TC Document

I. Basic Project Data

▪ Country/Region:	CHILE
▪ TC Name:	Promotion for the Development of a Green Hydrogen Market in Chile
▪ TC Number:	CH-T1235
▪ Team Leader/Members:	Marzolf, Natacha (INE/ENE) Team Leader; Walter, Martin (INE/CCH) Alternate Team Leader; Aiello, Roberto Gabriel (INE/ENE); Alatorre Frenk, Claudio (CSD/CCS); Aoki, Issei (INE/ENE); Carvalho Metanias Hallack, Michelle (INE/ENE); Casalino Franciskovic, Juan Manuel (LEG/SGO); Correa Poseiro, Cecilia (INE/ENE); Gaviano, Andrea (VPS/ESG); Macias Parra, Ana Maria (INE/ENE); Marquez Barroeta, Fidel (INE/ENE); Robles Alzamora, Paola A. (CSC/CCH); Salas Parra, Cristian (CSD/CCS)
▪ Taxonomy:	Operational Support
▪ Operation Supported by the TC:	CH-L1159
▪ Date of TC Abstract authorization:	08 May 2020
▪ Beneficiary:	Chile through the Ministry of Energy (MINENERGIA)
▪ Executing Agency and contact name:	Inter-American Development Bank
▪ Donors providing funding:	Japan Special Fund(JSF)
▪ IDB Funding Requested:	US$500,000.00
▪ Local counterpart funding, if any:	US$0
▪ Disbursement period (which includes Execution period):	24 months
▪ Required start date:	December 2020
▪ Types of consultants:	Firms and individual consultants
▪ Prepared by Unit:	INE/ENE-Energy
▪ Unit of Disbursement Responsibility:	INE-Infrastructure and Energy Sector
▪ TC included in Country Strategy (y/n):	Yes
▪ TC included in CPD (y/n):	No
▪ Alignment to the Update to the Institutional Strategy 2010-2020:	Productivity and innovation; Institutional capacity and rule of law; Environmental sustainability and climate change

II. Objective and Justification

2.1 The general objective of this technical cooperation (TC) is to support the development of a market for green hydrogen (H_2) as a future innovative and competitive energy carrier which will contribute to decrease Greenhouse Gases (GHG) Emission[1] and accelerate the decarbonization process.

[1] The focus of this TC is green H_2 which is produced by electrolysis of water using electricity from renewable sources (www.certifhy.eu).

2.2 Chile has been identified as one of the leading countries with great potential for production of green H_2, estimated at 160 million tons per year[2]. Competitive renewable electricity production costs and over 1.85 GW of identified renewable energy generation potential[3] are two key factors that could enable a green H_2 local and export market in the country. Experience operating the refineries of the National Company of Petroleum (ENAP), which produces H_2 in the order of 54,300 tons per year, and Production Development Corporation (CORFO), under its Proposal for a National Strategy for Green H_2[4], illustrate the existence of key institutions that could drive change.

2.3 International organizations such as the World Economic Forum (WEF)[5], International Renewable Energy Agency (IRENA)[6], International Energy Agency (IEA)[7] and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)[8], the governments of Japan[9] (which has declared its intention to consume up to 300,000 tons per year by 2030[10]), Australia[11] and Germany[12] and international companies in the automobile and hydrocarbon[13] sectors (Toyota, Mitsubishi, Honda, Daimler, Shell, Total, and BP) have concluded that the use of hydrogen as an energy carrier is key to the rapid, sustained and cost-effective reduction of GHG emissions.

2.4 Although gray and green H_2 – produced with carbon emissions from natural gas, and carbon-free from renewable electricity & water, respectively – offer environmental advantages over fossil fuels, preliminary studies indicate that green H_2 is most effective at accelerating the decarbonization of certain sectors of the economy, such as heavy transport, use of high temperature heat in industries, production of synthetic chemical and mining.

2.5 Chile is projected as one of the most competitive global producers given its untapped potential for renewable generation and its priority to craft a friendly regulatory and investment framework. Studies have shown that even considering storage and transport costs, green H_2 produced in Chile could reach competitive prices similar to those in California (2.7USD/kgH2)[14]. Potential for scale up is massive, considering that over 1.85 TW of unexploited cost-effective renewable energy production potential

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2 The Future of Hydrogen: Seizing today's opportunities. Report prepared by the IEA for the G20, Japan. June 2019. https://www.iea.org/reports/the-future-of-hydrogen.

