the country for which little published literature exists, yet the themes it exposes resonate with many other cases around the world. Given the burgeoning interest in decarbonization in general and green hydrogen in particular, researchers have much to learn from the early stages of this industry's penetration of a rural periphery in the global South. Uncovering the story of hydrogen development in Chile, as the country and region undergo a period of political change, will illuminate under-reported political and economic dynamics of the transition to clean energy around the world.

To understand the events of this phenomenon, I undertook a critical policy analysis of Chile's Green Hydrogen Strategy and the industrial developments associated with it. 'Critical' policy analysis – as opposed to the traditional, technocratic approach to policy analysis – aims to “identify and uncover influences on policy content from dominant ideologies, discourses, or material forces” (Dryzek 2009). As such, I examine Chile's hydrogen policy in its context as a post-neoliberal Latin American state pursuing an agenda of green growth and development. The primary method I deployed in service of this goal is content analysis of documents related to the Chilean hydrogen industry. Between October 2022 and March 2023, I examined a range of documents including local media articles, corporate press releases, government reports, and of course the Green Hydrogen Strategy itself (see Appendix). Each of these documents was read, in full, at least once, with rereadings as necessary of sections that dealt explicitly

with green hydrogen. The Chilean media articles were published in Spanish, and all other documents were available in both Spanish and English.⁹ While the documents come from a variety of sources, together they form a corpus of evidence that allowed me to answer the research question I posed in the preceding section.¹⁰

I consider these documents as both sources of ‘facts on the ground’ and as rich sources of subtext and thematic context; they offer both text as such with factual information and hints to the self-conception of the various actors involved in the hydrogen industry. Since this is a newly unfolding phenomenon, empirical data is limited. I put these documents into conversation with the theories about scalability, green development, and the pink tide detailed above to interpret the potential impacts of these policy documents. In addition to that primary source of data, I triangulated my findings by conducting two informal interviews, one with a Chilean scholar of the political ecology of hydrogen (hereafter, Informant 1) and one with a former government official involved in the Boric Administration’s effort to revamp the hydrogen strategy (Informant 2). Both interviews were conducted in autumn 2023 during my work with Andreas Malm and Wim Carton’s negative emissions technologies research collective; by this time, I was confident that I would adapt the Chilean portion of my research for this thesis, so questions concerned both projects. The conversations each lasted about 45 minutes. These informants helped me clarify the facts on questions for which little

⁹ In cases where bilingual documents were available, I utilized the English version. Given that the authors of such documents represent institutions with significant budgets and an orientation towards foreign audiences, the quality of the translations is very high.

¹⁰ Though I am familiar with methods such as thematic analysis that apply rigorous coding to linguistic themes or tropes in the dataset, I elected to use a more flexible approach. Because my documents come from multiple sources and two different original languages, I do not feel that coding for the appearance of specific words, phrases or concepts would have been appropriate. Rather, I consider the standpoint of each document’s author(s) as useful context for the themes that they elucidate. Furthermore, I trust my own intuition to interpret the documents’ words.

published data was available, and ensured that my analysis was informed by events on the ground.

3.2 Limitations

Though this case study offered rewarding insights, it is necessarily limited by a few factors. Due to time and budget constraints, I was unable to visit Chile during the course of this study. Doing so would surely have yielded unexpected connections, more locally-based informants to interview, and a more holistic, sensory understanding of how the hydrogen projects fit into the landscape.¹¹ Researchers wishing to move beyond this preliminary analysis of the industry would benefit from a field visit, but for my part, as a fee-paying international master's student at Lund University - a position that requires me to complete this thesis within the confines of the Spring 2023 academic semester - this was not a realistic option. Highly Innovative Fuels, the only company with an actually existing hydrogen plant in the key region of Magallanes, declined to be interviewed or provide comment for this research. Given their disinterest, I was forced to glean their opinions from media coverage, press releases, and public promotional materials. Though an interview with HIF representatives would have been enlightening, I believe their published statements are an equal or stronger indicator of their positions on issues related to their business.

3.3 Positionality

As a final caveat to this research, I must specify that this thesis is the product of one individual with a perspective situated in his own positionality. As a

¹¹ It is worth noting that, since the hydrogen industry in Chile is mostly speculative at this point, especially in Magallanes, I suspected there might be little in the way of field sites to tour or organized local groups to connect with. Informant 1 concurred with this view, and advised me that a research trip would yield limited returns to my investment of time and money. This is likely to change in the coming years for future researchers.

young researcher from the United States, I do not have the same fluid understanding of Chile's domestic politics and its role in the global economy as a researcher based in that country. Though I have studied and lived in Latin America before, I am new to research on Chile in particular and am mindful of the analytical limitations imposed by my inexperience. There is a level of privilege that allows me, a white U.S. citizen (albeit one horrified by his country's neocolonial past and present in the region), to critique the political decisions made by a Latin American government. Part of my decision to situate Chile's hydrogen policy in its regional and global context emerges from my greater comfort with working from that international perspective; I will leave the detailed domestic analysis of Chile's political economy to researchers with more experience in the country. Even so, I hope that this research offers a useful introduction to a novel case of green development in one of the region's most important economies.

I make no claim to objectivity in these pages. I come to this project as an environmental activist who wants to see a just transition to green energy succeed, and is rooting for the Latin American left in its efforts to eliminate poverty and social inequality. My objective is not to tear down green hydrogen, renewable energy, or any other facet of the environmental policy agenda of a Global South country. Rather, I intend to inform the reader about potential conflicts and contradictions that, if left unchecked, could backfire upon the environmental movement and derail the urgent task of transitioning the energy system away from fossil fuels and extractivism. All this work is presented in the service of the overarching climate justice agenda; if at any point I fail to live up to that ambition, the responsibility is mine alone.

