

# Decarbonizing the Global Economy with a USG-led Clean Technology Export Initiative

## *Memo Compilation*

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# MEMO I

# Geothermal Energy

## *Kenya*

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## Executive Summary

This memo provides an overview of the opportunities and challenges related to a potential United States public-private partnership (PPP) aimed at boosting the competitiveness of key segments of the U.S. clean technology sector through geothermal technology exports to Kenya. Currently the eighth largest geothermal power user, Kenya aims to nearly double its overall geothermal power output by 2030, making it the fourth-largest geothermal user globally.<sup>1</sup> This memo delivers a comprehensive analysis of stakeholders, competitors, the market, and policies. It also addresses challenges in exports and sectoral growth, while outlining public education requirements, to provide recommendations for the International Trade Administration (ITA).

**Key Stakeholders:** Our research identifies various stakeholders including government entities such as the Ministry of Energy and Petroleum, National Environment Management Authority of Kenya (NEMA), Kenya Wildlife Service (KWS), Energy and Petroleum Regulatory Authority (EPRA), National Oil Corporation of Kenya (NOCK), Kenya Electricity Generating Company (KenGen), Kenya Trade Network Agency (KenTrade), and

U.S. company Ormat Technologies, Inc. We also introduce the relevant academic institutions and civil society organizations, as well as stakeholders from the private sector.

**Market Analysis:** The Energy Act of 2019 in Kenya establishes a comprehensive regulatory framework for the exploration, recovery, and commercial utilization of geothermal energy, aligning with the country's goal to enhance energy security and sustainability. This legislation, which repealed prior energy-related laws, vests geothermal resources in the national government and outlines the licensing process, ensuring safety, environmental protection, and fair compensation for affected landowners. With strong government support and a focus on promoting renewable energy, particularly geothermal, the Kenyan geothermal sector has experienced remarkable growth, surpassing other major producers. The market's dispatchable nature makes it an attractive component in achieving improved energy security. The Energy Act of 2019 positions Kenya for continued growth, with the potential to extend its impact across borders in the Rift Valley region.

**Key Codes, Standards, and Regulatory Frameworks:** The Energy Act of 2019 in Kenya represents a significant transformation in the nation's energy regulatory framework, focusing on geothermal exploration and utilization. This

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<sup>1</sup> Maguire, G. (2023, October 5). Kenya steps up as global geothermal powerhouse. Retrieved from <https://www.reuters.com/markets/commodities/kenya-steps-up-global-geothermal-powerhouse-2023-10-05/>

legislation centralizes geothermal resources under the national government, offering a clear licensing process but presenting challenges due to non-tariff barriers and complex environmental regulations affecting the importation of geothermal components. Recent legislative changes, including the Finance Act 2020 and Tax Amendment Act 2020, have revoked tax exemptions for the renewable energy sector, increasing costs for investors. Concerns arise from the dynamic regulatory environment, impacting import duties and complicating cost projections. Recommendations include conducting a thorough regulatory analysis, streamlining processes, promoting certification collaboration, leveraging diplomatic channels, and encouraging industry-to-industry collaboration to enhance competitiveness and facilitate smoother collaboration between U.S. exporters and Kenyan developers.

**Export Challenges:** Economic success before COVID-19 has shifted, with a rising public debt crisis causing concerns for public procurement. Independent Power Producers (IPPs) own a third of Kenya's renewable energy capacity, while trade dynamics under the Least Cost Power Development Plan pose challenges for certain components. The economic relationship with the U.S. lacks a double tax treaty, and non-tariff barriers raise concerns. Recommendations for the ITA include engaging local expertise, leveraging the U.S. Embassy and Chamber of Commerce, partnering with Kenya Private Sector Alliance (KEPSA), and facilitating information exchange for U.S. companies entering the Kenyan geothermal sector.

**Challenges to Sectoral Growth:** Kenya, ranked the eighth highest geothermal energy producer globally, faces barriers hindering sector growth,

including high-risk financing, corruption, import taxation policies, and a grid size mismatch with energy supply potential. Geothermal projects entail substantial upfront costs, with drilling expenses of around 1 million USD per well. Obtaining investor funding is challenging due to perceived high risks in African countries. Collaboration with fossil fuel companies to de-risk activities faces obstacles, as industry data is private and not readily shared. Trade challenges and corruption further escalate geothermal costs, hindering industry expansion. Limited user capacity, with 77% of the population connected to the grid, poses a significant barrier, as the energy potential surpasses demand. Overcoming these obstacles requires investment in trade policy diplomacy, de-risking market investments, and exploring geothermal energy technology for green hydrogen generation and export.

**Main Competitors for US Export:** Japanese Toshiba, a significant geothermal player, contributes 40% of Kenya's geothermal capacity, emphasizing its vital role in its development. Pertamina Geothermal Energy (PGE) from Indonesia has also entered the Kenyan market. KenGen, a leading geothermal energy producer in Kenya, operates seven major geothermal power stations with a total portfolio of 707 MW. The unique opportunities and challenges in Kenya's geothermal sector require strategic navigation and collaboration for U.S. exporters. The involvement of foreign companies underscores Kenya's openness to global collaboration. To compete successfully, U.S. firms should leverage ITA assistance in building government relationships, fostering partnerships, accessing financial opportunities, and aligning with Kenya's renewable energy goals,

contributing to the country's aim to double geothermal output by 2030.

**Public Education:** Addressing public education needs regarding renewable technologies, especially geothermal, is essential for successful implementation and public acceptance. Despite widespread support for wind and solar energy, uncertainties persist around geothermal technologies, emphasizing the importance of public education and community engagement. In Kenya, as Africa's largest geothermal producer, challenges related to land management, fears of displacement, and ecosystem concerns have triggered public outrage. Research findings reveal ongoing land disputes with the Maasai community, leading to delays in geothermal plant operation. Recommendations include raising awareness among decision-makers, improving local education in impacted communities, and providing targeted education and promotion efforts. Training local administration, fostering social dialogue, and mutual learning are suggested to enhance community engagement and acceptance of geothermal energy.

Kenya's geothermal sector, a potential candidate for a PPP program, holds promise for economic growth not only in Kenya but also in neighboring East African countries. Learning from the success of Ormat Technologies Inc., the ITA, in collaboration with the Department of State, U.S. Chamber of Commerce, and U.S. geothermal companies, should engage with key Kenyan stakeholders to understand challenges and opportunities. Examining successful initiatives by the Japanese and Italian governments, along with the European Investment Bank (EIB) and Toshiba, can provide a blueprint for PPPs, not only in Kenya but also across the East African region. Key recommendations include aligning geothermal industry growth with the U.S.-Kenya agenda, consulting Ormat Technologies Inc., studying successful international initiatives, investing in trade policy diplomacy, collaborating with multilateral institutions for de-risking mechanisms, and facilitating PPPs for innovative geothermal applications like Green Hydrogen and Direct Air Capture.

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## Introduction

This memo discusses the potential for a United States public-private partnership (PPP) focused on promoting geothermal technology exports to Kenya. It introduces key domestic and international stakeholders, the current state of the geothermal market, key codes and regulatory frameworks, export challenges, sectoral growth challenges, competitor analysis, and public education requirements. We provide recommendations related to managing stakeholders, sectoral growth, and public education that can facilitate the success of a PPP targeted toward Kenya. The appendices at the end of the document provide further analysis.

## Key Stakeholders

We have identified the following stakeholders across government, the private sector, academic, and civil society in Kenya. See Appendix A for further analysis on each stakeholder, including whether they are likely to support this program and why or why not. See Appendix B for an analysis of U.S.-based stakeholders.

- *Government:* Ministry of Energy and Petroleum, National Environment Management Authority of Kenya (NEMA), Kenya Electricity Generating Company (KenGen), Kenya Wildlife Service (KWS), Energy and Petroleum Regulatory Authority (EPRA), National Oil Corporation of Kenya (NOCK), Kenya Electricity Generating Company (KenGen), Kenya Trade Network Agency (KenTrade)
- *Private Sector:* , Geothermal Development Company (GDC), Akiira Geothermal Limited (AGL), Ormat Technologies, Inc.
- *Academia:* Geothermal Training and Research Institute (GETRI), Dedan Kimathi University of Technology (DeKUT)
- *Civil Society:* The Nature Conservancy (TNC), Pastoralists, Fossil Fuel Workers

### *Recommendation*

The following interest-influence matrix displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely).



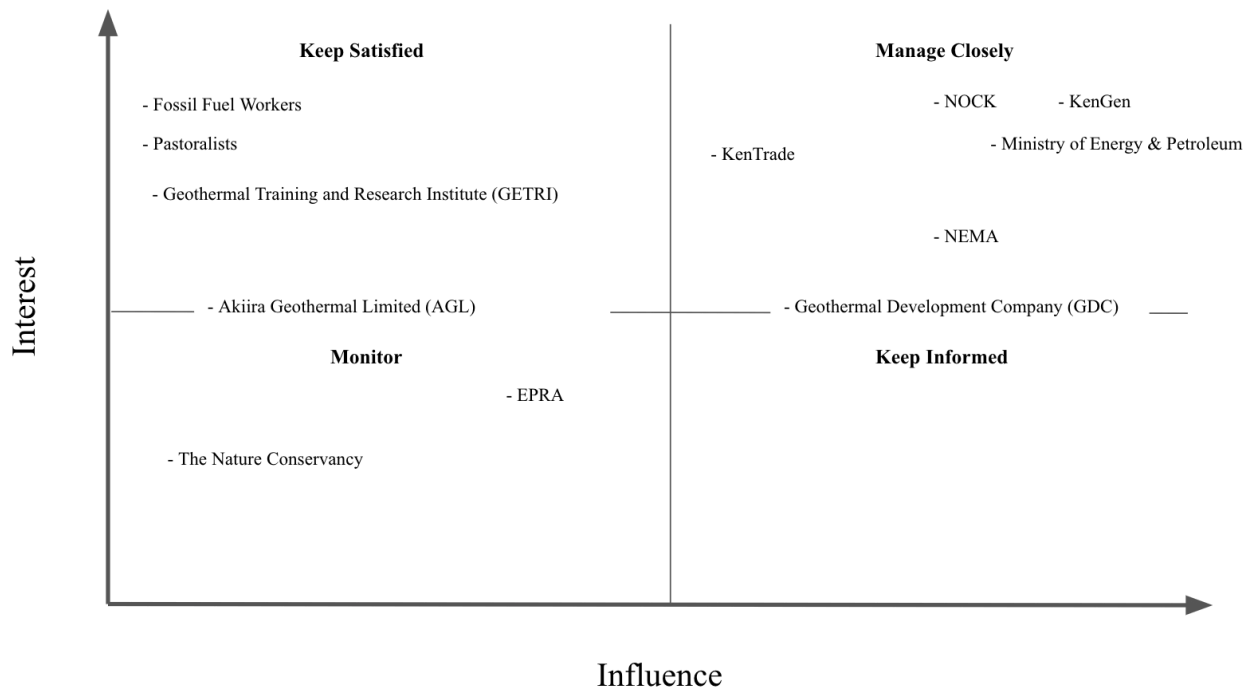


Fig. 1 Stakeholder Analysis Map

## Market Analysis

The Energy Act No. 1 of 2019 (hereinafter the Energy Act) Kenya establishes the regulatory framework for the exploration, recovery, and commercial utilization of geothermal energy. It vests geothermal resources in the national government and outlines the process for acquiring geothermal resource licenses. This framework governs the rights and obligations of licensees, including exploration, development, and production activities, while ensuring safety, environmental protection, and fair compensation for affected landowners. Additionally, the Act aims to promote renewable energy sources, including geothermal, through strategic planning, investment, and development initiatives, aligning with Kenya's goal to enhance its energy security and sustainability.<sup>2</sup>

The Kenyan geothermal sector is particularly attractive due to the expected increases from supportive policies at the federal level. The dispatchable nature of geothermal makes it more appealing to the Kenyan government as they work to improve energy security and availability. The market has seen very strong growth over the past decade with a total increase of 375% from 2010 to 2022, outpacing any other major geothermal producer.<sup>3</sup> Expansion of the Kenyan market also has the potential to cross borders to other countries in the region that also lie along the Rift

<sup>2</sup> The Energy Act (2019) Kenya Gazette Supplement

<sup>3</sup> Maguire, G., & Maguire, G. (2023, October 5). Kenya steps up as global geothermal powerhouse. Reuters. <https://www.reuters.com/markets/commodities/kenya-steps-up-global-geothermal-powerhouse-2023-10-05/>

Valley.<sup>4</sup> Overall, the market has strong prospects for growth with both a growing energy demand and a desire to increase the proportion of the energy mix that comes from geothermal.