3 Ministry of Energy & GIZ. (2014). *Energías Renovables en Chile – El Potencial eólico, solar e hidroeléctrico de Arica a Chiloé.*

4 www.comitesolar.cl/seminario-hidrogeno-verde/.

5 WEF (2020). Accelerating Clean Hydrogen.www.weforum.org/projects/accelerating-clean-hydrogen

6 www.irena.org/publications/2019/Sep/Hydrogen-A-renewable-energy-perspective

7 The Future of Hydrogen: Seizing today's opportunities. Report prepared by the IEA for the G20, Japan. June 2019 (see link in footnote 2 above).

8 http://4echile.cl/4echile/wp-content/uploads/2018/04/LIBRO-TECNOLOGIAS-H2-Y-PERSPECTIVAS-CHILE.pdf.

9 www.meti.go.jp/english/press/2019/0312_002.html.

10 Opening the Way to a Hydrogen Society, The Government of Japan. www.japan.go.jp/tomodachi/2018/Autumn2018/opening_the_way.html.

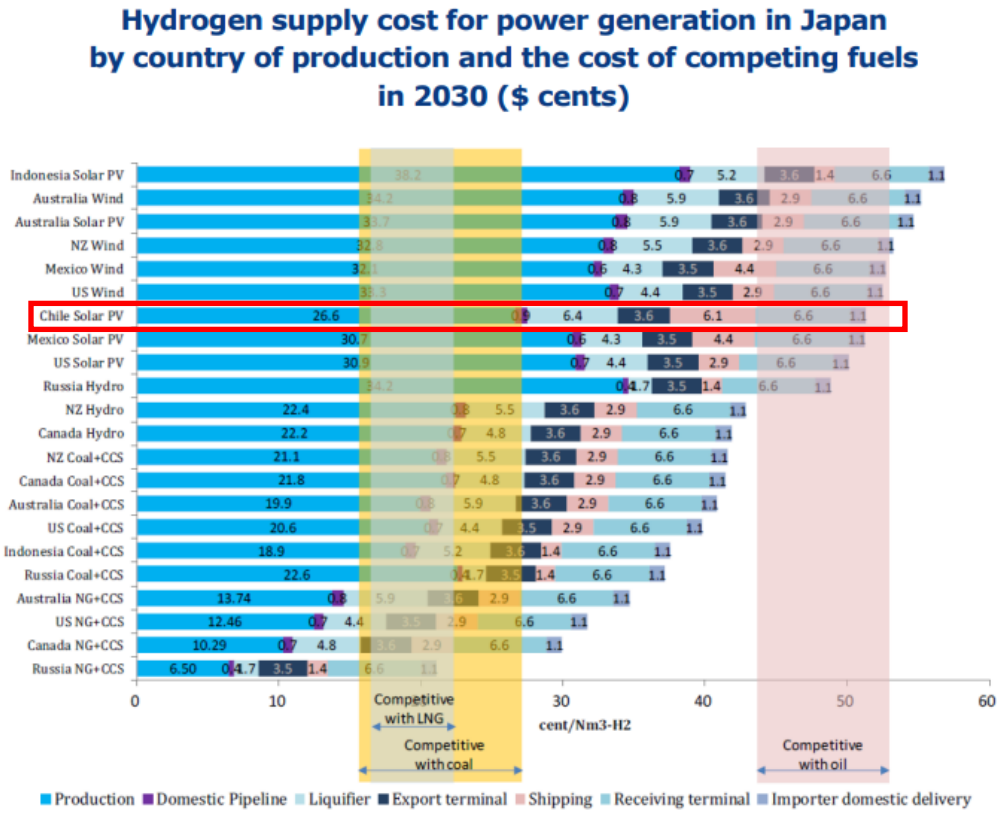
11 www.industry.gov.au/data-and-publications/australias-national-hydrogen-strategy.

12 www.hamburg.de/pressearchiv-fhh/13173414/2019-11-07-bwvi-wasserstoff-technologie/.

13 https://hydrogencouncil.com/en/category/news/executive-interviews/.