4. Findings & Analysis

4.1 National Policy

Under the government of Sebastian Piñera, starting in the late 2010s, the Chilean state established green hydrogen as a key plank in both its domestic energy transition and its global environmental leadership ambitions.¹² Three documents released in the final years of the Piñera administration – which are now in the hands of Boric’s new government – delineate the country’s goals. In 2021, the government and the World Bank collaborated on a report entitled *Green Growth Opportunities for the Decarbonization of Chile*, which framed hydrogen (and the country’s full net zero plan) as an opportunity for sustainable economic growth and value creation alongside climate mitigation. In the same year, the government released the newest version of its *Informe Planificación Energética de Largo Plazo* (Long-term Energy Planning Report, or PELP by its Spanish initials), which establishes green hydrogen as one of Chile’s primary methods of decarbonization. Finally, the Green Hydrogen Strategy itself (released in 2020, making it temporally first but analytically most granular and significant) outlines the full agenda to make green hydrogen the lynchpin of both decarbonization and economic development through a cross-sectoral approach that will cement Chile’s existing energy transition industry while establishing a robust export sector.

World Bank: Green Growth Opportunities for the Decarbonization of Chile

Chile’s environmental agenda is not only about decarbonizing the economy; rather, the country sees an imperative to decarbonize in a way that drives long-term economic growth and development. To promote this prospect,

¹² Piñera served two nonconsecutive terms as President of Chile, first from 2010-2014 and again from 2018-2022. This statement applies to his second term in office.

Piñera's Finance Ministry collaborated with the World Bank to produce a report entitled *Green Growth Opportunities for the Decarbonization of Chile* in 2020. The Bank's researchers used macroeconomic models to assess the impact that Chile's plans to achieve net zero carbon emissions by 2050 could have on the country's GDP. They conclude that the net zero plans will stimulate foreign investment and domestic consumption alike, resulting in an economy 4.4% larger than the business-as-usual scenario in 2050 – or an additional 0.13% of GDP growth annually (Antosiewicz et al 2020). The authors are careful to specify that their simulation was built before the 2019 social unrest and the 2020 pandemic lockdowns, so these numbers are not to be taken as sacrosanct. Even so, the potential for net zero to drive new economic activity is clear, and the report also leaves us with a warning. If implementation of Chile's climate strategy is further delayed, then the overarching goal of net zero by 2050 is not guaranteed – and by implication, the plan's economic gains are jeopardized as well (Ibid). To assure these benefits, Chile must act quickly to tread down the path towards (net) zero emissions.

Green hydrogen will play a significant role in Chile's net zero transition and the associated profits to the country's business sector. The report notes that Chile expects hydrogen to account for 21% of its carbon emissions reductions in its Nationally Determined Contribution to the Paris Agreement. With the upscaling of hydrogen, emissions can be cut and industrial production can continue to increase; freight transportation, manufacturing, and mining are identified as sectors that will transition to green hydrogen as a fuel or industrial feedstock. The total net value of the hydrogen industry by 2050 is estimated at US\$9.6 billion (Ibid, 14). This emphasis on productivity decoupled from carbon emissions is emblematic of the green capitalist approach, complete with the assertion that the transition to a sustainable economy will maintain, or even

increase, profits (Buller 2022). This report makes the underlying assumptions of the Chilean state clear. First, the net zero transition will entail the creation of new industries linked to lucrative international markets. Second, the economic potential of these industries requires the state to act rapidly.

2021 Long-term energy plan (PELP)

Chile establishes its energy policy agenda through a recurring process called “Long-term Energy Planning” (by its Spanish initials: *PELP*, for *Planificación Energética de Largo Plazo*). The Ministry of Energy, which leads this process, is bound by law to conduct several rounds of public consultation before the strategy can be ratified; the most recent report, presented to the public in 2021, projects Chile’s energy policy and demand from 2023-2027, and envisions a significant role for green hydrogen (Ministry of Energy 2021).¹³ Though domestic applications are far from the only motivations for green hydrogen development in the country, understanding the state’s vision for the domestic energy system sets important context.

The 2023-2027 *PELP* report envisions three scenarios of energy development. The first will be realized in the event that Covid-19 continues to act as a drag on Chile’s economic growth. In this scenario, emissions reductions are limited by a moribund economy. In the second scenario, the country’s economy is more dynamic, enabling it to meet its objective of carbon neutrality by 2050. For this to be realized, the *PELP* report sees extensive use of green hydrogen and electromobility in concert with each other. A third, more optimistic scenario

¹³ Since this report has been presented to the public for consultation in accordance with Chilean law, it may be changed before the final 2023-2027 energy strategy can be ratified. The consultation process extends through August 2023, so the final report will not be ready in time for the publication of this thesis.

posits what might happen if Chile is able to accelerate its energy transition; this would require “widespread development” of green hydrogen for domestic use and export, including grid-connected hydrogen power plants and synthetic e-fuels.

Two valuable insights emerge from these scenarios: first, Chile is depending on green hydrogen as a source of “indirect electrification” of hard-to-electrify industries that will be essential to meeting its climate goals (Ibid, 11). Second, all these scenarios posit that economic growth and the energy transition (or, to use the report’s own terminology, the “technological transformation”) are linked in a virtually linear fashion. The low-growth scenario delays the energy transition, the medium-growth scenario enables Chile to meet its carbon neutrality goal in 2050, and high growth would unlock an accelerated path to sustainability. This is a revealing insight into the state’s green developmentalist framework – economic growth is both a necessary condition and a desirable consequence of the energy transition.

Following this exploration of future scenarios for Chile’s energy transition, the PELP report prognosticates on the future level and composition of energy demand nationwide. In this section, the Ministry of Energy predicts that electrolysis to produce hydrogen for the domestic market only (this is a critical distinction) will account for 19-43% of the total electrical demand in the country by 2050 (Ibid, 88). That figure may appear to be high, but it is in fact a massive underestimate of the industry’s potential electrical consumption. This is because – despite hydrogen’s importance to Chile’s decarbonization plans – the industry’s ambitions extend far beyond domestic use. Many of the Ministry’s projections of energy demand exclude Magallanes and other far southern regions entirely, potentially reflecting uncertainty about the number of new energy projects that could enter development in the coming years. The following section will explore

all facets of Chile's hydrogen strategy, including its links to powerful industries and its role in the export market.