**The Energy Act of 2019** and the regulations thereunder, which repealed the Energy Act 2006, the Kenya Nuclear Electricity Board Order 2013 and the Geothermal Resources Act 1982, and which have consolidated all laws relating to energy – including renewable energy – in Kenya.<sup>5,6</sup>

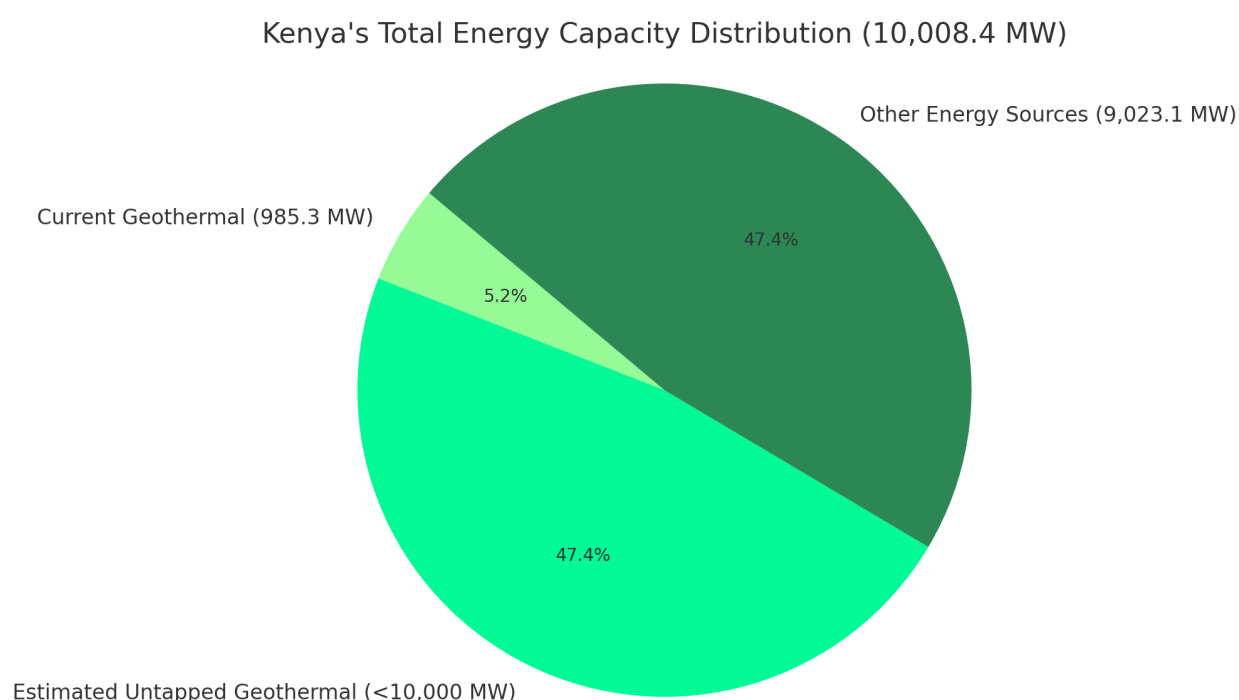


Fig. 2 Kenya's Total Energy Capacity Distribution

Current Number of country power plants: 9

Current capacity of geothermal production: 985.3

Estimated Geothermal Capacity: 10,000 mW<sup>7</sup>

Total energy capacity: 10,008.4 MW<sup>8</sup>

<sup>4</sup> How Kenya is helping its neighbors develop geothermal energy. (2023, July 12).

<https://www.sciencenews.org/article/geothermal-energy-africa-kenya-renewable-electricity>

<sup>5</sup> Renewable energy comparative guide— Kenya. (n.d.). Retrieved February 26, 2024, from

<https://www.mondaq.com/energy-and-natural-resources/1368424/renewable-energy-comparative-guide>

<sup>6</sup> Highlights of kenya's energy act 2019. (n.d.). Retrieved February 26, 2024, from

<https://www.roedl.com/insights/renewable-energy/2019-05/highlights-of-kenyas-energy-act-2019>

<sup>7</sup> Geothermal Energy – Renewable Energy Portal. (n.d.). <https://renewableenergy.go.ke/technologies/geothermal-energy/>

<sup>8</sup> Brown, W. (2022, December). KENYA TAPS THE EARTH'S HEAT. Retrieved from

<https://www.imf.org/en/Publications/fandd/issues/2022/12/country-case-kenya-taps-the-earth-heat>

## Key codes, standards, and regulatory frameworks

The Energy Act No. 1 of 2019 in Kenya marks a significant overhaul of the country's energy regulatory framework, particularly concerning the exploration, recovery, and commercial utilization of geothermal energy. By centralizing geothermal resources under the jurisdiction of the national government, the Act provides a clear pathway for acquiring licenses required for geothermal resource exploration and utilization. It details the rights and responsibilities of licensees, encompassing exploration, development, and production stages, while emphasizing safety, environmental protection, and equitable compensation for landowners impacted by geothermal projects.<sup>9</sup>

Kenya encounters several non-tariff barriers in its trade landscape. These barriers include the requirement for a Certificate of Conformity from a pre-export verification partner appointed by the Kenya Bureau of Standards. Additionally, certain sensitive products necessitate the acquisition of an Import Standards Mark.<sup>10</sup> Navigating the import landscape for geothermal components in Kenya is a multifaceted challenge, entangled with stringent environmental and safety regulations. Compliance with these regulations is imperative, yet discrepancies or variations can lead to prolonged processes.<sup>11</sup>

Adding complexity, detailed scientific considerations within safety and environmental parameters necessitate a meticulous calibration process to align differing causal factors. Moreover, Kenya's customs and import procedures are intricately tied to sector-specific regulations, guided by industry-specific laws such as the Electric Power Act of 1997. This act imposes specific regulations on those importing electric components into Kenya, underlining the need for a comprehensive understanding of sector-specific legal frameworks.<sup>12</sup> Furthermore, certification procedures are a prerequisite for imported components, not only in the geothermal sector but across various industries. Notably, equipment imported from the U.S. must undergo TARA testing and certification before entering the market.<sup>13</sup>

The regulatory landscape has undergone changes with the Finance Act 2020 and the Tax Amendment Act 2020, which collectively revoked tax exemptions previously granted to

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<sup>9</sup> The Energy Act (No. 1). (2019). Kenya Gazette Supplement.

[https://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/EnergyAct\\_No.1of2019.PDF](https://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/EnergyAct_No.1of2019.PDF)

<sup>10</sup> Privacy Shield Framework. (n.d.). Kenya - Trade barriers. Retrieved from

<https://www.privacyshield.gov/ps/article?id=Kenya-trade-barriers>

<sup>11</sup> Dr.Francis Kangure, personal communication. February 20, 2024.

<sup>12</sup> Ibid.

<sup>13</sup> Ibid.

businesses in the renewable energy sector.<sup>14</sup> These acts have introduced a combined 14% value-added tax (VAT) on supplies imported for use in the construction of power generating plants and off-grid solar power equipment, leading to heightened capital expenditure costs for IPPs.<sup>15</sup> Moreover, effective July 1, 2022, the East African Community Common External Tariff (EAC CET) has implemented a four-band tariff structure ranging from 0% to 35%. Notably, machinery used in oil, gas, or geothermal activities enjoys a duty exemption under this tariff regime.<sup>16</sup>

Investors frequently express concerns about the volatility of changing regulations, i.e. in areas such as taxation.<sup>17</sup> For instance, a new Finance Bill has the potential to undergo significant modifications within a relatively short time frame, approximately three to six months.<sup>18</sup> These alterations are often influenced by shifting government priorities.<sup>19</sup> One noteworthy consequence of such regulatory adjustments is the fluctuation in import duties, affecting components that were previously subject to minimal levies.<sup>20</sup> Consequently, investors may encounter challenges in accurately projecting their cost outlay.

### *Recommendations*

In light of the challenges outlined and the potential impact on exports, the ITA could consider the following recommendations:

- **Conduct Comprehensive Regulatory Analysis:**
  - Collaborate with industry stakeholders to conduct a detailed analysis of key codes, standards, and regulatory frameworks impacting the U.S. geothermal industry.
  - Identify specific regulatory barriers affecting project development and export prospects and work towards streamlining or reforming these regulations for enhanced competitiveness.
- **Streamline the Processes:**
  - Both Kenyan and U.S. regulatory frameworks present hurdles to rapid deployment of geothermal projects. The ITA could advocate for streamlined processes and bilateral agreements that facilitate smoother collaboration and project implementation between U.S. exporters and Kenyan developers.
- **Promote Certification Collaboration:**

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<sup>14</sup> Ibid.

<sup>15</sup> ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>

<sup>16</sup> Ibid.

<sup>17</sup> Dr.Francis Kangure, personal communication. February 20, 2024.

<sup>18</sup> Ibid.

<sup>19</sup> Ibid.

<sup>20</sup> Ibid.

- Facilitate partnerships between U.S. certification bodies and their Kenyan counterparts to streamline the certification process for geothermal components.
- Provide resources and support for mutual recognition agreements to expedite the approval of U.S. geothermal components in the Kenyan market.
- **Leverage Diplomatic Channels:**
  - Engage U.S. diplomatic missions in Kenya to advocate for the alignment of Kenyan regulations with international standards, creating a more seamless environment for geothermal component exports.
  - Work collaboratively with Kenyan government agencies to address any discrepancies in regulatory requirements that may impede trade.
- **Encourage Industry-to-Industry Collaboration:**
  - Facilitate matchmaking between U.S. geothermal component manufacturers and Kenyan developers and project operators.
  - Organize trade missions, virtual events, or business forums to enhance direct interactions and foster partnerships between U.S. and Kenyan industry players.

## Export challenges

Kenya's power sector faced challenges during the COVID-19 pandemic, witnessing a downturn in demand due to companies scaling back operations and businesses grappling to survive.<sup>21</sup> Persistent allegations of corrupt practices, particularly in land acquisitions and major government contracts, continue to cast a shadow over the sector.<sup>22</sup> Governance issues further compound challenges, with concerns about government inefficiency and weaknesses in regulatory and judicial systems.<sup>23</sup>

Before the onset of the COVID-19 pandemic, Kenya stood out as one of Africa's economic success stories, boasting an impressive annual average growth rate of 5.9% from 2010 to 2018. This robust performance propelled the country to lower-middle income status, underpinned by a substantial GDP of \$95 billion, highlighting the nation's strides in cultivating a diverse and dynamic economy. However, the economic landscape has witnessed a significant shift, particularly in the public sector. The mounting public debt crisis has cast a shadow, causing the debt-to-GDP ratio to rise from 65.8% in 2020 to 68.2% in 2021.<sup>24</sup> This surge raises concerns

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<sup>21</sup> ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>

<sup>22</sup> ITA. (2022, August 19). Kenya - Market challenges. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-market-challenges>

<sup>23</sup> Ibid.

<sup>24</sup> USAID. (n.d.). Economic growth and trade | Kenya | U.S. agency for international development. Retrieved from <https://www.usaid.gov/kenya/economic-growth-and-trade#:~:text=OVERVIEW,a%20diverse%20and%20dynamic%20economy>

about potential repercussions, particularly in terms of public procurement opportunities, as the country grapples with the challenges posed by its increasing debt burden.<sup>25</sup>

According to the Economist Intelligence Unit Country Risk Report, Kenya's sovereign risk assessment stands at CCC, with manageable risks posed by a wide budget deficit and the increasing cost of servicing external debt. The Kenyan government has responded by shifting its fiscal policy from stimulus to consolidation, supported by a 2.34 billion International Monetary Fund (IMF) extended credit facility.<sup>26</sup>

Approximately one-third of Kenya's renewable energy capacity is under the ownership and operation of Independent Power Producers (IPPs), spanning various plants, including geothermal.<sup>27</sup> The remaining capacity falls under the jurisdiction of KenGen, with the government holding a substantial 70% ownership stake. Notably, the majority of geothermal generation is orchestrated by the government, with only one IPP, the U.S. firm Ormat, participating in the sector and contributing 140MW.<sup>28</sup> The remainder of the geothermal power is generated by KenGen. Looking ahead, KenGen has strategic plans to augment the grid with an additional 560 MW of geothermal power through collaborative joint ventures.<sup>29</sup>

A decade ago, Kenya formulated the Least Cost Power Development Plan (LCPDP) to navigate its energy landscape. However, a persistent issue lies in the trade dynamics associated with this plan. Specific components crucial for the renewable energy sector often face challenges due to their importation being governed solely by cost merit, rather than receiving preferential trade considerations.<sup>30</sup> This means that, despite their pivotal role in advancing renewable energy initiatives, certain components may not benefit from preferential trade treatment. In addition, there is a lack of inherent support for the importation of renewable energy components in Kenya. This absence of preferential treatment is primarily attributed to the emphasis on cost considerations, where renewable energy components may incur higher expenses.<sup>31</sup>

Several notable aspects characterize the economic relationship between Kenya and the U.S. Firstly, it's crucial to note the absence of a double tax treaty between the two nations.<sup>32</sup> Moreover, identified by the U.S. government as ongoing concerns are certain non tariff barriers (NTBs),

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<sup>25</sup> ITA. (2022, August 19). Kenya - Market challenges. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-market-challenges>.

<sup>26</sup> Ibid.

<sup>27</sup> ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>

<sup>28</sup> Ibid.

<sup>29</sup> ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>.

<sup>30</sup> Ibid.

<sup>31</sup> Dr.Francis Kangure, personal communication. February 20, 2024.