14 Hydrogen Council. (2020). Hydrogen Path to Competitiveness: A cost perspective.

exists in Chile[15] and that several energy-intensive nations have declared interest in importing relevant quantities of hydrogen in the long-term such as Germany, Belgium, the Netherlands, Korea and Japan. In addition, studies have shown that the cost of green H_2 produced in Chile and imported into self-declared importing nations, such as Japan, can be even more competitive than green H_2 imported from closer locations[16] [17] due to comparatively lower production costs as shown in the following figure.



Source: APERC. (2018). *Perspectives on Hydrogen in the APEC Region*. Published by IEEJ.

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2.6 In the 2018-2022 Energy Path policy document, the Government of Chile (GoCh) highlighted the introduction of new technologies for zero or low GHG emissions such as hydrogen which would accelerate its decarbonization process and thus replace heavy dependence on fossil fuels. The future use of H2 as an energy carrier has also been included in Chile's citizens' agenda as an attractive viable alternative for a sustainable energy mix[18]. A new draft bill on Climate Change is currently under discussion in the Chilean Congress and calls for an obligation to achieve carbon

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15 Ministry of Energy of Chile & GIZ. (2014). *Energías Renovables en Chile – El Potencial eólico, solar e hidroeléctrico de Arica a Chiloé.*

16 APERC. (2018). *Perspectives on Hydrogen in the APEC Region*.

17 Gallardo, F., *et al*. (2020). *A Techno- Economic Analysis of on-grid solar hydrogen production by electrolysis in the north of Chile and the case of exportation from Atacama Desert to Japan*. International Journal of Hydrogen Energy Manuscript Draft, Elsevier.

18 Speech of president during the launch of the citizens' agenda; September 2, 2019. https://prensa.presidencia.cl/discurso.aspx?id=101103.

neutrality by 2050[19] where GHG emissions could be reduced by up to 20% using H_2 as an energy source[20]. All these targeted efforts are substantially contributing to help Chile meet its National Determined Contributions (NDC for its acronym in English)[21], reduce its GHG emissions by 2030, reach its 70% renewable energy target by 2050 and provide for a more sustainable, competitive and inclusive energy matrix.

2.7 Given the relatively small future domestic market for hydrogen in comparison to the untapped demand in industrialized nations[22], the potential for green H_2 export from Chile has become a pathway for facilitating the significant investments needed to make use of a higher fraction of the country's renewable energy sources. The physical nature of the gaseous product, green H_2 poses challenges to the process of overseas exportation. Dedicated large-scale infrastructure will be required to transform hydrogen into a form or carrier suitable for long-range maritime transportation, such as liquefied hydrogen (LH_2) at cryogenic temperatures, ammonia (NH_3), or Liquid Organic Hydrogen Carriers (LOHC).

2.8 Key challenges to the development of an export industry for green H2 include the uncertainty in technical and economic aspects of the optimal infrastructure for overseas export, coordination between multiple public and private stakeholders, an incipient regulatory framework and a general lack of understanding and awareness of this new technology. It is in this context that the Ministry of Energy (MINENERGIA) requested support from the Bank in developing a viable path for hydrogen as the future energy carrier in the country.

2.9 This TC is aligned with the Corporate Results Framework and the Second Update of the Institutional Strategy 2020 2023 (AB-3190-2) through the development challenge of Productivity and Innovation by promoting the development of green H2 as an innovative energy carrier and use of its by-products through its value chain as and with the cross-cutting areas of Institutional Capacity and Rule of law and Climate Change and Environmental Sustainability by promoting the elaboration of the regulatory framework for a suitable hydrogen market that seeks reduction/displacement of GHG emissions and decarbonization of the energy matrix. The TC is also consistent with the Energy Sector Framework Document (GN-2830-3) on the subject of sustainability, energy efficiency and renewable energy and with the Climate Change Sector Framework (GN 2835-8) in the area of mitigation as it supports the development of clean energy technologies in Chile. The TC is aligned with the IDB Group Country Strategy with Chile 2019-2022 (GN-2946) as it will contribute to the strategic objective to reduce electricity costs for businesses and households through increased investments in electricity generation from non-conventional renewable energy sources (such as solar). Lastly, this TC is linked to the preparation of the Programmatic Policy-Based Loan (PBP) CH-L1159[23] currently under preparation (and which was declared

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19 Project submitted to Congress on January 13, 2020.

20 Hydrogen Council: Hydrogen could contribute to 20% of CO2 emissions reduction targets by 2050. Business Wire. November 13, 2017.