National Green Hydrogen strategy

In the context of Chile's extant energy policy and green growth agendas, the Green Hydrogen Strategy itself lays out the full scope of the country's planned hydrogen economy. For the Chilean state, hydrogen is far more than a means for local decarbonization or even a source of foreign investment. The report's subtitle immediately makes it plain: Chile intends to be nothing less than "a clean energy provider for a carbon neutral planet." In the report's introductory letter, former energy minister Juan Carlos Jobet contextualizes this against Chile's small size; despite the country's diminutive contribution to global emissions, he says, "we too have an outsized role to play in turning the tide on emissions and pursuing a low carbon path to growth and development" (Ministry of Energy 2020, 2). Given its remote location and lack of fossil fuel reserves, Chile has been dependent on foreign energy sources since the republic's foundation. Now, though, green hydrogen will give the country an opportunity to become a green energy exporter (Ibid). An advisory board of public and private sector leaders concurs, adding that this export orientation will rebrand the country as an environmental leader: "this opportunity can have a great impact on our country's brand, adding a green value to the products created in Chile" (Ibid, 3). These fawning missives from national leaders set the stage for the ambitious policy pronouncements that will follow, establishing with utmost clarity the potential of hydrogen to link emissions mitigation and financial profit.

An investor or international policymaker reading this strategic document may be tempted to ask: why Chile? Why build out this industry in a country

located so far from the planet's productive centers? The Ministry of Energy makes a compelling case. Chile, per an analysis by their McKinsey & Co. coauthors, has a massive 1,800 gigawatts of untapped renewable energy potential, more than 70 times the country's currently installed capacity (Ibid, 10). Moreover, the costs of this energy are already low and decreasing by the year. Solar PV in Antofagasta, home to the driest non-polar desert on Earth, can reach a capacity factor of 35% under optimal conditions. On the country's other geographic extreme, onshore wind turbines in Magallanes can reach an exceptional 60% capacity factor; in the rest of the world, this level of efficiency is only possible using much more expensive offshore wind farms (Ibid.). This massive renewable energy potential offers immense opportunity to the people of Chile, but the rest of the world stands to benefit from one opportunity in particular: the world's cheapest green hydrogen. By 2030, Chile projects an average Levelized Cost of Green Hydrogen (LCoH) of US\$1.30 per kilogram, the lowest on Earth and fully half the cost of producing green hydrogen within the EU. By 2050, the country could push this figure to \$1/kg or lower (Ibid, 11). This would be a massive economic boon that would obviate many of the existing obstacles to scale faced by the green hydrogen industry. Below that astonishing number, a footnote makes an important disclaimer: "does not consider compression, transport, and distribution costs" (Ibid). But if these figures are even close to true, that portends enormous potential for this industry to grow in the coming decades.

With ample wind and sun ripe for the taking, the state sees green hydrogen as the wellspring of a "new productive identity" for Chile – if the country acts fast. If combined with public-private coordination and dedicated investment, 300 GW of cheap renewables – a mere fraction of what McKinsey says the country can build – could power a hydrogen industry with a growth rate of 15% per year through 2050. This will yield a total market of US\$33 billion, of which \$24

billion is destined for export (Ibid, 12). This industry would create more than 100,000 manufacturing jobs and make a significant contribution to Chile's net zero plans. However, victory is not assured. A first mover advantage, says the report, is key to capturing these gains. A delay in implementing the strategy "would forfeit significant opportunity capture" to rival states; the country will need to acquire capital investments by locking in large-scale investment contracts as soon as possible (Ibid, 16). The strategy envisions three waves of development. From 2020-2025, domestic production will ramp up in preparation for the export market; government assistance will help the industry reach financial breakeven points early. From 2025-2030, the industry will expand into export markets, starting with a relatively safe bet on green ammonia for fertilizers. After 2030, Chile will be producing 25 GW of electrolysis capacity for green hydrogen each year, positioning the country to "exploit synergies and economies of scale" to become a world-leading supplier (Ibid 17-19). If the country is willing to capitalize on its natural advantages, the report says, a path to sustainable growth, decarbonization, and profit will be unlocked from the present day through mid-century.

If the bureaucrats and McKinsey consultants drafting Chile's Green Hydrogen Strategy looked out their office windows while drafting their calculations, they could not have missed the epochal scenes unfolding on the streets below. Starting in October 2019, the country was roiled by the largest protests since the end of the Pinochet dictatorship. Sparked by a modest increase in Santiago's metro fare, the demonstrations metastasized into an excoriation of President Sebastián Piñera's neoliberal regime and calls to abolish the republic's Pinochet-era constitution (Larsson 2019). Chile elected a left-wing constitutional assembly with a high degree of representation from women, Indigenous peoples, and activist groups, who presented a much more progressive constitution to the

electorate. Meanwhile, the tarnished reputation of the Chilean right drove Gabriel Boric, a long-term left activist and congressman from Magallanes, to victory in the 2021 Presidential election. Though the constitutional referendum later failed, Boric remains in power and is determined to enact his agenda.