<sup>32</sup> Congressional Research Service. (2023, August 8). U.S.-Kenya Trade Negotiations. Retrieved from <https://crsreports.congress.gov/product/pdf/IF/IF11526>.

with weak intellectual property protections being a significant issue for U.S. businesses.<sup>33</sup> For instance, the 2019 Data Protection Act in Kenya introduces potential uncertainties for cross-border data flows due to opaque rules.<sup>34</sup>

Kenya's non-membership in the World Trade Organization (WTO) Government Procurement Agreement is underscored, coupled with a government practice of granting exclusive preference to Kenyan companies for procurements under approximately \$450,000.<sup>35</sup> Furthermore, Kenya's Access to Government Procurement Opportunities program aims to boost the allocation for women, youth, and persons with disabilities to 30% of total public procurement spending.<sup>36</sup> Under this policy, if young men and women from Kenya enter into agreements with foreign companies, such collaborations or agreements would still be considered acceptable and in compliance with the rule mandating that 30% of procurement be allocated to the specified demographic. That however means that U.S. companies will be selling to a third party, affecting business transactions.<sup>37</sup>

Kenya maintains an average applied Most Favored Nation (MFN) tariff rate of 14.3% for all trade partners in 2022.<sup>38</sup> Notably, certain high-value U.S. exports, including machinery and aircraft, encounter favorable conditions with low or zero tariffs when entering the Kenyan market.<sup>39</sup> However, Kenya is actively engaged in renegotiating current power tariffs with IPPs to alleviate the impact of rising costs on the general population.<sup>40</sup>

### *Recommendations*

In light of the potential opportunities for U.S. companies to export geothermal components to Kenya, it is essential for the ITA to leverage local expertise and navigate the regulatory landscape effectively. The following recommendations aim to guide ITA in supporting American businesses seeking entry into the Kenyan market:

- Engage with the U.S. Chamber of Commerce in Kenya to tap into their local expertise and gain insights into the Kenyan market's policies and regulations regarding geothermal projects. Collaborate with the chamber, utilizing its advisory services, including legal and financial expertise, to assist U.S. companies in understanding and complying with local requirements.

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<sup>33</sup> Congressional Research Service. (2023, August 8). U.S.-Kenya Trade Negotiations. Retrieved from <https://crsreports.congress.gov/product/pdf/IF/IF11526>.

<sup>34</sup> Ibid.

<sup>35</sup> Ibid.

<sup>36</sup> Dr.Francis Kangure, personal communication. February 20, 2024.

<sup>37</sup> Ibid.

<sup>38</sup> Congressional Research Service. (2023, August 8). U.S.-Kenya Trade Negotiations. Retrieved from <https://crsreports.congress.gov/product/pdf/IF/IF11526>.

<sup>39</sup> ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from <https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>

<sup>40</sup> Ibid.

- Foster a close working relationship with the U.S. Embassy in Nairobi to capitalize on their on-the-ground insights and networks. Leverage the embassy's capabilities to provide valuable information on market trends, regulatory changes, and potential challenges, offering crucial assistance to US companies.
- Establish partnerships with the Kenya Private Sector Alliance (KEPSA) to further enhance business collaboration opportunities for American companies. Leverage KEPSA's proactive efforts in building relationships with foreign entities to create a conducive environment for U.S. geothermal component exports.
- Facilitate regular information exchange forums, webinars, or seminars with relevant stakeholders, including the U.S. Chamber of Commerce in Kenya, U.S. Embassy in Nairobi, and KEPSA. Ensure that U.S. companies receive updated and accurate information on market conditions, regulatory changes, and business opportunities in the Kenyan geothermal sector.

## Challenges to sectoral growth

Kenya represents a unique energy market to explore for geothermal energy as it is the highest producing African country and eight highest in the world.<sup>41</sup> Yet, due to factors such as high-risk financing, corruption, unfavorable import and taxation policies, and most importantly the incompatibility of the size of grid users to the energy supply potential, certain barriers to growth of the sector remain.

Geothermal energy, despite being a cost-effective resource once harnessed, involves significant upfront expenses related to components, drilling, and infrastructure. The cost of drilling a single well amounts to approximately \$1 million, and each project requires a minimum of three wells.<sup>42</sup> The overall cost of projects is high. In addition, receiving investor funding is difficult as these investments are seen as high risk. Investing in African countries is much more expensive than elsewhere due to the high perceived risk. For that reason, most funding shall be expected to come from the private sectors and from the European Union (EU) (as it is concessional)<sup>43</sup>. Overall, stable financing mechanisms are needed to provide stability and reduce actual and perceived project risks. The Geothermal Risk Mitigation Facility (GRMF), a collaboration between the EU and African Union, is an example of such a current major course of funding.<sup>44</sup> Overall, capital cost reduction strategies for geothermal projects need to be implemented.

<sup>41</sup> Koech, G. (2023, November 24). Kenya ranked among largest geothermal energy producers. The Star. <https://www.the-star.co.ke/news/2023-11-24-kenya-ranked-among-largest-geothermal-energy-producers/>

<sup>42</sup> Dr. Francis Kangure, personal communication, Feb 23, 2024.

<sup>43</sup> Jabri Ibrahim - Climate Champions Team, personal communication, Feb 13, 2024.

<sup>44</sup> How Kenya is helping its neighbors develop geothermal energy. (2023, September 12). Science News. <https://www.sciencenews.org/article/geothermal-energy-africa-kenya-renewable-electricity>



We inquired about the potential to collaborate with fossil fuel companies to de-risk exploration and well drilling activities. We hypothesized that fossil fuel companies already have exploration and development processes established, and trusted, which includes data on methodologies for doing so. Yet, in discussion with Jabari Ibrahim, Africa Special Programmes Lead, Climate Champions Team, he noted how fossil fuel industry data is private and won't be shared as it is what allows them to remain competitive. Unless an investment benefits them, they won't partake.

An additional factor increasing the cost for geothermal is trade. Components crucial for the renewable energy sector often face challenges due to their importation being governed solely by cost merit, rather than receiving preferential trade considerations. Without policies or tax incentives facilitating infrastructural components, barriers for industry expansion will remain. But even if such policies or incentives were adopted, an element that may persist in spiking upfront costs is the corruption that impedes upon free trade. It is often the reality that any goods imported into the country will face restrictions to entry by authorities unless bribery is made, which increases cost of projects and complicates doing business, even with 'favorable regulation'.

Lastly, the most significant barrier to expanding geothermal in Kenya would be the limited available user capacity. Around 77% of the Kenyan population is connected to the grid<sup>45</sup>, which equates to around 40.8 million electricity users. To place this statistic in terms of electric capacity being utilized, Ibrahim mentioned a statistic that states that "a single metals factory in the Xinjiang region [of China] has more onsite coal capacity (~5.1GW) than the power generation capacity of the whole country of Kenya (~3.1GW, 53 million ppl)."<sup>46</sup> What this means is that Kenya's geothermal, and other, energy potential in fact exceeds the demand by the population and overall grid users. Kenya's geothermal sectoral growth depends on more individuals and large users of electricity getting on the grid. The lack of transmission infrastructure and inability to export geothermal energy poses another barrier.

To overcome market barriers impeding geothermal energy project development in Kenya, the ITA should:

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<sup>45</sup> Kenya: Population with access to electricity. (2024, February 21). Statista.  
<https://www.statista.com/statistics/1221124/population-with-access-to-electricity-in-kenya/#:~:text=In%202021%2C%20the%20share%20of,value%20in%20the%20observed%20period>

<sup>46</sup> Wang, S. [@wang\_seaver]. (2023, July 9). Since I've mentioned this statistic to folks in some recent conversations, may as well share here. This single metals factory in. Twitter.  
[https://twitter.com/wang\\_seaver/status/1678131250538885120?t=wcY61\\_ejI5KoHPxNlz1Eew&s=19](https://twitter.com/wang_seaver/status/1678131250538885120?t=wcY61_ejI5KoHPxNlz1Eew&s=19)

- Invest resources in trade policy diplomacy to facilitate Kenya receiving technology imports from abroad.
- Work on de-risking energy market investments through policy de-risking from within multilateral institutions, and through financial de-risking, encouraging private investing and deploying mechanisms such as debt, equity, and guarantees.<sup>47</sup>
- Explore the technology of utilizing geothermal energy for the purpose of generating Green Hydrogen from electrolysis, wherein the electricity produced can then be exported to neighboring countries, overcoming the barrier of non-transmittable geothermal energy.<sup>48</sup>

## Main competitors for U.S. exports

The global geothermal market is characterized by a competitive landscape with 28 key players<sup>49</sup> (Appendix C). This landscape highlights the significant competition U.S. firms face internationally, with Italian and Japanese geothermal companies not only having an expansive global footprint that includes a growing presence in East Africa, but also benefiting from supportive government initiatives, such as Japan's Africa Business Education program<sup>50</sup> and the European Investment Bank's \$95 million investment in Eastern Africa's geothermal projects<sup>51</sup>. Despite this stiff competition, the U.S. leads with eight companies (Appendix C), showcasing the experience and a broad geographical reach in the geothermal sector.

Toshiba has been a key foreign player, having signed several Memorandums of Understanding (MOUs) with KenGen and delivering approximately 300 MW worth of steam turbines for geothermal power plants<sup>52</sup>. This contribution represents 40% of Kenya's geothermal capacity, highlighting Toshiba's significant role in the country's geothermal development. Additionally, Pertamina Geothermal Energy (PGE), a unit of the Indonesian state energy firm Pertamina, has

<sup>47</sup> Choi, E. S., Zhou, L., & Laxton, V. (2022, July 22). How to de-risk low-carbon investments. World Resources Institute. <https://www.wri.org/insights/de-risking-low-carbon-investments>

<sup>48</sup> Hamdhani, T. (2023, March 13). *Exporting Indonesia's geothermal*. LinkedIn. <https://www.linkedin.com/pulse/exporting-indonesias-geothermal-trihanggara-hamdhani/>

<sup>49</sup> Geothermal energy companies - Top company list. (n.d.). Retrieved from <https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>, Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from <https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721> & Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from <https://www.gminsights.com/industry-analysis/geothermal-energy-market>

<sup>50</sup> Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝. <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>

<sup>51</sup> EIB. (2021, June 17). East African rift geothermal. European Investment Bank. <https://www.eib.org/en/projects/pipelines/all/20210194>

<sup>52</sup> Delivery records. (2021). トップページ | 東芝. <https://www.global.toshiba/ww/products-solutions/renewable-energy/delivery-records/geothermal-power.html#geohttps://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshibas-energy-solutions-in-africa.htm>

also made strides into the Kenyan market by signing MOUs with the Geothermal Development Company and Africa Geothermal International No. 1 Ltd, with the potential to produce up to 500 MW.<sup>53</sup> KenGen stands as a leading producer of geothermal energy in Kenya, operating seven larger geothermal power stations in the Olkaria area and holding a total portfolio of 707 MW.

In conclusion, the dynamics within Kenya offer unique opportunities and challenges for U.S. exporters. The significant involvement of foreign companies like Toshiba and PGE in Kenya's geothermal sector reflects the country's openness to international collaboration and investment. For U.S. firms to successfully compete and expand their geothermal exports to Kenya, like Ormat Technologies Inc has, it will be crucial that the ITA helps to navigate the competitive landscape by growing relationships between the U.S. and Kenyan government and fostering strategic partnerships with local industry leaders. In addition, the ITA should support companies in leveraging financial investment opportunities, and aligning with Kenya's renewable energy goals. By doing so, U.S. companies can contribute to Kenya's ambitious plan to double its geothermal output by 2030.

## Public Education

Addressing the public education needs surrounding renewable technologies is crucial to increasing public acceptance and for the seamless implementation and working of the geothermal plants to generate electricity. Community engagement has remained a vital component in the successful progress of PPPs. Although wind and solar energy enjoy widespread support for sustainable solutions, uncertainties persist around geothermal technologies, including technical concerns like potential water contamination and micro-seismic activity. Additionally, social and ethical issues, such as distrust of decision-makers and concerns about fair risk and benefit distribution, highlight the importance of prioritizing public education and community engagement for a sustainable and equitable transition to renewable energy. Kenya stands as Africa's largest geothermal producer, with a target to triple its clean electricity output by 2025 through harnessing natural underground heat. The country has demonstrated a strong commitment and significant progress in transitioning to clean energy to fulfill its energy needs. However, challenges surrounding the implementation of geothermal plants, such as land management issues, fears of mass displacement, and ecosystem degradation concerns, have sparked public outrage in Kenya.

## Research Findings

Kenya's stretch of the Great Valley, encompasses areas like Olkaria and Mount Suswa, which are inhabited by the semi-nomadic pastoralist Maasai community, known for their dependence on

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<sup>53</sup> Reuters.com. (2023, August 21). [reuters.com.  
https://www.reuters.com/business/indonesias-pertamina-geothermal-explores-partnership-with-kenyan-firms-2023-08-22/](https://www.reuters.com/business/indonesias-pertamina-geothermal-explores-partnership-with-kenyan-firms-2023-08-22/)

the land for grazing and sustenance. Ongoing land disputes and repeated relocation of these communities have previously caused significant delays in the operation of geothermal energy plants before.<sup>54</sup> Protests by the Maasai community in 2016 halted the construction of Kenya's Olkaria V plant, located approximately 62 miles northwest of Nairobi, on ancestral land revered for community rituals.<sup>55</sup> Likewise, in March 2021, the Maasai of Mount Suswa expressed their fear of geothermal energy plants and threat of being relocated.<sup>56</sup> In response, authorities have tried to introduce measures such as land concessions and revenue-sharing arrangements, where geothermal companies allocate up to 2.5% of their site revenue into a fund for a decade, with increasing royalties in subsequent years. According to the energy bill, the national government would retain a minimum of 75%, with 20% allocated to local governments and 5% to the local community.<sup>57</sup>

The primary concerns expressed by the community revolve around the potential disruption of their way of life and loss of livelihood. The failure of local authorities and the government to effectively communicate the necessity and significance of the plant, coupled with inadequate compensation for land loss, limited employment opportunities, and the politicization of the issue has exacerbated tensions and worsened the situation.

### *Recommendations*

Efforts should focus on raising awareness among decision-makers, administrative bodies, and civil society groups, leveraging knowledge of national strategies to stimulate citizen engagement and acceptance of renewable energy sources.