21 https://mma.gob.cl/wp-content/uploads/2016/05/2015-INDC-web.pdf.

22 The Ministry of Energy has estimated that 450 kton of hydrogen would be required to shift **all** existing mining trucks and heavy duty on-road transport from diesel to H_2 in Chile. In comparison, 1600 kton of hydrogen are used today in Germany only as a feedstock for chemical processes.

23 The objective of the PBP is to support Chile's fair, clean and sustainable energy transition and its specific objectives which are to: (i) perfect the regulatory framework of the energy sector to advance its

eligible on November 3rd, 2020) as the studies performed under this TC will contribute to the implementation of the actions contemplated under the Green Hydrogen National Strategy.

2.10 This TC is aligned with the objectives and eligibility criteria established in the Japan Special Fund Operating Guidance as it will contribute to promote quality infrastructure investments which will cover these aspects: (i) maximizing of the positive impact of infrastructure to achieve sustainable growth and development as this TC will finance the studies for a hydrogen export project and a synthetic fuel project which are indispensable to achieve sustainable development, including related capacity development activities; (ii) integration of environmental and social safeguards as these safeguards will be integrated in the studies supported by this TC, and (iii) link to PBP CH-L1159 that is under preparation.

III. Description of Activities and Outputs

3.1 **Component I. Development of pre-investment studies for flagship projects (US$290,000).** This component will finance the pre-investment studies for flagship projects associated with the deployment of green H_2 production and use. Several studies have shown the large potential production capacity of the North of Chile for green H_2 (82.5Mt/year)[24] and the competitive prices that could result (1.6-3.0USD/kgH2)[25] by using its solar energy potential to produce low cost H_2. Under this component the following activities will be carried out:

3.2 Activity 1: Pre-feasibility study for a hydrogen export project (US$210,000) [26]. This activity will finance the studies to gage the potential projected international demand for hydrogen and develop a hydrogen export project on the coast of Chile (exact location to be determined). It will include analyzing existing and potential methods of transporting hydrogen overseas, either in pure form or in the form of carriers. Relevant processes, infrastructure, installations, and equipment necessary to carry out the transformation and transportation of hydrogen are to be reviewed. Recommendations for optimal technologies and location, considering both renewable potential in the North of Chile and the Magellan Region, are to be provided. Recommendations should be based not only on production potential but also by identifying potential importers and the transportation technology.

3.3 Specifically, this component will finance the following: (i) identify potential importers of hydrogen considering projected local production and consumption; (ii) assess maritime hydrogen transportation technologies in development and potential for dominance; (iii) provide international experience in construction and operation of hydrogen and research and development in hydrogen transformation and loading terminals; (iv) issue recommendations for a hydrogen carrying technology for overseas

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modernization with a citizen seal; (ii) support policy reforms aimed at accelerating the decarbonization of the energy matrix, and (iii) enable and promote technology innovation in the energy sector.

24 Tractebel. (2018). *Oportunidades para el desarrollo de una industria de hidrógeno solar en las regiones de Antofagasta y Atacama*, http://www.comitesolar.cl/wp-content/uploads/2018/08/Comite-Solar-2018-Oportunidades-Industria-del-Hidr%C3%B3geno_Informe-Final.pdf.

25 IEA. (2019). *The Future of Hydrogen*. IRENA. (2019). *Hydrogen: A renewable energy perspective*.

26 Chile has already carried out a demand market study (McKinsey) showing that there is a competitive market for Chile's green energy worldwide with a shortlist of clients pre-identified.

transportation (ammonia, liquid hydrogen, methanol); (v) determine infrastructure, installations and equipment required to store, transform and export H_2 from a coastal location considering the recommended technology for overseas transportation; (vi) design variables that significantly affect costs and efficiencies; (vii) provide recommendations for coastal sites either in the North of Chile (between the Arica y Parinacota, and the Atacama Regions) or in the South of Chile (in the Magallanes region), as well as determine storage capacity order of magnitude and high-level design decisions in order to tend to the optimization of project lifetime costs and maximize opportunities for successful commercial operation; (viii) propose a conceptual layout for envisioned project (terminal, dock, and associated infrastructure, installations, and major equipment); (ix) estimate investments and operational costs for the recommended siting, technology and sizing, at a Class 4 estimation level as defined by the AACE[27]; (x) assess potential regulatory, environmental and social challenges for the construction and operation of the hydrogen export terminal; (xi) draft a high-level implementation plan for project development with expected timeframes and possible contingencies, including basic social and environmental considerations and safeguards, permitting times, time needed to obtain vessel or vessel availability, commissioning of terminal, among other relevant milestones; (xii) estimate job creation during the construction and operation phases of the project; and (xiii) recommend potential business models and identify main commercial and financial challenges for an investor or operator of the project.