The National Green Hydrogen Strategy sets up a dilemma for Chile's democratic process. After Piñera's downfall, Boric's government has inherited this policy alongside a mandate to reverse the neoliberal consensus embodied by his predecessors. The political upheaval of those years challenged conventional wisdom in all corners of Chilean politics, and the hydrogen strategy was not immune to this reexamination of the status quo. The Strategy document stipulates that it should be updated every three years, and Boric's government is taking the opportunity to smooth down some of the rough edges it inherited from its neoliberal predecessor. In 2021, a joint council of 11 ministries is already revising the strategy. According to Informant 2, who sat on this council, a consensus has emerged among government decision-makers that Piñera and McKinsey were "too soft on sustainability" and laser-focused on carbon emissions at the expense of local ecological impacts. To avoid the impression that the hydrogen strategy is a neoliberal program imposed upon the southern fjords and northern deserts by Santiago bureaucrats, the new government is endorsing stricter environmental, social, and governance standards, including increased participation from local communities. Although the consultations are ongoing and updated documents are not yet available, the underlying strategy is unlikely to change. Chile will still leverage a massive upscaling of green hydrogen to position itself as a leader in the green economy. These reforms, the new government may hope, should be enough to blunt any emerging political confrontation.

4.2 Illustrative Case: Highly Innovative Fuels in Magallanes

The documents reviewed in the above section lay out how the Chilean state imagines that its green hydrogen agenda will unfold. In keeping with the government's stated agenda of urgent and expeditious industrial buildout, there are already half a dozen pilot projects in development across the country, largely in the peripheral regions of Antofagasta and Magallanes (Chilean Hydrogen Association 2023). This section will analyze one of the most advanced pilots, a scheme to export hydrogen fuels for personal automobiles from Magallanes. Placing this project in its socio-ecological context offers numerous insights about the translation of green hydrogen from page to practice.

Chilean Patagonia looks like an unlikely place for an unprecedented industrial buildout. This region lies far beyond the Amazonian rainforests that draw most of the global climate movement's attention. The Pan-American highway dead-ends above a fjord in Puerto Montt, a thousand kilometers south of Chile's bustling capital, Santiago. For centuries, that was where empire ended in South America. Southern campaigns by the Inca, the Spanish, and the Republic of Chile all floundered due to fierce resistance from both Indigenous nations and the geography itself. In 1976, the Pinochet dictatorship began its project to tame the interminable frontier by constructing a two-lane road through another 1,200 kilometers of rugged coasts, thick forests, and towering glacial peaks to the hamlet of Villa O'Higgins. When it was completed in the year 2000, most of the region was accessible to state power for the first time. With Patagonia incorporated into the Chilean state project, a new era of history (and resistance) began (Silva 2016).

Far from even the reaches of the southern highway, empire had already established one outpost in Patagonia. The Magallanes region (named after Ferdinand Magellan, who 'discovered' the territory during his circumnavigation

of the Earth) lies at the far end of the world, where the Andes sink into the sea – only Antarctica lies beyond. After a few disastrous Spanish colonial ventures, Chile established the settlement of Punta Arenas in the 19th Century. From that spot, a small city flourished and served as an outpost to assert Chilean sovereignty in the south. Settler colonists from Chile and Europe submitted the land to ranching, in the process committing one of history’s most total genocides, driving all Indigenous nations in the area to the brink of extinction (Gigoux 2020). Since then, land in Magallanes has been under the near total control of a small coterie of private landowners. It is here where Chile intends to save the world from fossil fuels.

Highly Innovative Fuels is eager to profess their love for Magallanes. In a video available on their website, the Santiago- and Houston-based hydrogen fuels company extols the landscape and its people over a montage of soaring music and starkly beautiful vistas. Why? The wind. It “blows constantly, tirelessly;” a wind that they claim they can harness to “decarbonize the planet.” Then, a luxury SUV appears, sporting EU plates. The text says: “Finally, a solution to global warming.” A clip of the company’s logo over a wind turbine closes out the advertisement (HIF 2021). But HIF is not a wind power company, not exactly. After all, the meager population of Magallanes could hardly consume the energy from such relentless austral winds. Their product: net-zero hydrocarbon fuels, synthesized by carbon capture.

A glossy graphic on HIF’s website explains the process. A Direct Air Capture plant draws anthropogenic carbon dioxide from the atmosphere. The facility then applies an electric current – courtesy of those prolific wind turbines – to water from a local source, extracting the hydrogen molecules. Hydrogen and carbon molecules secured, HIF can now synthesize a hydrocarbon fuel chemically identical to automobile gasoline, jet fuel, or any industrial compound the heart

desires. These can then be burned by the end user; the carbon they store will be emitted back into the atmosphere, and some may even disperse back to Magallanes to be captured again (HIF 2022). No need for people to give up their gas and diesel cars – fossil fuels are now fossil-free, with (net) zero emissions.

The boundless potential of the landscape and the country's dedication to the green hydrogen industry would imply that HIF has found itself in a favorable political environment. In a national sense, that is true. The company also boasts more than US\$260 million in capital raised from international investors including the Italian utility company ENAP, Siemens, and Porsche, the latter of which has already agreed to purchase its "eFuels" (HIF 2020; HIF 2022b). A small demonstration plant, named Haru Oni, is already up and running a few kilometers outside Punta Arenas. The company is already expanding operations, with new hydrogen plants slated for construction in Texas, Australia, and Japan. Despite these lofty ambitions and the success of its pilot project, in October 2022 HIF withdrew the environmental permit application for its flagship "Faro del Sur" plant in Magallanes. Citing "exceptional requirements" from government agencies that "exceed the usual standard" for information, HIF intimated that political issues may not enable the project to go forward (HIF 2022c). This short press release on the company's website portends a complicated future for green hydrogen in Chile.