- **Improving local education<sup>58</sup>:** Maasai communities in Narok and Nakuru counties, Kenya, impacted by geothermal exploration, were slated to undergo a four-year literacy and vocational education program. The initiative was prompted by the government's discovery of a 42% illiteracy rate in these areas. The project, funded with approximately \$7.5 million received 63% of its funding from the Swedish International Development Agency, with contributions from Akiira Geothermal Company.
- **Education and Promotion Directed at Decision Makers:** Provide education and promotion efforts targeted at decision-makers and administrative bodies at various levels, as well as civil society groups. Elected officials play a major role in facilitating

<sup>54</sup>Koissaba, B. (2014, July 7). Maasai Protest Against New Land Concessions For Geothermal Extraction In Kenya . Intercontinental Cry.

<https://intercontinentalcry.org/maasai-protest-against-new-land-concessions-geothermal-extraction-kenya-24504/#:~:text=Going%20by%20recent%20events%20in,that%20also%20require%20all%20multinational>

<sup>55</sup> Mwanza, K. (2018, March 18). When the Maasai met the Maori: Kenya seeks to end geothermal land conflicts. Reuters. <https://www.reuters.com/article/idUSKBN1GV00G/>

<sup>56</sup> Collins, T. (2021, March 11). Kenya's Maasai fear mass displacement from geothermal plant. African Business. <https://african.business/2021/03/energy-resources/kenyas-maasai-fear-geothermal-plant-development>

<sup>57</sup> Mwanza, K. (2018, March 18). When the Maasai met the Maori: Kenya seeks to end geothermal land conflicts. Reuters. <https://www.reuters.com/article/idUSKBN1GV00G/>

<sup>58</sup> Cariaga, C. (2019, September 16). Education offered to Maasai affected by geothermal development in Kenya. Think Geoenergy. <https://www.thinkgeoenergy.com/education-offered-to-maasai-affected-by-geothermal-development-in-kenya/>

community engagement and can help bridge the gap between civil society, state/national government, and the energy company.

- **Training and Capacity Building:** Train local administration and employees to proficiently oversee land and geothermal plant projects, ensuring seamless operations and reducing conflicts while safeguarding existing employment opportunities. Additionally, utilize this training to facilitate alternative employment opportunities for young individuals from displaced communities, emphasizing the community's gains from project implementation.
- **Social Dialogue and Mutual Learning:** Reinforce knowledge, awareness, and collaboration between societal actors through social dialogue and mutual learning exercises to foster acceptance and community engagement with geothermal energy.

## Conclusion

This report highlights the growing potential for a United States (U.S.) public-private partnership (PPP) aimed at promoting geothermal technology exports to Kenya. The Rift Valley provides tremendous opportunities for not only Kenya but several East African countries that seek to grow their economies using geothermal energy. This makes Kenya **a potential candidate** for a geothermal technology PPP program.

The ITA, working with the Department of State, U.S. Chamber of Commerce and U.S. geothermal companies should learn from the success story of Ormat Technologies Inc and engage Kenya's key geothermal stakeholders, namely Kenya Electricity Generating Company, Ministry of Energy and Petroleum and National Environment Management Authority of Kenya to better understand how U.S. companies. Moreover, initiatives by the Japanese and Italian governments as well as the European Investment Bank (EIB) to create an enabling environment for Japanese companies, like Toshiba and Italian investors should be reviewed by the ITA. Such initiatives could be replicated with the Department of State for not only Kenya, but also in other East African countries that have access to the Great Rift Valley.

Below is a summary of our key recommendations for exploring and developing an East African -targeted geothermal PPP program;

- The ITA should understand the Department of State's key priorities for U.S. - Kenya relations. Based on findings the ITA could encourage the inclusion of geothermal industry growth on the agenda for both states and the East African Region, with the sidelines of the U.S.-Africa Leaders Summit, being an excellent opportunity.

- The ITA should consult Ormat Technologies Inc inquiring into how they achieved success, what challenges they faced, and how they are planning on growth in Kenya and East Africa.
- Initiatives by the Italian and Japanese governments, and of EIB and Toshiba, should be closely studied to serve as a blueprint for the PPPs that enable U.S. exports to Kenya and East Africa.
- The ITA should invest in trade policy diplomacy that can facilitate Kenya and other East African Countries receiving technology imports from U.S. companies.
- The ITA should collaborate with multilateral institutions to implement policy and financial de-risking mechanisms for energy market investments in Kenya and East Africa to better facilitate private investment.
- The ITA should facilitate PPPs between U.S. and Kenyan relevant entities ( geothermal firms and universities) and that explore the technology of utilizing geothermal energy for the purpose of generating Green Hydrogen and Direct Air Capture, with the Great Carbon Valley being an exemplar that can be consulted further.



## Bibliography

1. Brown, W. (2022, December). KENYA TAPS THE EARTH’S HEAT. Retrieved from <https://www.imf.org/en/Publications/fandd/issues/2022/12/country-case-kenya-taps-the-earth-heat>
2. Cariaga, C. (2019, September 16). Education offered to Maasai affected by geothermal development in Kenya. Think Geoenergy. <https://www.thinkgeoenergy.com/education-offered-to-maasai-affected-by-geothermal-development-in-kenya/>
3. Choi, E. S., Zhou, L., & Laxton, V. (2022, July 22). How to de-risk low-carbon investments. World Resources Institute. <https://www.wri.org/insights/de-risking-low-carbon-investments>
4. Collins, T. (2021, March 11). Kenya’s Maasai fear mass displacement from geothermal plant. African Business. <https://african.business/2021/03/energy-resources/kenyas-maasai-fear-geothermal-plant-development>
5. Delivery records. (2021). トップページ | 東芝. <https://www.global.toshiba/ww/products-solutions/renewable-energy/delivery-records/geothermal-power.html#geohttps://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshiba-as-energy-solutions-in-africa.htm>
6. Dr. Francis Kangure, personal communication, Feb 20, 2024.

7. EIB. (2021, June 17). East African rift geothermal. European Investment Bank.  
<https://www.eib.org/en/projects/pipelines/all/20210194>
8. Geothermal energy companies - Top company list. (n.d.). Retrieved from  
<https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>
9. Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from  
<https://www.gminsights.com/industry-analysis/geothermal-energy-market>
10. Geothermal Energy – Renewable Energy Portal. (n.d.).  
<https://renewableenergy.go.ke/technologies/geothermal-energy/>
11. Highlights of Kenya's energy act 2019. (n.d.). Retrieved February 26, 2024, from  
<https://www.roedl.com/insights/renewable-energy/2019-05/highlights-of-kenyas-energy-act-2019>
12. How Kenya is helping its neighbors develop geothermal energy. (2023, July 12).  
<https://www.sciencenews.org/article/geothermal-energy-africa-kenya-renewable-electricity>
13. ITA. (2022, August 19). Kenya - energy-electrical power systems. Retrieved from  
<https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems>
14. Jabri Ibrahim - Climate Champions Team, personal communication, Feb 13, 2024.
15. Kenya: Population with access to electricity. (2024, February 21). Statista.  
<https://www.statista.com/statistics/1221124/population-with-access-to-electricity-in-kenya/#:~:text=In%202021%2C%20the%20share%20of,value%20in%20the%20observed%20period>
16. Maguire, G. (2023, October 5). Kenya steps up as global geothermal powerhouse. Reuters.  
<https://www.reuters.com/markets/commodities/kenya-steps-up-global-geothermal-powerhouse-2023-10-05/>
17. Mwanza, K. (2018, March 18). When the Maasai met the Maori: Kenya seeks to end geothermal land conflicts. Reuters. <https://www.reuters.com/article/idUSKBN1GV00G/>
18. Privacy Shield Framework. (n.d.). Kenya - Trade barriers. Retrieved from  
<https://www.privacyshield.gov/ps/article?id=Kenya-trade-barriers>
19. The Energy Act (No. 1). (2019). Kenya Gazette Supplement.  
[https://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/EnergyAct\\_\\_No.1of2019.PDF](https://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/2019/EnergyAct__No.1of2019.PDF)
20. Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝. <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>
21. Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from  
<https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721>
22. Toshiba's energy solutions in Africa. (n.d.). トップページ | 東芝.  
<https://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshibas-energy-solutions-in-africa.htm>
23. Wang, S. [@wang\_seaver]. (2023, July 9). Since I've mentioned this statistic to folks in some recent conversations, may as well share here.
24. This single metals factory in. Twitter.  
[https://twitter.com/wang\\_seaver/status/1678131250538885120?t=wcY61\\_ejI5KoHPxNlz1Eew&s=19](https://twitter.com/wang_seaver/status/1678131250538885120?t=wcY61_ejI5KoHPxNlz1Eew&s=19)



## Appendix A

|            | Stakeholder                                               | Stakeholder Description                                                                                                                                                               | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i>                                                                                                                                                                                                                            |
|------------|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Government | Ministry of Energy and Petroleum                          | The Ministry is charged with the mandate to develop and implement policies that create an enabling environment for efficient operation and growth of Kenya's energy sector.           | Support                                                                                     | This program would support the Ministry's mission, in particular the development of clean and sustainable energy services. The Ministry has been involved in several geothermal expansion and development activities including strategy development for fast tracking geothermal exploration and development in Kenya. |
|            | National Environment Management Authority of Kenya (NEMA) | NEMA is in charge of supervising and coordinating environmental activities and serving as the main national body to implement environmental policies in all sectors within Kenya.     | Depends                                                                                     | While this program would not directly conflict with NEMA's mandate, the agency would require any new geothermal plant development to undergo a robust environmental impact assessment to mitigate any potential harm to the country's natural resources.                                                               |
|            | Energy and Petroleum Regulatory Authority (EPRA)          | Established in 2019, EPRA is responsible for technical and economic regulation of electric power, renewable energy, coal and petroleum subsectors in Kenya.                           | Neutral                                                                                     | By potentially increasing geothermal energy production in Kenya, this program would impact EPRA's work on the sector's regulation but would not conflict in any way with their mandate.                                                                                                                                |
|            | National Oil Corporation of Kenya (NOCK)                  | NOCK is a state corporation of Kenya founded with a mandate of participating in all aspects of the Kenyan petroleum industry.                                                         | Resist                                                                                      | NOCK is solely involved in petroleum-based energy production, and would resist initiatives to pivot the country toward renewable energies.                                                                                                                                                                             |
|            | Kenya Electricity Generating Company (KenGen)             | KenGen is a government enterprise charged with the production of electricity for the country.                                                                                         | Support                                                                                     | KenGen owns five geothermal power stations and would likely support this program as a potential opportunity to procure advanced, competitive geothermal technologies.                                                                                                                                                  |
|            | Kenya Trade Network Agency (KenTrade)                     | KenTrade is a state agency designated with easing cross-border trade through the establishment, management, and implementation of the first National Electronic Single Window System. | Support                                                                                     | KenTrade would likely support this initiative as it would stimulate trade and business in the geothermal industry.                                                                                                                                                                                                     |



|                       |                                                    |                                                                                                                                                                                                                                                                                                                                     |         |                                                                                                                                                                                                                                                                |
|-----------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Academia</b>       | Geothermal Training and Research Institute (GETRI) | Dedan Kimathi University of Technology (DeKUT) has taken the challenge and established the Geothermal Energy Training and Research Institute (GeTRI). The institute has been founded as a response to an existing need in the geothermal industry (within Kenya and beyond) in developing capacity to exploit this energy resource. | Support | GETRI's mission is development and breakthrough in geothermal technologies in Kenya                                                                                                                                                                            |
| <b>Private Sector</b> | Geothermal Development Company (GDC)               | GDC is tasked with developing steam fields and selling geothermal steam for electricity generation to Kenya Electricity Generating Company PLC (KenGen) and private investors.                                                                                                                                                      | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|                       | Akiira Geothermal Limited (AGL)                    | Akiira Geothermal Limited (AGL), is an electric energy generating company in Kenya. The company owns and will build and operate Akiira One Geothermal Power Station, a proposed 70 MW (94,000 hp), power station in Kenya.                                                                                                          | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
| <b>Civil Society</b>  | The Nature Conservancy (TNC)                       | TNC is a global conservation-focused NGO that aims to improve natural resource management in Kenya.                                                                                                                                                                                                                                 | Depends | While TNC is supportive of renewable energy development, its focus on conservation and responsible land management could lead to challenges against new geothermal power generation without appropriate environmental risk mitigation undertaken.              |
|                       | Pastoralists                                       | Pastoralists are estimated to comprise 25% of the national population and mainly occupy the arid lands of northern Kenya and towards the border between Kenya and Tanzania.                                                                                                                                                         | Resist  | Maasai and other residents have fought against displacement and environmental degradation caused by geothermal power generation.                                                                                                                               |
|                       | Fossil Fuel Workers                                | All workers currently employed in any position within the fossil fuel sector.                                                                                                                                                                                                                                                       | Resist  | Without adequate workforce training, fossil fuel-related employees will resist widespread transition to clean energy due to uncertainty over employment.                                                                                                       |