3.4 Activity 2: Pre-feasibility study for a synthetic fuel project in the Magallanes region (US$80,000). The southernmost areas of Chile, the Magallanes and Chilean Antarctica region have been identified with a potential of almost 126 GW of capacity for wind power generation, with several zones showing potential capacity factors of over 50%[28] and onshore sites with capacity factor of up to 80%. However, its electric grid is isolated from the rest of the country and has a peak demand of only 40 MW. Hence, the production of green H_2 becomes an attractive alternative to make use of the region's renewable potential to displace use of hydrocarbons in sectors such as transportation, residential/industrial heat, as well as creating a potential export to other regions in the form of hydrogen or its derivatives. Facilitating projects equivalent to only 1GW of renewable power production for green H2 could translate into investments of over US$3 billion considering power and H2 installations and equipment, as well as 1.5 Mton of CO_2 emissions reduction if hydrogen were to be used to replace diesel oil in multiple applications.

3.5 This activity will finance the pre-feasibility study of a synthetic liquid fuel production in the Magallanes region based on green H_2 for wind energy. Specifically this activity (consisting of consultancy work with firms and/or individuals) will include: (i) reviewing the different technologies of synthetic fuel production from hydrogen (including technical, economic and regulatory aspects); (ii) identifying key opportunities and challenges related to the production of synthetic liquid fuels and their scaling up; and (iii) producing key information for private and public project developers to assess the viability of such synthetic liquid fuel production plant.

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27 AACE. (2019). *Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries*. AACE International Recommended Practice No. 18R-97.

28 Ministry of Energy. (2017). *Política Energética: Magallanes y Antártica Chilena*. "Energía 2050" process.

3.6 The specific studies will consist of the following, amongst others: (i) identify and analyze the production process and technologies for synthetic liquid fuel production from hydrogen and carbon dioxide (CO2); (ii) determine high-level of opportunities and challenges for the development of a commercial synthetic liquid fuel production plant in the Magallanes region; (iii) recommend a specific technological solution for the development of a synthetic liquid fuel production plant powered by electricity coming from a wind power plant, as well as a capacity sizing estimate, a specific area to be considered for the plant's location, and a high-level plan for sequential scale-up; (iv) provide required major infrastructure, installations, and equipment in order to develop the plant in point (iii) above; (v) determine all the design variables and values for the selected area or site considering the expected operation of the plant and related facilities; (vi) estimate corresponding investments and operational costs as well as job creation during the construction and operation phases of the plant, and (vii) propose a potential business model for the development and operation of the proposed plant, identifying private and public partners to be included in the project, main commercial, technical and financial challenges that could be faced by investors and operator, risk allocation between the potential investors/sponsors, government and potential financiers and corresponding mitigants, economic and socioenvironmental impacts.

3.7 **Component II. Support for development of regulatory framework and institutional capacity building (US$210,000)**. This component will contribute to establish a regulatory framework for H_2 as an energy carrier together with providing capacity building and knowledge transfer to key stakeholders.

3.8 Activity 1: Technical and regulatory feasibility assessment for blending hydrogen into existing gas transport and distribution infrastructure (US$80,000). This activity will finance the technical, environmental, and regulatory studies that will serve as key inputs to develop a regulatory framework for H_2 as an energy carrier in Chile. Specifically this activity will: (i) analyze the operational and regulatory state of the art of hydrogen blending into natural gas pipelines and distribution grids in five (5) countries leading the deployment of hydrogen as a clean fuel; (ii) determine the technical feasibility of blending hydrogen into existing natural gas pipelines and distribution infrastructure, and (iii) recommend and develop standards, codes, and regulatory framework that enable and regulate blending of hydrogen into natural gas pipelines and distribution grids (including adaptation of standards to the Chilean context).