Deeper scrutiny of the project indicates more fundamental shortcomings with this "solution to global warming." A study by the Center for Social and Environmental Analysis indicates that, if the Chilean state were to produce the 25 GW of green hydrogen implicated by the national strategy, the country would have to double its renewable energy output by 2030. This massive upscaling would also demand significant amounts of water, minerals, and land (CASA 2022). Communities across the country, especially in the hydrogen "poles" of

Magallanes and Antofagasta are beginning to question whether this material burden is justified to produce a commodity whose primary purposes are export to the Global North and the intensification of mining in rural areas. In 2022, a group of more than 80 scientists, environmental activists, and community members addressed an open letter to President Boric expressing “profound concern” with the implementation of the hydrogen strategy in Magallanes. Boric’s stated ambition for his home region¹⁴ to produce 13% of the world’s green hydrogen supply would imply the construction of 126 GW of wind power capacity, implicating 13,000 square kilometers of previously unspoiled land (Saavedra et al 2022). The letter stops short of opposing hydrogen development outright, but criticizes the government’s imposition of the strategy upon the citizenry with limited public consultation; this may not violate the letter of the law, but certainly contravenes the spirit of Chile’s long-term energy planning guidelines. Given the significant socio-ecological impacts bearing down on Magallanes, the petitioners demanded that hydrogen development should be conducted only after a “regional participatory process” in which local communities and Indigenous Peoples can “define the scale and placement” of such infrastructure (Saavedra et al 2022).

Alongside local objections, state capacity to enforce environmental rules is lacking in Magallanes; what HIF termed “exceptional requirements” might be corporate-speak for an exceptional lack of data and staff in this remote corner of the world. The electrolysis plants may have detrimental impacts on ecological elements including water supplies and migratory bird populations, but not enough is known to make a determination. The aforementioned government official indicated that the Boric administration is conducting studies targeted at the

¹⁴ Boric’s close connection to Magallanes is notable. The President formerly represented his hometown of Punta Arenas in the Chamber of Deputies, and his great-grandfather was one of the first arrivals of what became a significant Croatian settler community in the area (Gonzalez & Riquelme 2021).

problem (results for these studies will not be available until after the publication date of this thesis). The remoteness also poses logistical challenges for those wishing to realize the government's vision of a hydrogen utopia at the edge of the world. Informant 1 highlighted the fact that the Magallanes region only has one port, which remains in the hands of the oil company ENAP; though HIF would be loath to admit it, they had no cost-effective way to even import the 65 wind turbines required to power the Faro del Sur project, environmental approval notwithstanding. Consider the multifarious transformations required to bring hydrogen to Magallanes: a once-remote frontier pockmarked with new ports and factories, a state unable to intervene, and a small country using the vast majority of its electricity production to make fuels for export.

For now, then, the massive hydrogen upscaling foretold by the Chilean government may be a fantasy. But the hydrogen fad is already having real, material effects on Magallanes and the world that sits above it. Informant 1, when interviewed, named a winner that will be familiar to students of green capitalist fads around the world: real estate speculators. Since the early colonization of Magallanes, nearly all the region's land has been in the hands of a few powerful landowners. Previously, the industrial applications of this land were limited to sheep grazing and a smattering of ecotourism, but the hydrogen strategy and the HIF pilot project have driven up the value of rural land. For the already-rich, profit may come before results.

Here, one might recall Tsing's notion of "spectacular accumulation." Such terminology grows more relevant by the hour amidst the neoliberal takeover of the green transition – in both senses of the word "spectacular." Startups deploy media spectacle to promote their technological solutions, while speculation strikes the territories targeted for the intervention. Previously marginal land skyrockets in value, enriching the landowning class while the rest of the population wonders if

jobs in the hydrogen facilities will ever emerge. So it may be as investors plot their hydrogen boom at the edge of the world.

Unlike Tsing's mythical mother lode of Kalimantan, green hydrogen is not a scam. The technology works. In a way, however, that is precisely the problem. What truly moves the world is not the occasional brazen fraud, but the plausible-enough techno-fix that can mobilize serious resources despite a deficient political-economic justification. To summarize Chile's proposal once more: massive industrial infrastructure will be erected in remote areas of Patagonia and the Atacama Desert in order to power a world-historical carbon removal operation. The carbon they capture will, through a herculean array of hydrogen electrolyzers installed on site, be combined with water to form hydrocarbon fuels. In the Atacama they will power Chile's enormous mines; in Patagonia, new ports will also be built to ship the hydrogen (on purpose-built ocean tankers) to Europe to power German cars. Is this technically possible? Yes. But those concerned with the climate emergency should consider the alternatives. If it is possible to capture massive amounts of carbon from the air in Chile's hinterlands, perhaps those plants should be used to actually sequester carbon. After all, transportation can be decarbonized by other means – electric cars, reinvesting in railways, etc – and does not depend on the indirect electrification potential of green hydrogen. While there will certainly be some legitimate demand for green hydrogen by certain industries, personal transportation is not one of them. The central, urgent, and immediate demand of those who take the climate crisis seriously is to stop, and even reverse, global warming by relying on proven technologies to decarbonize the economy. If a company is to expend the resources to construct carbon capture plants at such a remote edge of the world, a rational choice might be to utilize that

infrastructure to remove carbon from the atmosphere entirely.¹⁵ Capital's need for profit demands that carbon instead be turned into a commodity – a commodity that will be returned to the air once the Porsche runs out of gas.

4.3 A Future for Green Hydrogen? Industrial appropriation and expansion across the country

Highly Innovative Fuels may be the most advanced green hydrogen pilot in Chile (notwithstanding its political barriers to scale), but it is not the only one. Most development, of course, is taking place in Magallanes and Antofagasta, the peripheral regions identified in the Strategy as hydrogen “poles.” However, the speed and scale of development the state is calling for imply that the industry will spread out from these far reaches into the populated center of the country. This is where the social and environmental implications will be most significant, but also where data is most opaque. This final section will assess the manner and purpose with which hydrogen is being deployed across Chile, bridging the actually-existing pilot projects and the imagined hydrogen future. Such an endeavor risks blurring the distinction between reasonable interpretation of the (limited) data available and wild speculation about roughly-sketched futures. Still, a review of industry publications, hydrogen trade websites, and media articles further

¹⁵ Whether, and how, carbon removal technologies can be used to advance climate justice is a vital question for the climate movement, a question with which this research intersects, but lacks the scope to engage directly. Recommended readings on this topic include: Buck (2021), “Mining the air: Political ecologies of the circular carbon economy;” Carton, Asiyani, Beck et. al. (2020), “Negative emissions and the long history of carbon removal;” Malm & Carton (2021), “Seize the means of carbon removal: The political economy of direct air capture;” and Markusson, McLaren, & Tyfield (2018), “Towards a cultural political economy of mitigation deterrence by negative emissions technologies (NETs).”

demonstrates the extent of the link between hydrogen and Chile's full green development agenda.