## Appendix B

|            | Stakeholder                                    | Stakeholder Description                                                                                                                              | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i>                                                                                                                                                                                                                    |
|------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Government | Office of the U.S. Trade Representative (USTR) | Part of the Executive Office of the President, USTR coordinates trade policy, resolves disagreements, and frames issues for presidential decision.   | Support                                                                                     | USTR has been a leading advocate for global liberalization of trade in environmental goods and services, including clean energy technologies.                                                                                                                                                                  |
|            | U.S. Trade and Development Agency (USTDA)      | The USTDA helps companies create U.S. jobs through the export of U.S. goods and services for priority infrastructure projects in emerging economies. | Support                                                                                     | This program could support business growth within the geothermal sector, thereby creating domestic employment opportunities. Fossil fuel dominant states may resist due to potential negative business impact.                                                                                                 |
|            | State Governments                              | State-level government officials across states developing renewable and/or fossil fuel energy production technologies.                               | Depends                                                                                     | States with major geothermal technology production would support a program that can boost the state's economy.                                                                                                                                                                                                 |
|            | Export-Import Bank of the United States (EXIM) | The EXIM Bank is the official export credit agency of the U.S.                                                                                       | Support                                                                                     | EXIM has been broadly supportive of existing clean technology export initiatives. Since 1992, EXIM has had a mandate in its congressional charter to increase support for environmental exports, including renewable energy.                                                                                   |
|            | International Trade Administration (ITA)       | The ITA is an agency within the U.S. Department of Commerce focused on export development and competitiveness.                                       | Support                                                                                     | This program would support the ITA's mission of strengthening U.S. global competitiveness and promoting trade and investment opportunities                                                                                                                                                                     |
|            | U.S. Department of Energy (DOE)                | DOE is the executive department of the U.S. that oversees national energy policy and energy production.                                              | Support                                                                                     | DOE has already undertaken significant measures to support the global transition to renewable energy. Its Geothermal Technologies Office works to reduce costs and risks associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges. |

|                       |                                              |                                                                                                                                                                                                                                                                           |         |                                                                                                                                                        |
|-----------------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Academia</b>       | National Renewable Energy Laboratory (NREL ) | NREL researches, develops, and demonstrates technologies to advance the use of geothermal energy as a clean, renewable, domestic energy source for the United States.                                                                                                     | Support | This program would benefit the expansion of US geothermal technologies, in line with the interest of NREL                                              |
| <b>Private Sector</b> | Calpine                                      | Calpine is the largest producer of geothermal power in the US, operating several plants in The Geysers located in north of San Francisco.                                                                                                                                 | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                |
|                       | Ormat Technologies                           | Nevada-based Ormat Technologies claims to have developed more than 150 geothermal power plants across the world with a combined capacity of more than 2.1GW.                                                                                                              | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                |
|                       | Berkshire Hathaway                           | Berkshire Hathaway's geothermal operations, which comprise 10 geothermal power plants in the Imperial Valley in southern California, are carried out by its subsidiary CalEnergy Operations. The plants are owned by another Berkshire Hathaway subsidiary CE Generation. | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                |
|                       | Northern California Power Agency             | The Northern California Power Agency (NCPA), a California Joint Action Agency, owns and operates two geothermal power plants with a combined generation capacity of 220MW.                                                                                                | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                |
|                       | Terra-Gen Power                              | The company operates three geothermal power plants in the US with a combined generation capacity of 86.7MW.<br><br>The firm operates 67MW Dixie Valley Geothermal Power Plant located in Churchill County, Nevada. It was commissioned in 1988.                           | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                |
|                       | Natural Resources Defense Council (NRDC)     | The NRDC is a U.S.-based non-profit environmental advocacy organization.                                                                                                                                                                                                  | Depends | The NRDC has published largely positive resources on its website regarding geothermal energy's potential to contribute to fighting the climate crisis. |

**Civil Society**

|  |                                 |                                                                                                                              |        |                                                                                                                                                                                             |
|--|---------------------------------|------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | The Sierra Club                 | The Sierra Club is U.S.-based non-profit environmental advocacy organization.                                                | Resist | The Sierra Club takes a cautious stance on geothermal, pointing out its adverse environmental impact and that it should be kept to a highly limited segment of renewable energy generation. |
|  | Center for Biological Diversity | The Center for Biological Diversity is a non-profit membership organization focused on the protection of endangered species. | Resist | The organization has been involved in prior lawsuits against geothermal energy producers over the adverse impact production has on biodiversity.                                            |

## Appendix C

| Country       | Company Name                                   |
|---------------|------------------------------------------------|
| United States | Ormat Technologies Inc                         |
|               | Chevron                                        |
|               | Calpine                                        |
|               | Green Mountain Energy                          |
|               | Haliburton                                     |
|               | Tetra Tech Inc                                 |
|               | Fervo Energy                                   |
|               | Berkshire Hathaway Energy                      |
| Japan         | Toshiba Energy Systems & Solutions Corporation |
|               | Fuji Electric Co. Lt                           |
|               | Mitsubishi Power Ltd                           |
|               | Sumitomo Corporation                           |
| Italy         | Ansaldo Energia SpA                            |
|               | Enel SpA                                       |
|               | Turboden SpA                                   |
|               | Enel Green Power                               |
| Indonesia     | PT Pertamina Geothermal Energy                 |
|               | Supreme Energy                                 |
| Philippines   | Energy Development Corporation                 |
|               | First Gen Corporation                          |
| Kenya         | Kenya Electricity Generating Company           |
|               | Sosian Menengai Geothermal Power Ltd.          |
| Iceland       | Geothermal Energy Development Company          |
|               | Reykjavik Geothermal                           |
| Sweden        | Atlas Copco Ab                                 |
| France        | Engie SA                                       |
| South Korea   | Doosan Škoda Power                             |
| Australia     | Macquarie Group Limited                        |



# MEMO I

# Geothermal Energy

## *Indonesia*

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March 4, 2024

## Executive Summary

This memo discusses the potential for a United States (U.S.) public-private partnership (PPP) focused on promoting geothermal technology exports to Indonesia, the second largest geothermal energy producer in the world with 2280 Megawatts (MW) of current installed capacity.

**Key Stakeholders:** Our research identifies the following stakeholders across government, the private sector, academia, and civil society in Indonesia's geothermal energy sector.

- Government: Ministry of Energy and Mineral Resources (ESDM), Ministry of Environment and Forestry, Ministry of Trade, PT Pertamina (Persero), Perusahaan Listrik Negara (PLN)
- Private Sector: PT PLN Gas & Geothermal (State-owned), PT Geo Dipa Energi (State-owned), PT Pertamina Geothermal Energy (State-owned), Sarulla Operations, Ltd., Supreme Energy, Star Energy Geothermal, Ormat, Chevron, Baker Hughes, Schlumberger, INPEX, Kaishan Group
- Academia: Geothermal Research Center (GRC), Institut Teknologi Bandung (ITB)
- Civil Society: Indonesian Forum for Living Environment (WALHI), Asia Clean Energy Partners, Yayasan Konservasi Alam Nusantara (YKAN), Indonesia Geothermal Association (INAGA) Local Communities and Indigenous Populations, Fossil Fuel Workers

**Market Analysis:** Indonesia's leading geothermal company, PT Pertamina Geothermal

Energy, aims to export clean energy to neighboring countries amid the country's substantial geothermal potential, accounting for 40% of global resources. Despite having an estimated 24 gigawatts of geothermal reserves, Indonesia currently utilizes only 10% of this potential. To meet the country's goal of achieving 20% geothermal power by expanding plant capacity, Indonesia emerges as a robust market for geothermal technologies.

**Key Codes, Standards, and Regulatory Frameworks:** The section delves into key codes, standards, and regulatory frameworks impacting the export of clean technology products for geothermal energy production in Indonesia. Despite its potential as the world's second-largest geothermal producer, Indonesia faces challenges in infrastructure, high initial construction costs, and regulatory hurdles. Trade and investment partnerships, including the U.S.-Indonesia Strategic Partnership, offer opportunities for collaboration, but infrastructure limitations and bureaucratic inefficiencies hinder progress. Recommendations for the U.S. government include exporting affordable geothermal technology, fostering partnerships with Indonesian counterparts, and advocating for regulatory reforms to promote renewable energy investment in Indonesia.

**Export Challenges:** Indonesia faces significant challenges in meeting its geothermal energy targets, aiming to commission 6.2 GW by 2030. Regulatory reforms are needed to streamline permitting processes, update tariffs, and simplify concession agreements to support the country's net-zero program. However, the geothermal



sector contends with market and regulatory barriers, with coal's dominance, technological advancements in wind and solar power, and limited renewable energy utilization hindering competitiveness. Only 12% of Indonesia's energy is renewable, with geothermal utilization at just 2%. The government aims to attract foreign investment through the Omnibus Law, offering tax incentives and increased foreign capital ownership limits.

**Challenges to Sectoral Growth:** Geothermal technology is witnessing a surge in Indonesia, spurred by government aims to increase its share in the national energy mix to 5% by 2025. However, significant market risks persist, both upstream and downstream, posing challenges to widespread adoption. Upstream challenges include resource exploration risks, such as insufficient heat sources and inadequate well capacities impacting project profitability. Downstream challenges encompass unattractive geothermal electricity pricing, as well as remote geothermal sites with low electricity demand leading to underutilized capacities or shutdowns. To address these challenges, recommendations include investing in Research and Development (R&D) for thermal well exploration and project site development promoting public-private partnerships to collaborate with private entities, addressing regulatory uncertainties, and facilitating market access.

**Main Competitors for US Export:** The global geothermal market presents a competitive landscape with 17 key players strategically

headquartered worldwide. Japan and Italy lead with four companies each, while other countries like the Philippines, Indonesia, Kenya, Sweden, Iceland, South Korea, Australia, New Zealand, and France contribute one to two companies each. The United States, nevertheless, leads with eight companies. Indonesia's state-owned enterprises (SOEs) like Pertamina and Perusahaan Listrik Negara (PLN) dominate the market, covering 82% of national production. To navigate this complex landscape, the ITA should facilitate strategic partnerships between U.S. firms, and local companies, and SOEs.

**Public Education:** While geothermal technology is generally viewed positively in Indonesia, public acceptance varies due to factors like environmental impact and cultural considerations. Environmental concerns including forest cover disruption and water scarcity, and social issues revolving around indigenous land management, and community well-being are the primary issues reported in the country. Recommendations for the ITA include engaging with local decision-makers, and administrative bodies to monitor environmental and social impact assessments of projects to assess public perceptions, and training local administration to promote effective management of geothermal projects while increasing community engagement.

While several challenges persist, the entry of foreign firms in supplying components is an indicator that Indonesia is a **strong potential candidate** for a geothermal technology PPP program for the US.

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## Introduction

This memo discusses the potential for a United States (U.S.) public-private partnership (PPP) focused on promoting geothermal technology exports to Indonesia, the second largest geothermal energy producer in the world with 2280 Megawatts (MW) of current installed capacity. It delves into the intricate network of key stakeholders both domestically and internationally, examines the current state of the geothermal market, analyzes relevant codes and regulatory frameworks, discusses export challenges, sectoral growth obstacles, competitor dynamics, and identifies the critical need for public education. Through a comprehensive examination, this memo offers recommendations for effectively managing stakeholders, fostering sectoral growth, and addressing public education requirements to enhance the success of a PPP targeted towards Indonesia. The appendices appended to this document offer supplementary analysis for further insights.

## Key Stakeholders

Identifying and understanding the various stakeholders involved in the implementation of an energy project is vital for strategic alignment, risk management, and resource allocation. Stakeholder analysis, in the context of Indonesia's energy and environmental landscape, can be effective in building relationships, enhancing legitimacy, and ensuring accountability within a complex system. Likewise, we have identified the following stakeholders across government, the private sector, academic, and civil society in Indonesia.<sup>59</sup>

- *Government*: Ministry of Energy and Mineral Resources (ESDM), Ministry of Environment and Forestry, Ministry of Trade, PT Pertamina (Persero), Perusahaan Listrik Negara (PLN), World Bank
- *Private Sector*: PT. PLN Gas & Geothermal (State-owned), Geo Dipa Energi, PT (State-owned), Pertamina Geothermal Energy, PT (State-owned), Sarulla Operations, Ltd, Supreme Energy, Star Energy Geothermal, Ormat, Chevron, Baker Hughes, Schlumberger, INPEX
- *Academia*: Geothermal Research Center (GRC), Institut Teknologi Bandung (ITB)
- *Civil Society*: Indonesian Forum for Living Environment (WALHI), Yayasan Konservasi Alam Nusantara (YKAN), Indonesia Geothermal Association (INAGA), Asia Clean Energy Partners, Local Communities and Indigenous Populations, Fossil Fuel Workers

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<sup>59</sup> See Appendix A for further analysis on each Indonesian stakeholder, including whether they are likely to support this program and why or why not. See Appendix B for analysis of U.S.-based stakeholders.

### Recommendation

The following interest-influence matrix displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely).

