



# Potential of **Article 6** and other financing instruments to promote **Green Hydrogen** in the **Steel**, **Cement** and **Mining** Industries

## EXECUTIVE SUMMARY



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### Background and Objective

The purpose of this study is to generate technical inputs for the future development of pilot initiatives for international carbon markets, in addition to other alternative climate financing instruments included under Article 6 of the Paris Agreement, based on the following case studies:

1. Replacement of petcoke with green hydrogen in **cement industry** clinker furnaces.
2. Injection of green hydrogen into blast furnace nozzles to reduce the consumption of coke in the **steel industry** (integrated process).
3. Replacement of diesel-fueled and electric buses in the **mining industry for the transportation** of workers with green hydrogen buses.

### Methodology

It was decided that the onsite production of Green Hydrogen (H2V) under optimal generation conditions would be considered for the economic assessment of implementing H2V in the case studies. This configuration allowed Levelled Costs of Hydrogen (LCOH) of 2.16 - 3.41 USD/kgH2 for the "Present" scenario and 0.89 - 1.141 USD/kgH2 for the "Long Term Scenario," which vary depending on the production location (north, center, south, and Patagonia) and the technology mix used for electricity generation. Based on this analysis, the expected yield of the projects was studied and the main variables affecting the profitability of each initiative were identified.

On the other hand, it was determined that the prices of emissions reduction certificates that pilot projects can obtain under Article 6 should be in the range of USD10 - 51/tonCO2-eq for the "present" scenario and 52 - 83 USD/tonCO2-eq for the Long-Term Scenario and that the credit periods that could be accessed would be as much as 15 years, using 5-year credit periods, renewable up to 2 times.

### Results

The main results are summarized in the table below, which considered an optimistic certificate sales price corresponding to the maximum estimated value that could be obtained in the three scenarios and for a credit period of 15 years. The table shows that the Total Cost of Ownership (TCO) for the H2V-based project and the equivalent project based on fossil fuels. It also identifies the potential average abatement of the projects, their feasibility gaps, and the estimated income from the sale of emissions reduction certificates.

	Scenario	Present	Medium Term	Long Term
<b>Steel</b>	TCO H2V CASE (USD)	1,268,632,268	1,090,929,499	932,128,932
	TCO baseline case (USD)	839,440,012	839,639,379	907,670,795
	Feasibility Gap (USD)	-429,192,255	-251,290,119	-24,458,137
	Average annual abatement potential (tonCO <sub>2</sub> -eq/year)		297,954	
	Certificate price to close the feasibility gap (USD/ tonCO <sub>2</sub> eq)	205	120	12
	Revenues from certificate sales (SUP scenario and 15 years) (USD)	138,400,740	168,251,880	225,240,420
<b>Cement</b>	TCO H2V CASE (USD)	198,754,278	142,575,329	107,001,022
	TCO baseline case (USD)	97,944,460	75,148,477	77,653,348
	Feasibility Gap (USD)	-100,809,818	-67,426,852	-29,347,673
	Average annual abatement potential (tonCO <sub>2</sub> -eq/year)		47,751	
	Certificate price to close the feasibility gap (USD/ tonCO <sub>2</sub> eq)	291	201	90
	Revenues from certificate sales (SUP scenario and 15 years) (USD)	22,778,579	26,812,860	34,752,479
<b>Mining</b>	TCO H2V CASE (USD)	14,186,618	11,056,423	8,592,993
	TCO baseline case (USD)	4,946,779	5,390,119	5,710,988
	Feasibility Gap (USD)	-9,239,839	-5,666,304	-2,882,005
	Average annual abatement potential (tonCO <sub>2</sub> -eq/year)		519	
	Certificate price to close the feasibility gap (USD/ tonCO <sub>2</sub> eq)	2,391	1,527	834
	Revenues from certificate sales (SUP scenario and 15 years) (USD)	240,123	234,575	210,337

**Table 1.** Main results of the analysis

All relevant information on these initiatives' economic feasibility and abatement potential has been synthesized in technical files for each project, allowing parties interested in providing climate financing to be approached (see Annexes section of the final report).

The **cooperative approaches in Article 6 offer a significant opportunity to incorporate additional income into the business model of H2V projects**, where the sale of emission reduction certificates contributes to bridging the feasibility gap that these initiatives currently face. The study also analyzes the sources of uncertainty associated with the sale of emission reduction certificates. The main risks will be associated with credit periods, the need to adjust the baseline during renewal processes, and uncertainty in the prices that could be obtained for the sale of certificates, among others.

As the results show, these pilot projects have feasibility gaps even after the sale of emission reduction certificates. Hence, an additional source of income is required if one seeks to move toward the materialization of the pilot projects and set a precedent that promotes the replication of these projects. This additional income must come from a combination of public funds from the Chilean state

and/or international donors with an additional interest in this type of projects, such as promoting a given technology in the commercialization process or testing business models.

The study also identifies the main endogenous risks as technological risks (as solutions still under development and with scant experience in real applications) and the credit risks associated with high levels of uncertainty in the carbon market. To address these risks, the financial instruments that could help improve the projects' risk-reward ratio and attract private capital to implement them would be debt guarantees to cover technological risks and to address the uncertainty surrounding the sales price of emission reduction certificates.

Lastly, the study's conclusions make recommendations that could help to reduce the uncertainties associated with this market and align the parties' interests in such a way as to foster demand for green hydrogen in Chile for the applications studied.

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[Study Report](#)