This analysis must first turn to one of the most technically and economically credible use cases of green hydrogen in Chile: as fuel for the country's booming mining industry. Chile is a world leader in mineral extraction, especially for minerals key to the electromobility transition such as copper and lithium (International Trade Administration 2022). Demand for such minerals, already high, is expected to skyrocket as industrialized countries build more electric cars, batteries, and renewable energy plants (IEA 2020).¹⁶ This translates into immense pressure on the commodities frontier in the Atacama Desert, and immense profits for the mining sector. Copper and lithium mining are already held up by the Green Hydrogen Strategy itself as the standard of profitability against which the hydrogen industry should be measured (Ministry of Energy, 12). Though the text mentions that green hydrogen could be a "rival" to the mining industry in size, the state in reality views the two industries as complementary exemplars of Chile's green capitalist bona fides.

Green hydrogen will enable Chile's mining industry to increase its profit margins and secure a green branding opportunity simultaneously. Across the desert of Antofagasta, massive pits bearing copper and other minerals bore into the Earth, often powered by solar arrays soaking in the relentless year-round sun. Because these power plants are located so far from population centers, and – as previously mentioned – generate electricity with exceptional efficiency, the mines

¹⁶ On this issue, all researchers in climate-related fields are obligated to be clear: the material extraction footprint of fossil fuels and traditional heavy industry dwarfs that of the minerals needed for the energy transition (Transport and Environment 2021). However, Chile, with its paucity of fossil fuel reserves and its richness in minerals such as copper and lithium, may yet experience this transition as a ratcheting up of extractive pressure. This may not be the case across most of the world, but it still merits discussion on its own terms.

often receive more energy than they can use; selling back to the grid is likewise unrealistic with few other consumers of energy in these remote desert highlands. Rather than letting it dissipate, mining conglomerates are planning to use the excess energy on hand to power hydrogen electrolyzers, deriving a second profitable commodity from their capital. To be sure, there are technical challenges to this approach, but these pale in comparison to the political confrontations over renewable energy expansion in the south. Making this doubly useful, there are also opportunities to use hydrogen fuels onsite. Anglo American's investments in hydrogen-powered mining haul trucks – such a prototype has already been tested at the company's South African properties – would allow mines to slash their carbon footprint and their fuel expenses at once (Anglo American 2022). This potential is recognized in the Green Hydrogen Strategy, which foresees a US\$1.6 billion market for such vehicles within Chile by 2050 (Ministry of Energy, 17). Far from being a revolutionary substance, hydrogen will place a green sheen over Chile's most entrenched extractive industry.

This interconnection between green hydrogen and other industries – especially mining – reveals the larger utility of hydrogen to the Chilean economy. In light of the hydrogen-mining nexus, the introductory letter to the National Strategy, with its ambition to leverage hydrogen to “add a green value” to Chilean products, especially copper, must be revisited. Not only is hydrogen itself a valuable commodity, but it will decarbonize other strategic sectors in order to brand them as green. There is one critical weakness in this strategy: carbon emissions are far from the only ecological damage linked to mining in Chile. The copper and lithium mining industries have been connected to a litany of local environmental crises that have led many scholars to label northern Chile as a sacrifice zone (Castán & Salzana 2020, Valenzuela Pérez 2016). The previous subsection of this thesis raised the potential for green hydrogen to transform the

landscape of Magallanes in the service of industry; Antofagasta, the other major hydrogen pole in Chile, has already been made subservient to the interests of capital. To ensure the availability of the hydrogen market outlined in the National Strategy, mining must continue, and even expand. The zone must be sacrificed for decades to come.¹⁷

In *Planetary Mine* (2020), Martín Arboleda goes beyond the designation of ‘sacrifice zone’ to articulate the exact form of territorial transformation wrought by mining in northern Chile. This part of the world has borne the brunt of what Arboleda calls the “logistics turn” in the extractive industries, in which the swift movement of commodities from the point of extraction to market is seen as integral to the business model, an obligation that trumps all other uses of the territory and constructs the landscape as little more than a conduit for extraction. This spatial reorganization is centralized by the state and the private sector, making it impervious to local democratic control and setting off a wave of automatization that has polluted and impoverished local communities (Ibid). Despite these developments, the extractive industries’ status as an economic lifeline for many rural populations has also created a significant pro-mining constituency in these areas. Notably, mining and smelting communities rejected Chile’s proposed left-wing constitution by a larger margin than the national average out of fears that this new order would not secure prosperity for workers (Vergara 2022). The use of green hydrogen to facilitate the expansion of mining

¹⁷ On April 20, 2023 – after the research that undergirds this thesis was concluded – President Boric announced his intention to nationalize Chile’s lithium industry. If his plan is implemented, existing lithium mines will be transferred to public ownership starting in 2030 and future mining contracts will only be considered under public-private partnership. This plan is subject to approval from Congress, so it remains to be seen if, and how, it will be implemented (Villegas and Scheyder, 2023). This will be an important sequence of events to watch for observers of Chile’s lithium sector, with potential implications for the green hydrogen industry as well.

will likely serve to deepen the existing contradictions in the region rather than fundamentally change the socio-ecological dynamics of mining in northern Chile.