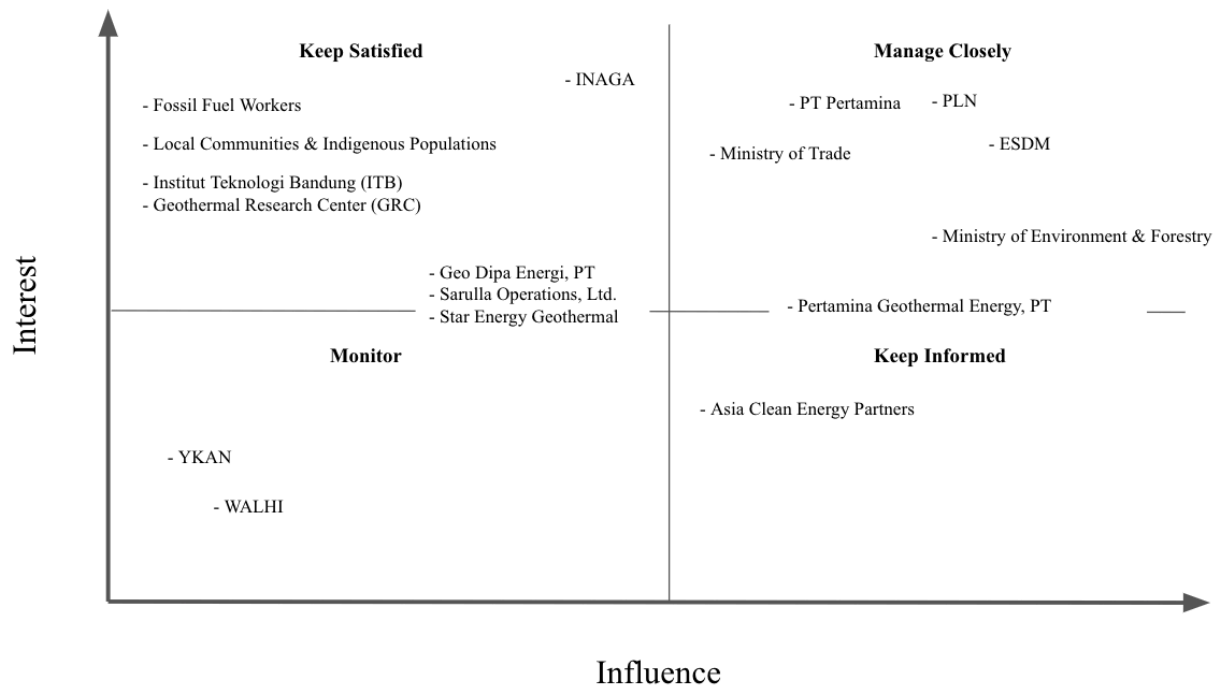


Fig. 1 Stakeholder Analysis Map

## Market Analysis

Current number of geothermal power plants: 16<sup>60</sup>

Current capacity of existing plants: 2280 MW

Estimated potential untapped geothermal reserves: 23,700 MW

Total energy capacity from all sources: 63,300 MW<sup>61</sup>

<sup>60</sup> Koons, E. (2024, February 28). *Indonesia's untapped geothermal energy potential*. Energy Tracker Asia. <https://energytracker.asia/geothermal-energy-indonesia/#:~:text=Indonesia%20has%2016%20operating%20geothermal,with%20the%20highest%20geothermal%20potential>

<sup>61</sup> *International—U. S. Energy information administration(Eia)*. (n.d.). Retrieved February 26, 2024, from <https://www.eia.gov/international/analysis/country/IDN>

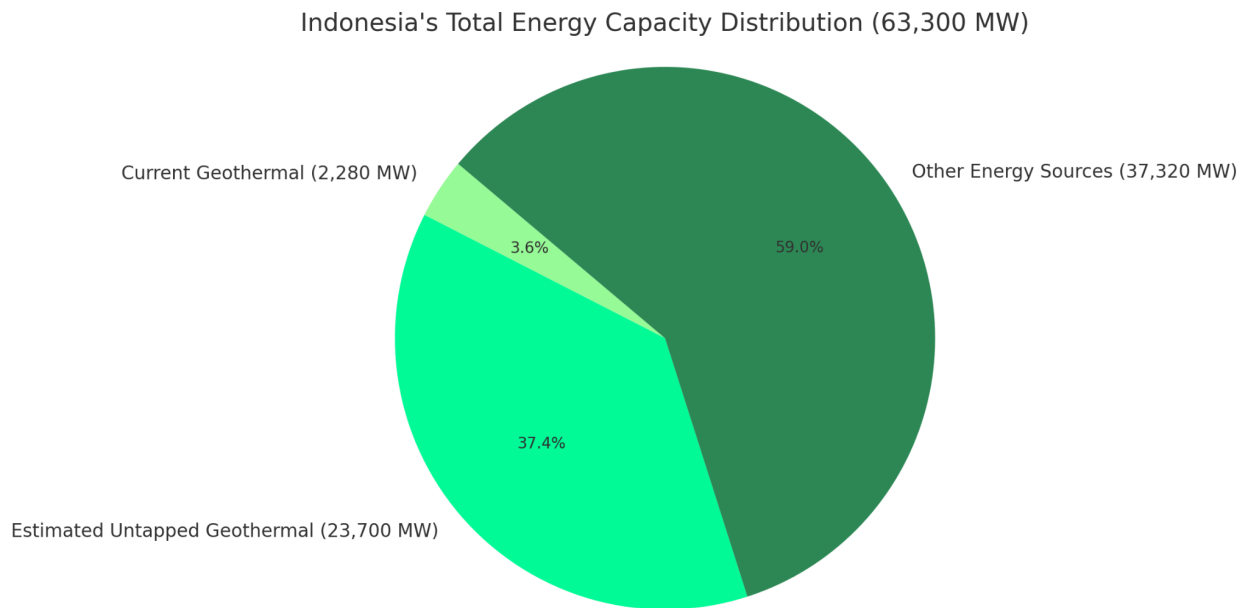


Fig. 2 Indonesia's Total Energy Capacity Distribution

### Outlook

Indonesia's largest geothermal company, PT Pertamina Geothermal Energy, is aiming to export clean energy to neighboring countries. The country possesses 40% of the world's potential geothermal resources, with an estimated 24 gigawatts of reserves ready to be developed. However, it is currently harnessing just 10% of this energy potential. The move towards exporting geothermal energy aligns with the region's shift towards green alternatives and away from fossil fuels.<sup>62</sup> Current plans involve tripling the capacity of geothermal power within the country over the coming decade.<sup>63</sup> In order to achieve the country's goals of reaching 20% geothermal power during this period, many new plants will need to be built, positioning Indonesia as a strong and growing market for geothermal technologies.<sup>64</sup>

<sup>62</sup> With its abundant geothermal reserves, Indonesia aims to harvest more green energy. (n.d.). CNA. Retrieved February 26, 2024, from <https://www.channelnewsasia.com/asia/indonesia-geothermal-energy-reserves-green-energy-sustainable-clean-electricity-renewable-climate-change-3874151>

<sup>63</sup> (2021, May). *Indonesia: Geothermal Energy Market Overview*. Think Geoenergy. [https://www.thinkgeoenergy.com/country\\_overviews/indonesia/#:~:text=Geothermal%20Energy%20Market%20of%20Indonesia,exploration%20started%20already%20in%201918](https://www.thinkgeoenergy.com/country_overviews/indonesia/#:~:text=Geothermal%20Energy%20Market%20of%20Indonesia,exploration%20started%20already%20in%201918)

<sup>64</sup> Guild, J. (2023, November 21). *Indonesia's Coming Geothermal Boom*. The Diplomat. <https://thediplomat.com/2023/11/indonesias-coming-geothermal-boom/>

## Key Codes, Standards, and Regulatory Framework

Exporting clean technology products that bolster geothermal energy production in Indonesia holds significant promise. Indonesia is the second biggest producer of geothermal energy in the world (with the U.S. being the largest producer of geothermal energy).<sup>65</sup> The country is located in the Ring of Fire which gives Indonesia a high potential for geothermal energy.<sup>66</sup> This analysis will explore the policy, regulatory framework, and trade barriers/opportunities associated with the export opportunities between the U.S. and Indonesia.

### *Policy:*

The government of Indonesia has set ambitious plans for geothermal energy, with the goal of reaching 7.24 GW of geothermal energy by 2025, requiring an investment of \$15 billion.<sup>67</sup> However, the country faces challenges due to a lack of supporting infrastructure in geothermal-rich areas, many of which are rural and difficult to access. Therefore, the initial construction costs for geothermal plants are high,<sup>68</sup> compounded by the need to build roads in remote, high-terrain locations where reservoirs are situated.<sup>69</sup> Likewise, drilling into these reservoirs is extremely expensive,<sup>70</sup> with each well potentially exceeding \$1 million due to uncertain resource estimates, making it difficult for the government to allocate enough funding towards geothermal energy production, and geothermal energy production is vastly more expensive than coal production in Indonesia.<sup>71</sup> Additionally, land acquisition poses further challenges, as geothermal sites often overlap with residential areas that are often within protected forest lands, complicating the process and potentially displacing people.<sup>72</sup>

### ***Regulation Framework:***

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<sup>65</sup> Koty, A. C. (2022, July 22). An Overview of Indonesia's Geothermal Energy Sector. *Asean Briefing*. Retrieved from <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/n/>

<sup>66</sup> Ibid.

<sup>67</sup> Ibid.

<sup>68</sup> Fadhilah, F., et.al. (2023). Challenges in Getting Public Acceptance on Geothermal Project in Indonesia. In *48th Workshop on Geothermal Reservoir Engineering* (Vol. 6, Issue 8). Stanford University. <https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2023/Fadhilah.pdf>

<sup>69</sup> n. 6

<sup>70</sup> Mukano, R., Jibiki, K., & Shiga, Y. (2023, January 25). Indonesia's geothermal plants billow with foreign investments. *Nikkei Asia*. Retrieved from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>

<sup>71</sup> Koty, A. C. (2022, July 22). An Overview of Indonesia's Geothermal Energy Sector. *Asean Briefing*. Retrieved from <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/n/>

<sup>72</sup> Fadhilah, F., et.al. (2023). Challenges in Getting Public Acceptance on Geothermal Project in Indonesia. In *48th Workshop on Geothermal Reservoir Engineering* (Vol. 6, Issue 8). Stanford University. <https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2023/Fadhilah.pdf>

PR 112/2022 introduces a new regulatory framework for the electricity sector in Indonesia, specifically targeting renewable energy ventures. Under this regulation, most upcoming renewable energy projects will be subject to a maximum benchmark price, encompassing solar, geothermal, hydro (excluding peaker plants), wind, biomass, or biogas power facilities solely constructed by Independent Power Producers (IPPs).<sup>73</sup> Additionally, the regulation prohibits the establishment of additional coal-fired power plants, with a few exceptions (exceptions include if they were already in progress or had secured financial backing according to the Electricity Supply Business Plan (RUPTL) before September 13, 2022).<sup>74</sup>

Despite these efforts, there remains a lack of significant regulations mandating the use of renewable energy in Indonesia, posing challenges for geothermal energy to compete with coal production prices.<sup>75</sup> However, PR 112/2022 introduces a new tariff regime with predetermined maximum benchmark prices for renewable energy projects, varying based on factors such as plant type, size, PPA term, and location, aiming to promote renewable energy development.<sup>76</sup>

Indonesia is currently behind in its original goal of reaching 7 GW by 2025 and is now set to reach it by around 2030. Its geothermal production isn't accelerating at the rates that the government originally aimed for.<sup>77</sup> Yet, the primary challenge lies in making renewable energy accessible to consumers who highly favor purchasing it through renewable energy certificates, as well as to other potential consumers who remain unengaged. Vital for fostering demand is the support for infrastructure development, including smart grids and smart meters.<sup>78</sup> It takes around 15 years from the start of researching a geothermal spot and then generating power from it, which is often time-consuming due to the various bureaucratic levels that some projects have to pass through to gain permits.<sup>79</sup>

### ***Trade:***

Corporations from countries, including Japan and Singapore, have invested billions of dollars in Indonesia's geothermal energy production.<sup>80</sup> Likewise, the U.S.-Indonesia Strategic Partnership,

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<sup>73</sup> Sambado, M. T. (2023, May 3). Policy uncertainty stalls Indonesia's energy transition. *East Asia Forum*. Retrieved from <https://eastasiaforum.org/2023/05/03/policy-uncertainty-stalls-indonesias-energy-transition/>

<sup>74</sup> Ibid.

<sup>75</sup> Koty, A. C. (2022, July 22). An Overview of Indonesia's Geothermal Energy Sector. *Asean Briefing*. Retrieved from <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/n/>

<sup>76</sup> n. 12

<sup>77</sup> Koty, A. C. (2022, July 22). An Overview of Indonesia's Geothermal Energy Sector. *Asean Briefing*. Retrieved from <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/n/>

<sup>78</sup> n. 12

<sup>79</sup> Mukano, R., Jibiki, K., & Shiga, Y. (2023, January 25). Indonesia's geothermal plants billow with foreign investments. *Nikkei Asia*. Retrieved from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>

<sup>80</sup> The White House. (2023, November 14). *Joint statement from the leaders of the United States and the Republic of Indonesia: Elevating relations to a comprehensive strategic partnership*. Retrieved from

established in 2015,<sup>81</sup> includes a Trade and Investment Framework Agreement (TIFA)<sup>82</sup> facilitating increased trade between the two countries. In November 2023, the U.S. and Indonesian governments made a joint statement on their intent to continue working together to foster a clean energy transition<sup>83</sup>

However, the infrastructure and service networks in Indonesia have not kept pace with the expanding economy, leading to heightened transaction costs and inefficiencies that hinder exporters and investors. Non-tariff barriers persist, alongside a cumbersome bureaucracy, with laws often ambiguous or contradictory. Import licensing procedures, permit requirements, product labeling mandates, pre-shipment inspections, local content stipulations, domestic manufacturing requisites, and quantitative import restrictions also act as obstacles to U.S. exports.<sup>84</sup> Numerous rule-of-law concerns persist, particularly regarding the inefficacy of formal dispute resolution mechanisms, with business and regulatory disputes, often considered administrative or civil matters in the US potentially facing criminalization in Indonesia. The judiciary's integrity is widely questioned due to prevalent corruption, and the Indonesian government actively discourages international arbitration, complicating the enforcement of foreign arbitration awards within the country.<sup>85</sup> These factors compounded by the intense competition from firms based in other countries like Singapore, China, Japan, Australia, Korea, Russia, France, and other regional competitors prompt U.S. firms to frequently adjust their business models and pricing strategies to remain competitive.<sup>86</sup>

### *Recommendation*

The challenges that Indonesia faces with its geothermal energy infrastructure and the high cost of initial construction of geothermal plants offer several indications to the U.S. government.