3.9 Activity 2: Support development of a regulatory framework for hydrogen and multi-fuel refueling stations for vehicles (US$50,000). This activity will consist in a technical and regulatory feasibility study for the supply of H2 as a fuel for vehicles and mobile machinery in both public and private refueling stations. In particular, this activity will build upon the upstream work carried out by MINENERGIA and the German International Cooperation Agency (GIZ) and will focus on developing regulations and standards (for design, construction, operation and maintenance) needed by policymakers to craft a friendly investment climate for hydrogen development.

3.10 Activity 3: Education and dissemination of knowledge on green H_2 as a clean energy carrier (US$80,000)[29]. This activity will contribute to raise awareness, educate and disseminate the knowledge of green H_2 as a viable energy carrier and will finance the following, among others: (i) design and development of a web platform with educational material that can effectively convey the most relevant topics on hydrogen to a wide variety of audiences; (ii) development of a centralized and publicly available library with documentation on green H2 with special relevance to Chile; (iii) establishment of an outreach channel to disseminate knowledge and communications with regard to global advancement that hold relevance to the Chilean and Latin American context, and (iv) support for the overall management and coordination of the project.

IV. Indicative budget

4.1 Indicative budget for TC is US US$500,000, of which US$500,000 is financed by IDB. MINENERGIA will provide in-kind resources. The breakdown is detailed as follows:

Indicative budget (US$)

Activity / Component	Description	IDB / Financing by Fund
Component I	Development of pre-investment studies for flagship projects	290,000
Component II	Support for development of regulatory framework and institutional capacity building	210,000
Total		**500.000**

V. Executing agency and execution structure

5.1 At the request of the beneficiary and to expedite the implementation of the TC, the GoCh has expressly requested that the Executing Agency for this TC be the IDB through the Energy Division (INE/ENE). Technical supervision, monitoring, evaluation and decisions related to the contracting of individual consultants and consulting firms will be the responsibility of the Bank through INE/ENE. INE/ENE will closely work with the Bank's Division of Climate Change (CSD/CCS), the Mining, Geothermal Energy and Hydrocarbons (MGH) Cluster and the Bank's Representation in Chile (CSC/CCH). The Bank's project team will also coordinate with the team of the Ministry of Energy to ensure that the studies performed are of the substance that is being sought to develop a green hydrogen market.

5.2 The Bank will be responsible for the selection and hiring of consulting firms and individual consultants which will be in accordance with IDB policies and procedures (GN-2350-9). In addition (i) the individual consultants will be hired in accordance with appendix 10 of GN-2629-1 and guidelines set out in AM-650 and a) will not perform functions similar to those of the staff of the Bank or the Beneficiary and b) will not be

[29] Activity 3 under Component 2 does not involve: (i) the acquisition or software development for the web platform and (ii) the purchase of goods for the centralized and publicly available library.

hired to act as the Bank´s counterpart on behalf of the Beneficiary; (ii) the procurement process for consulting firms will follow IDB Policy for the Selection and Contracting of Consulting Firms for Bank-executed Operational Work (GN-2765-4) and its related Operational Guidelines (OP-1155-4); and (iii) the procurement of non-consultant services will follow the IDB Corporate Procurement Policy (GN-2303-28). Following IDB Operational Guidelines for Technical Cooperation Products revised version (GN-2629-1), this TC is classified as a product for Operational Support.

VI. Important risks

7.1 The main risk for the implementation of this TC lies with the technical complexity of the green H_2 technology and the coordination with all the stakeholders associated with each component. This risk will be mitigated with the establishment at the level of the Ministry of Energy of an Executive Committee which will serve as a quality peer reviewer of the technical aspects of the project. Additionally, MINENERGIA has established a strong technical team and obtained the endorsement and participation of their Office of International Affairs which reports to the Minister of Energy's cabinet.

VII. Environmental and social safeguards

8.1 According to the IDB's Environment and Safeguards Compliance Policy (OP-703) and due to the nature and objectives of the TC, this TC has been categorized as Category "C", since is aimed at the preparation of pre-feasibility studies and it will not finance infrastructure construction. The studies will include considerations on potential environmental and social challenges and safeguards' application related to the future projects' implementation.

Required Annexes:

Request from the Client - CH-T1235

Results Matrix - CH-T1235

Terms of Reference - CH-T1235

Procurement Plan - CH-T1235