In the green transition writ large, there is a massive opportunity to reduce the primacy of extractivism in the global economy. Despite the criticisms of lithium mining articulated above, it must be emphasized that the life-cycle raw materials usage of electric cars is far lower than that of their oil-powered counterparts, even under business-as-usual scenarios (Transport and Environment 2021). Despite the clear ecological and material benefits of switching from gas to electric cars, the transition could go further by reimagining mobility to further reduce the economy's reliance on primary commodities. A coalition of researchers has found that the world could reduce lithium demand by 92% against baseline 2050 estimates if the green transition were to emphasize smaller electric vehicles, public transportation, and e-bikes (Riofrancos et al 2023). This has significant implications for the Chilean green hydrogen industry because, if lithium demand were to crater, a key driver of demand for hydrogen would fade away with it. This creates a scenario in which the most ecologically and socially sustainable pathway – a reduced reliance on extractive industry – is at odds with the profitability of two core “green” industries.

Mining, despite its strategic significance to the industry, is far from the only use case for green hydrogen in Chile. Recalling the strategy document, most of the others – e-fuels, fertilizers, industrial feedstocks, etc. – have a firm export orientation. Yet, the other government documents analyzed above pitch green hydrogen as critical to Chile's domestic decarbonization efforts. This implies a disconnect between the political justification for green hydrogen being pitched to the Chilean public and the economic rationale being pitched to investors. Some scholars have noted that many of the uses for green hydrogen envisioned as part of Chile's net zero plan are undefined or even illegal under Chilean law. Attempts

to reform these codes have thus far stalled in Congress (Cabaña Alvear & Paz Adeo 2021). Meanwhile, the vast majority of renewable energy plants established for green hydrogen production will not be connected to the country's electrical grid, operating exclusively for the production of a commodity that will, in most cases, be pumped directly into the new network of pipelines and ports that will take it abroad (Ibid.).

The two poles of the National Green Hydrogen Strategy face interlinked but distinct futures under the implementation of Chile's hydrogen economy. Where Magallanes may be transformed from 'pristine' nature to industrial landscape by a few major landowners and investors, Antofagasta will see the existing fractures wrought by mining driven deeper into the Earth. However, green hydrogen will not stop at the fringes of the country. The National Strategy also contains projections for hydrogen production and utilization in the populated center of Chile, where industry coalitions are already mobilizing to install capacity. One notable case is the south-central region of Biobío. A coalition composed of the regional and national governments, a local university, and industry associations has already begun promoting the region as another hub for green hydrogen in Chile. Alongside significant solar energy potential, the Biobío Green Hydrogen Alliance touts the region's advanced port infrastructure that could be retrofitted to export hydrogen, serving as a hub linking the entire country to export markets (Biobío Green Hydrogen Alliance, 2023). If this industry is to come within reach of the government's projections, expansions beyond Magallanes and Antofagasta into Biobío and other central regions will be a necessity.

As the network of renewable energy facilities, plants, pipelines, and ports demanded by the hydrogen industry snakes across the country, new territories will be entangled within this web of infrastructure. Biobío is not only the core of

Chile's petrochemical industry, but also the heartland of the Indigenous Mapuche people. The Mapuche's centuries-long struggle against Spanish and Chilean colonialism has intensified since the beginning of the Pinochet dictatorship, when neoliberal reforms that devolved collective land rights to individual Mapuche landowners, kicking off a wave of extractive development that has been staunchly resisted by Mapuche into the present day. The return of democracy has in no way ended the conflict; on the contrary, Biobío remains the center of Indigenous resistance to state- and corporate-led development in Chile (Azócar et al 2005; Bidegain 2017). This fact distinguishes Biobío from Antofagasta, where the territory has been subsumed to the interests of capital, and also from Magallanes, where Indigenous Peoples were virtually exterminated during the aforementioned series of 19th-century colonial genocides (Gigoux 2020).

These poles of development at the extreme ends of Chile are where green hydrogen is beginning to take root; though the industry is locally controversial, it does not yet face a concerted anti-extractive movement of the kind led by Indigenous Peoples across South America. When hydrogen creeps into the Biobío, it is likely that the Mapuche will be facing a more established accumulative entity than the small-scale pilot projects under present consideration. Certainly, this case exemplifies Anna Tsing's assertion that scaling up links capitalist projects with new sets of relations that challenge their form (Tsing 2012). It remains to be seen whether this industry will triumph in its ambitions to transform the economic, political, and physical landscape across Chile. While it is incumbent upon scholars to avoid straying too far into speculation, these early moves by the hydrogen industry and resistance to it in less populated areas like Magallanes may presage a much larger conflict in the center of the country.

A Note on Futures

One of the great challenges of research on contemporary subjects is that, after the research has been completed and the paper has been written, the world moves on. On May 7, 2023, Chile held elections to select the membership of its next constitutional committee, who will attempt once again to rewrite the constitution of the republic and submit its draft to a national plebiscite this December. The right wing dominated the election. A far-right, pro-Pinochet coalition convened by Antonio Kast, Boric's rival in the 2021 election, won the most votes by far. Alongside traditionally conservative members, this will give Chile's right wing a veto-proof majority of delegates on the constitutional council. The aftershocks of this "earthquake in Chilean politics," as one Chilean journalist puts it, may well reverberate for decades as the country is forced to choose between a Pinochet-era constitution and a new one drafted by Pinochet's supporters (Montes 2023). Amidst flagging approval ratings for Boric and voters' decisive turn to the right, one might wonder if the new pink tide in Chile has already receded.

This development, in the final days of the writing process of this thesis, casts these research findings in a new light. Boric's attempt to remake Chile may be remembered not as a vanguard of the new Latin American left, but rather as an abortive experiment in social democracy that succumbed to reactionary forces after just two years. Such electoral whiplash recalls a claim I made in the preceding pages – that the neoliberal state, in Chile and elsewhere, displays remarkable continuity against political mobilizations from both the left and right. In the arena of Chile's National Green Hydrogen Strategy, then, electoral results may not change the overall trajectory of the green hydrogen industry in the region. The findings from this thesis, as a study in how a left government may approach the deployment of a novel green technology, remain instructive, even if

that very government's dreams do not come to pass. The far right's victory (for now) in Chile does demonstrate, however, that alternative futures are always on the horizon. The best one can do is to present the facts as one sees them, to better prepare those who intervene to bring a liberated future to fruition.