- ITA has the opportunity to export geothermal technology materials to Indonesia to meet these needs, but it is essential that this exportation is affordable to Indonesia, especially

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<https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/13/joint-statement-from-the-leaders-of-the-united-states-and-the-republic-of-indonesia-elevating-relations-to-a-comprehensive-strategic-partnership/>

<sup>81</sup> The White House. (2023, November 14). *Joint statement from the leaders of the United States and the Republic of Indonesia: Elevating relations to a comprehensive strategic partnership*. Retrieved from <https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/13/joint-statement-from-the-leaders-of-the-united-states-and-the-republic-of-indonesia-elevating-relations-to-a-comprehensive-strategic-partnership/>

<sup>82</sup> Ibid.

<sup>83</sup> The White House. (2023, November 14). *Joint statement from the leaders of the United States and the Republic of Indonesia: Elevating relations to a comprehensive strategic partnership*. Retrieved from <https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/13/joint-statement-from-the-leaders-of-the-united-states-and-the-republic-of-indonesia-elevating-relations-to-a-comprehensive-strategic-partnership/>

<sup>84</sup> (n.d.). *Indonesia - Market Challenges*. Privacy Shield Framework; International Trade Administration.

<sup>85</sup> Ibid.

<sup>86</sup> Ibid.



due to the high costs they face associated with investing initially into geothermal energy as geothermal energy production continues to expand in Indonesia.

- ITA could facilitate partnerships between American clean technology companies and Indonesian counterparts to jointly invest in geothermal energy projects. Additionally, collaboration with multilateral organizations such as the World Bank or Asian Development Bank could help mobilize additional financing for geothermal development in Indonesia.
- ITA could advocate for regulatory reforms in Indonesia to create a more conducive environment for renewable energy investment. This could include lobbying for streamlined permitting processes, clearer regulations on renewable energy tariffs, and measures to address non-tariff barriers and bureaucratic inefficiencies.

## Export Challenges

To attract leading energy players to support Indonesia's geothermal ambitions and achieve its target of commissioning 6.2 GW of geothermal energy by 2030, regulators must work with stakeholders in the electricity sector to streamline permitting processes, update renewable energy tariffs and simplify concession agreements to allow Indonesia to achieve the goals of its net-zero program.<sup>87</sup>

### **Market and regulatory barriers**

Developing geothermal energy in Indonesia present a number of challenges, including the energy source's positioning in the regulatory and market landscape. Geothermal energy in Indonesia continues to be significantly more expensive than coal, which is also abundant in the country. Coal makes up about 60% of Indonesia's electricity production, and the government continues to subsidize its use for energy production.<sup>88</sup>

With new coal plants in development, it is far from being phased out as a key energy source, even if its share gradually declines. In the absence of regulations that require the use of

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<sup>87</sup> Post, T. J. (n.d.). *International partnerships key unlocking Indonesia's geothermal potential—Academia*. The Jakarta Post. Retrieved February 26, 2024, from <https://www.thejakartapost.com/opinion/2023/06/12/international-partnerships-key-unlocking-indonesias-geothermal-potential.html>

*Indonesia's geothermal plants billow with foreign investments*. (n.d.). Nikkei Asia. Retrieved February 26, 2024, from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>

<sup>88</sup> *An overview of Indonesia's geothermal energy sector*. (2022, July 28). ASEAN Business News. <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/>

renewable energy, it is extremely challenging for geothermal energy producers to compete with the price of coal energy.

Apart from coal, wind and solar power are increasingly cost-effective and competitive energy sources with advancements in technology. In contrast, cost efficiencies in geothermal energy production – especially in Indonesia – have not kept pace.

Just 12% of Indonesia's energy comes from renewables, compared to 20% of the Philippines, another large island-based country in Southeast Asia. Indonesia only capitalizes on 2% of its combined potential of geothermal, solar, wind, hydro, and biomass energy sources. Without further innovation in geothermal energy, the potential of wind and solar energy may become increasingly prioritized by the Indonesian government.

Three state-owned enterprises dominate geothermal energy production in Indonesia: PT Pertamina Geothermal Energy (PGE), PT PLN Gas and Geothermal, and PT Geo Dipa Energi. PGE is especially dominant, as it is responsible for about 82 percent of the country's entire geothermal energy production. This lack of competition in the sector risks hampering innovation.

The government is trying to address these various challenges by making the sector more attractive to foreign investors, via reforms through the Omnibus Law. Business lines involving exploration and drilling in the geothermal sector will be considered a priority business sector and companies can receive a tax allowance for such activities. Further, foreign capital ownership for projects in this sector has increased to 70% for ASEAN-based companies, and 67% for non-ASEAN-based companies.

## Challenges to Sectoral Growth

As geothermal technology is on the rise in Indonesia, the government claims to increase its utilization in the national energy mix to 5% by 2025. However, certain market risks remain with adopting geothermal, both upstream and downstream. Such risks include exploration uncertainties, high costs, public resistance, and regulatory uncertainty.

### *Upstream challenges*

A primary challenge is resource exploration risk wherein insufficient heat sources and inadequate well capacities might not offer the returns needed to make the projects profitable.

And since the projects require high upfront costs, assurance that returns on investments will be received is crucial. Better exploration technology and studies need to be conducted in order to increase the certainty of well potentials<sup>89</sup>. Lastly, the overlap of thermal wells of interest with existing forest land and heritage sites has led development to face public resistance.

### *Downstream challenges*

Possible downstream challenges are based on Indonesia's geothermal electricity pricing, which is unappealing for new investments due to low Feed-in Tariffs, complex pricing mechanisms, and the absence of long-term contracts.<sup>90</sup> Many geothermal sites in remote areas have a low electricity demand. The small market size does not support the high costs of developing geothermal power plants. Additionally, connecting these areas to the national grid adds to high costs and, leads to underused capacities or shutdowns due to insufficient demand. Further, regulatory uncertainties result in significant barriers to geothermal development, with constant policy shifts, complex permitting processes, and national-local regulatory discrepancies creating challenges for investors. These factors contribute to planning difficulties, project delays, and increased costs.<sup>91</sup>

### *Recommendation*

- a) ITA could enable private investments in research and development (R&D) for both thermal well exploration as well as project site development in order to minimize project costs and reduce financial risk.
- b) Enabling financing exploration and development drilling for geothermal sites might establish more central power plants with a better connection to the central power grid. Additionally, reducing infrastructure costs by public-private partnerships facilitated through the ITA and regulatory uncertainties will establish more opportunities for market access and reduce barriers.

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<sup>89</sup>Pambudi, N. A., & Ulfa, D. K. (2024). The geothermal energy landscape in Indonesia: A comprehensive 2023 update on power generation, policies, risks, phase and the role of education. *Renewable and Sustainable Energy Reviews*, 189, 114008.

<sup>90</sup> World Bank. 'Indonesia Geothermal Resource Risk Mitigation Project.' World Bank, 2019.

<sup>91</sup> APEC. 'Geothermal Energy in Australia and Indonesia.' Asia-Pacific Economic Cooperation, 2013.

## Main Competitors for U.S. Exports

The global geothermal market is characterized by a competitive landscape with 28 key players<sup>92</sup> (Appendix C). This landscape highlights the significant competition U.S. firms face internationally, with Italian and Japanese geothermal companies not only having an expansive global footprint that benefit from supportive government initiatives, such as Japan's Africa Business Education program<sup>93</sup> and the European Investment Bank's \$95 million investment in Eastern Africa's geothermal projects.<sup>94</sup> Japan International Cooperation Agency (JICA) has also signed a technical cooperation project with Kenya focusing on capacity strengthening for geothermal steam supply and management.<sup>95</sup> Despite this stiff competition, the U.S. leads with eight companies (Appendix C), showcasing the experience and a broad geographical reach in the geothermal sector.

In Indonesia, the geothermal market dynamics are influenced heavily by state-owned enterprises such as Pertamina and PLN, alongside their subsidiaries Geo Dipa and Pertamina Geothermal Energy (PGE), which play a significant role. The market, while moderately consolidated, is dominated by Indonesian SOEs, with PGE covering 82% of national production.<sup>96</sup> The entry of key foreign players like Toshiba, delivering 307MW worth of steam turbines, exemplifies the competitive environment.<sup>97</sup> However, the lack of transparency in PGE's supplier structure and the signing of Memorandums of Understanding with companies like Chevron New Energy International and KS Orka Renewables for significant geothermal capacities highlight the strategic collaborations shaping the market.<sup>98</sup> Despite these developments, the growth of renewable energies, including geothermal, faces challenges from the expanding coal power capacity.

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<sup>92</sup>Geothermal energy companies - Top company list. (n.d.). Retrieved from <https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>. Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from

<https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721> & Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from <https://www.gminsights.com/industry-analysis/geothermal-energy-market>

<sup>93</sup> Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝. <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>

<sup>94</sup> EIB. (2021, June 17). *East African rift geothermal*. European Investment Bank. <https://www.eib.org/en/projects/pipelines/all/20210194>

<sup>95</sup> Signing of Record of Discussions on Technical Cooperation Project with Kenya: Capacity building to promote geothermal development in the county. *Press Releases. JICA*. (n.d.). [www.jica.go.jp](http://www.jica.go.jp). [https://www.jica.go.jp/Resource/english/news/press/2021/20211210\\_30.html](https://www.jica.go.jp/Resource/english/news/press/2021/20211210_30.html)

<sup>96</sup> *An overview of Indonesia's geothermal energy sector*. (2023, October 16). ASEAN Business News. <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/>

<sup>97</sup> *Delivery records*. (2021.). トップページ | 東芝.

<https://www.global.toshiba/ww/products-solutions/renewable-energy/delivery-records/geothermal-power.html#geo><https://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshibas-energy-solutions-in-africa.html>

<sup>98</sup> (Persero), P. P. (2023, July 12). *Massively developing renewable energy, Pertamina group signs 9 mous*. Pertamina. <https://www.pertamina.com/en/news-room/news-release/massively-developing-renewabl-energy-pertamina-group-signs-9-mous>

In conclusion, the US, with its leadership in the number of geothermal companies and extensive industry experience, is well-positioned to compete in the global market. However, the competitive landscape, particularly in Indonesia, is complex, characterized by strong domestic players and the strategic involvement of foreign companies backed by government initiatives. To navigate this environment, the ITA should enable US firms to form strategic partnerships with local companies and SOEs and facilitate engagement via diplomatic channels for supportive trade negotiations.

## Public Education

Public education on geothermal technology is indispensable in Indonesia due to various factors. Traditional geothermal systems are favored over Enhanced Geothermal Systems (EGS), which require hydraulic stimulation involving high-pressure water injection, potentially inducing earthquakes. Moreover, technical concerns including water contamination and micro-seismic activity, alongside social and ethical considerations, underscore the importance of informed decision-making. Decision-makers and administrative bodies wield significant influence in geothermal energy adoption, emphasizing the necessity of citizen engagement and clear communication channels. Instances of public outrage in regions like South Korea and Italy highlight the global variance in public opinion on geothermal energy. To address this, educational strategies must be implemented, starting with surveys and policy-level changes to alter public perception and increase acceptance. Efforts should also concentrate on raising awareness among decision-makers, administrative bodies, and civil society groups, utilizing national strategies to stimulate citizen engagement and acceptance of renewable energy sources.

In Indonesia, geothermal technology was not generally perceived as threatening but more linked to clean and green technology. However, the public acceptance of geothermal energy plants varies nationally and locally due to factors like proximity to power plants, environmental impact, and cultural and political considerations. The main concerns of the local communities can be classified into environmental, social, and cultural.

- Environmental concerns: Due to less road connectivity in the rural areas where projects are established, large forest covers are affected. Therefore, the management of road access is crucial to mitigate the risk of increased pressure on forests and forest wildlife.<sup>99</sup> Furthermore, water scarcity and contamination threats were widespread, while fear of

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<sup>99</sup> Ampaire, C. (2020, October 6). Environmental and Social Impacts of Geothermal Development in Conservation Forest Areas in Indonesia [Review of Environmental and Social Impacts of Geothermal Development in Conservation Forest Areas in Indonesia]. *Profor*.

increased seismic activity was also noted in different parts of the country including Tampomas, and Mount Talang.<sup>100</sup>

- **Social Concern:** Social concerns were mostly concerning the well-being of the community and the potential economic benefits and impact on the local community. The majority of the community works as farmers, therefore they look forward to improved access to electricity, road connectivity, job opportunities as well as tax revenues through these infrastructure projects. However, they also fear the negative impacts that may occur in Mt. Lawu. They depend heavily on water springs throughout Mt. Lawu. If the project causes a decrease in water quantity that they cannot irrigate their field, they fear that they will be forced to move to a profession other than a farmer.<sup>101</sup> Land management issue - On Saturday 25 November, numerous indigenous communities organized a new protest demonstration against the geothermal power plant of the public energy company PLN which is taking shape on the slopes of Poco Leok, a volcano in the western part of the island of Flores, Indonesia.<sup>102</sup>
- **Cultural:** Studies have hinted at the existence of a spiritual relationship with geothermal resource sites. Disturbance to sacred places due to project activities was a major concern for local communities in several locations including Bali and Mount Lawu.<sup>103</sup>

### *Recommendation*

The ITA should monitor the following actions by the Indonesian government to identify inflection points for launching a successful PPP program for geothermal technologies. These recommendations highlight key improvement areas for Indonesia that would make it a more attractive export destination:

- a) In Indonesia, the main concerns encompass adverse effects on livelihoods, environmental degradation, challenges in land management, and disruption of sacred sites.
- b) The ITA should actively monitor the environmental and social impact assessment report to gain deeper insights into public perceptions regarding the ongoing project.
- c) ITA could establish training and capacity-building sessions for local administration and employees on the exported technologies, facilitating effective management of the

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<sup>100</sup> Fadhillah, F., et.al. (2023). Challenges in Getting Public Acceptance on Geothermal Project in Indonesia. In *48th Workshop on Geothermal Reservoir Engineering* (Vol. 6, Issue 8). Stanford University.