5. Conclusion

In recent years, green hydrogen has become a core component of the Chilean state's ambition to be a leader in the global green development agenda and a key supplier of material for the transition from fossil fuels to electromobility. As an engine of "indirect electrification" and a potentially profitable commodity market, green hydrogen has been exalted as a method to link ecological sustainability with economic growth. There is much to laud about Chile's National Green Hydrogen Strategy; if implemented, it would decarbonize key industrial sectors and create stable employment for thousands. Another mark on which to commend Chile: their strategy focuses on *green* hydrogen above all, avoiding the compromises with fossil capital and the reliance on CCS technology implied by blue, gray, or other colors on the hydrogen rainbow. However, the full-throated pursuit of a profit-generating green hydrogen market obscures alternatives that could achieve those same impacts, and others, with better socio-ecological outcomes. As the green hydrogen agenda in Chile moves from infancy to adolescence, there are three potential flash points to watch: the linkages to green development (and therefore a profit-oriented economy), the interplay between the hydrogen industry and the progressive state, and the industry's reliance on rapid scaling to achieve its goals.

The first contradiction of green hydrogen is the question of its underlying motivation. Does this industrial program exist to decarbonize the economy or to generate profit? Hydrogen's boosters would answer in the affirmative to both. In the National Strategy and the World Bank report alike, hydrogen is explicitly marketed as a pathway for green growth; the Strategy elaborates that this growth will ripple beyond the hydrogen industry itself as the industry creates a green halo around the entire Chilean industrial sector. One of the most important findings of this research is the close synergy the state envisions between green hydrogen and

mining. Hydrogen will be a profitable means of decarbonization for the mining industry, which will only deepen the existing controversies and contradictions wrought by one of Chile's flagship industries. By aggressively moving to create a favorable regulatory environment for green hydrogen, the Chilean state hopes to generate additional surplus value for the economy while establishing itself as an indispensable partner in the specific type of environmental transition envisioned by the established order: a transition driven by corporate innovation, decarbonized industrial growth, and green development. This recalls the notion of ecologically unequal exchange with novel, 21st-century characteristics. Green hydrogen will help the world economy, especially the Global North, decarbonize. Ecological impacts will be made invisible by their concentration in a peripheral region of a peripheral country. Or, in Hornborg's parlance: the North's environmental load will be displaced. The result: a carbon-free, global, industrial economy that stands astride a set of utterly transformed local landscapes.

The second contradiction emerges when one considers the agency of those who call the aforementioned local landscapes home. Green hydrogen is an important test for the leftist administration of Gabriel Boric. As Boric and the other leaders of Latin America's new pink tide inherit the neoliberal policies of their predecessors, they must make a choice that has bedeviled progressive governments for decades: what does democracy mean in a leftist state? Communities across Chile, especially in Boric's home region of Magallanes, have criticized the technocratic and centralized manner in which Santiago developed the hydrogen strategy. Advocates demand more consideration of local environmental impacts and community participation in project development; while they are not resisting hydrogen itself, they are in staunch opposition to the industry-first approach taken by previous administrations. In the first pink tide, leftist governments saw Indigenous and environmental movements turn on them

for their embrace of the oil and mining industries. Those leaders doubled down on a path of resource nationalism that subsumed local communities into a national unit and throttled the potential for systemic change. Boric faces a similar dilemma in contemporary Chile, with oil and gold replaced by renewable energy and lithium. It is, fundamentally, a question not of ecology but of democracy. The new government has initiated reforms to the hydrogen strategy that will tackle these issues, but their text has not yet been published. As such, it remains to be seen how successful Boric will be in his endeavor to create a progressive state that responds to these demands for local sovereignty.

When those two demands – green development from above, local governance from below – come together, the third contradiction of Chile’s green hydrogen strategy emerges. The National Strategy both assumes and demands that the hydrogen industry will grow at an unprecedented scale. This pursuit of scale abuts unresolved issues such as cost, unsuitable infrastructure, and the political controversies of the sort that are already brewing in Magallanes. In drafting this strategy, the state made an ontological assumption that a project that works at a pilot site can grow to national abundance without fundamental challenges to the industry’s model of accumulation. The inability – so far – of Highly Innovative Fuels to scale up to commercial operations in Punta Arenas, the resistance of communities and environmentalists, and the paucity of infrastructure for export already belie this assumption. This industry, with its dependence on abundant sun, relentless wind, and easy port access, is as embedded within the landscape as any other. As green hydrogen projects jump to different landscapes around Chile and worldwide, they will face unique challenges in each one. Scaling is far from assured. As stated, though, the exhortation to scale was both an assumption and a demand on the part of the Chilean state. The National Strategy calls on the government and the private sector to act quickly, capture early-mover advantage,

and build a formidable industry before the rest of the world catches up. This signals not just a clever business move but also a political insurance policy. If the green hydrogen industry can grow to a national force in a few short years, it will have established hydrogen as a fait accompli before community resistance can develop. A certain amount of pre-existing scale will help the hydrogen industry confront the resistance that is likely to intensify as it expands into more populated and contested regions of the country like Biobío.

If managed with careful consideration for the social and political pitfalls detailed above, Chile's emerging green hydrogen sector could be a boon for industries that are difficult to decarbonize through conventional means. The challenge faced by Chile's leftist government is that, like most facets of the green transition, the country's hydrogen strategy is organized not for maximum ecological returns but for maximum profit. Aggressive expansion and a staunch orientation towards conquering export markets put this industry at odds with the domestic environmental movement and many of the local communities it has allied with, leading to a potential backlash that could jeopardize the country's decarbonization plans. It remains to be seen whether Boric will be able to repurpose its predecessor's hydrogen policy from a vehicle of the neoliberal status quo to an engine for its transformative ambitions.

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