<https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2023/Fadhillah.pdf>

<sup>101</sup> Prasetyo, I., et.al. (2019). Understanding Social Acceptance of Geothermal Energy: A Case Study from Mt. Lawu, Indonesia. *IOP Conference Series: Earth and Environmental Science*, 254, 012009. <https://doi.org/10.1088/1755-1315/254/1/012009>

<sup>102</sup> Hariyadi, M. (2023, November 30). Flores, indigenous people protesting against geothermal power plant attacked. *Asia News*. <https://www.asianews.it/news-en/Flores.-indigenous-people-protesting-against-geothermal-power-plant-attacked-59663.html>

<sup>103</sup> Trisiah, A., et.al (2022) Framing Geothermal Energy in Indonesia: A Media Analysis in A Country with Huge Potential, *Environmental Communication*, 16:7, 993-1001, DOI: [10.1080/17524032.2022.2144403](https://doi.org/10.1080/17524032.2022.2144403)

geothermal plant projects, thereby promoting operational efficiency and mitigating potential disputes.

## Conclusion

This report highlights the immense potential for a United States (U.S.) public-private partnership (PPP) aimed at promoting geothermal technology exports to Indonesia, the world's second-largest geothermal energy producer. While Indonesia's state-owned enterprises (SEO) dominate the geothermal sector, the entry of foreign firms in supplying components is an indicator that Indonesia is a **strong potential candidate** for a geothermal technology PPP program.

Despite the challenges posed by regulatory complexities, infrastructure limitations, and competition from other countries, Indonesia's commitment to renewable energy and its vast untapped geothermal resources present significant opportunities for U.S. exporters. Strategic recommendations outlined below, including stakeholder engagement, regulatory reforms, and public education initiatives, offer pathways to enhance the success of a PPP targeted toward Indonesia's geothermal market.

- The ITA should focus its efforts with those of the Department of State in engaging the Indonesian government and SEO in understanding what their medium to long-term plans are for geothermal development and what role U.S. companies could play.
- Increasing engagement with the Ministry of Energy and Mineral Resources, Ministry of Environment and Forestry, Ministry of Trade, PT Pertamina, and Perusahaan Listrik Negara as well as convening foras whereby SEOs like PT. PLN Gas & Geothermal, PT Pertamina Geothermal Energy, and Supreme Energy could also identify key entry points for growth.
- Based on outcomes of discussions the ITA could enable U.S. firms to form strategic partnerships with local companies and SOEs through PPPs that facilitate engagement via diplomatic channels for supportive trade negotiations
- The ITA may be able to encourage investment from U.S. companies into research and development for both upstream and downstream geothermal supply chain routes to 1) minimize exploration risk and cost, and 2) better integrate geothermal into the central grid, which will increase market access and access to new development opportunities. U.S. companies' technological and experience lead could be well employed in this area.

- If the ITA chooses to focus on the Philippines, successes and synergies from these states should be translated and replicated in Indonesia.

By leveraging its expertise and experience in the geothermal sector, the U.S. has the potential to play a pivotal role in supporting Indonesia's clean energy transition and driving sustainable economic growth. Through collaborative efforts between government, private sector, academia, and civil society, the implementation of geothermal technology projects in Indonesia can not only address energy challenges but also contribute to environmental preservation, social development, and economic prosperity.





## Bibliography

1. APEC. 'Geothermal Energy in Australia and Indonesia.' Asia-Pacific Economic Cooperation, 2013.
2. Ampaire, C. (2020, October 6). Environmental and Social Impacts of Geothermal Development in Conservation Forest Areas in Indonesia [Review of Environmental and Social Impacts of Geothermal Development in Conservation Forest Areas in Indonesia]. *Profor*.
3. *An overview of Indonesia's geothermal energy sector*. (2022, July 28). ASEAN Business News.  
<https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/>
4. *An overview of Indonesia's geothermal energy sector*. (2023, October 16). ASEAN Business News.  
<https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/>
5. *Delivery records*. (2021.). トップページ | 東芝.  
<https://www.global.toshiba/ww/products-solutions/renewable-energy/delivery-records/geothermal-power.html#geohttps://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshibas-energy-solutions-in-africa.html>
6. EIB. (2021, June 17). *East African rift geothermal*. European Investment Bank.  
<https://www.eib.org/en/projects/pipelines/all/20210194>
7. Fadhilah, F., et.al. (2023). Challenges in Getting Public Acceptance on Geothermal Project in Indonesia. In *48th Workshop on Geothermal Reservoir Engineering* (Vol. 6, Issue 8). Stanford University.  
<https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2023/Fadhilah.pdf>
8. Geothermal energy companies - Top company list. (n.d.). Retrieved from <https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>, Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from <https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721>
9. Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from <https://www.gminsights.com/industry-analysis/geothermal-energy-market>
10. Guild, J. (2023, November 21). *Indonesia's Coming Geothermal Boom*. The Diplomat.  
<https://thediplomat.com/2023/11/indonesias-coming-geothermal-boom/>
11. Hariyadi, M. (2023, November 30). Flores, indigenous people protesting against geothermal power plant attacked. *Asia News*.

- <https://www.asianews.it/news-en/Flores,-indigenous-people-protesting-against-geothermal-power-plant-attacked-59663.html>
12. *Indonesia's geothermal plants billow with foreign investments*. (n.d.). Nikkei Asia. Retrieved February 26, 2024, from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>
  13. *Indonesia's geothermal plants billow with foreign investments*. (n.d.). Nikkei Asia. Retrieved February 26, 2024, from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>
  14. (n.d.). *Indonesia - Market Challenges*. Privacy Shield Framework; International Trade Administration.
  15. (2021, May). *Indonesia: Geothermal Energy Market Overview*. Think Geoenergy. [https://www.thinkgeoenergy.com/country\\_overviews/indonesia/#:~:text=Geothermal%20Energy%20Market%20of%20Indonesia,exploration%20started%20already%20in%201918](https://www.thinkgeoenergy.com/country_overviews/indonesia/#:~:text=Geothermal%20Energy%20Market%20of%20Indonesia,exploration%20started%20already%20in%201918)
  16. *International—U. S. Energy information administration(E)*. (n.d.). Retrieved February 26, 2024, from <https://www.eia.gov/international/analysis/country/IDN>
  17. Koty, A. C. (2022, July 22). *An Overview of Indonesia's Geothermal Energy Sector*. Asean Briefing. Retrieved from <https://www.aseanbriefing.com/news/an-overview-of-indonesias-geothermal-energy-sector/n/>
  18. Mukano, R., Jibiki, K., & Shiga, Y. (2023, January 25). *Indonesia's geothermal plants billow with foreign investments*. *Nikkei Asia*. Retrieved from <https://asia.nikkei.com/Business/Energy/Indonesia-s-geothermal-plants-billow-with-foreign-investments>
  19. Pambudi, N. A., & Ulfa, D. K. (2024). *The geothermal energy landscape in Indonesia: A comprehensive 2023 update on power generation, policies, risks, phase and the role of education*. *Renewable and Sustainable Energy Reviews*, 189, 114008.
  20. Persero, P. P. (2023, July 12). *Massively developing renewable energy, Pertamina group signs 9 mous*. Pertamina. <https://www.pertamina.com/en/news-room/news-release/massively-developing-renewable-energy-pertamina-group-signs-9-mous>
  21. Post, T. J. (n.d.). *International partnerships key unlocking Indonesia's geothermal potential—Academia*. The Jakarta Post. Retrieved February 26, 2024, from <https://www.thejakartapost.com/opinion/2023/06/12/international-partnerships-key-unlocking-indonesias-geothermal-potential.html>

22. Prasetyo, I, et.al. (2019). Understanding Social Acceptance of Geothermal Energy: A Case Study from Mt. Lawu, Indonesia. *IOP Conference Series: Earth and Environmental Science*, 254, 012009. <https://doi.org/10.1088/1755-1315/254/1/012009>
23. Sambado, M. T. (2023, May 3). Policy uncertainty stalls Indonesia's energy transition. *East Asia Forum*. Retrieved from <https://eastasiaforum.org/2023/05/03/policy-uncertainty-stalls-indonesias-energy-transition/>
24. *Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝.* <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>
25. The White House. (2023, November 14). *Joint statement from the leaders of the United States and the Republic of Indonesia: Elevating relations to a comprehensive strategic partnership*. Retrieved from <https://www.whitehouse.gov/briefing-room/statements-releases/2023/11/13/joint-statement-from-the-leaders-of-the-united-states-and-the-republic-of-indonesia-elevating-relations-to-a-comprehensive-strategic-partnership/>
26. Trisiah, A, et.al (2022) Framing Geothermal Energy in Indonesia: A Media Analysis in A Country with Huge Potential, *Environmental Communication*, 16:7, 993-1001, DOI: [10.1080/17524032.2022.2144403](https://doi.org/10.1080/17524032.2022.2144403)
27. *With its abundant geothermal reserves, Indonesia aims to harvest more green energy.* (n.d.). CNA. Retrieved February 26, 2024, from <https://www.channelnewsasia.com/asia/indonesia-geothermal-energy-reserves-green-energy-sustainable-clean-electricity-renewable-climate-change-3874151>
28. World Bank. 'Indonesia Geothermal Resource Risk Mitigation Project.' World Bank, 2019.

## Appendix A

|  | Stakeholder | Stakeholder Description | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i> |
|--|-------------|-------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
|  |             |                         |                                                                                             |                                                                                             |

|                   |                                                 |                                                                                                                                                                                                                                                        |                    |                                                                                                                                                                                                                                                                                                          |
|-------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Government</b> | Ministry of Energy and Mineral Resources (ESDM) | The Ministry is responsible for providing assistance to the President and Vice President in performing government affairs in the field of energy and mineral resources.                                                                                | Support            | ESDM is highly involved in the evaluation and development of geothermal energy production.                                                                                                                                                                                                               |
|                   | Ministry of Environment and Forestry            | The Ministry is responsible for managing and conserving the nation's forests.                                                                                                                                                                          | Resist             | Most geothermal potential in Indonesia is in or close to forest areas, which increases concern about new production's adverse environmental impacts. Therefore, the Ministry would require robust environmental risk mitigation measures to be undertaken for any new development.                       |
|                   | Perusahaan Listrik Negara (PLN)                 | PLN is an Indonesian government-owned corporation which has a monopoly on electric power distribution in Indonesia and generates the majority of the country's electrical power.                                                                       | Support or Neutral | PLN has large debts due to expensive coal power contracts and is exploring geothermal power production potential through its subsidiary PLN GG. In the medium term it would likely support this program for its potential to increase renewable energy production through more competitive technologies. |
|                   | PT Pertamina (Persero)                          | PT Pertamina is a state-owned oil and natural gas corporation based in Jakarta. It is the largest company in Indonesia.                                                                                                                                | Resist             | Pertamina Geothermal Energy is a fully owned subsidiary of PT Pertamina focused on geothermal energy development, however given the parent company's focus on fossil fuels it may resist rapid changes in the country's energy mix.                                                                      |
|                   | Ministry of Trade                               | The Ministry directs the formulation of policies related to the development of trade in Indonesia.                                                                                                                                                     | Support            | The Ministry would likely support this initiative as it would stimulate trade and business in the geothermal industry.                                                                                                                                                                                   |
| <b>Academia</b>   | Institut Teknologi Bandung (ITB)                | BANDUNG, itb.ac.id--Institut Teknologi Bandung (ITB) and Kyoto University, Japan, strengthen research collaboration on geothermal exploration technology development through a project called BAGUS, or Beneficial and Advanced Geothermal Use System. | Resist             | Already in partnership with Japan, a potential conflict of the US in geothermal technology export                                                                                                                                                                                                        |

|                |                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |         |                                                                                                                                                                                                                                                                |
|----------------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                | Geothermal Research Center (GRC) | Geothermal Research Center (GRC) Faculty of Engineering UGM was established on 16th February 1995 by the Minister of Mining and Energy of the Republic of Indonesia. It was initiated through the Faculty of Engineering UGM and PERTAMINA joint research on heat and mass transfer in geothermal system (1993 – 1998) that involved the Departments of Geological Engineering, Mechanical Engineering, Electrical Engineering, Chemical Engineering, and Physical Engineering. | Support | GRC's mission is development and breakthrough in geothermal technologies in Indonesia                                                                                                                                                                          |
| Private Sector | PT. PLN Gas & Geothermal         | PT. PLN Gas & Geothermal (PLN GG) is a subsidiary of PT. PLN (Persero).                                                                                                                                                                                                                                                                                                                                                                                                         | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|                | Geo Dipa Energi, PT              | PT. Geo Dipa Energi has since dedicated itself to capitalizing the economical and environmental value of geothermal energy. Leveraging the vast capacity of their power generator projects in Dieng and Patuha with potential energy being 400 MW of each. Geo Dipa Energi strives to meet national electrical power demand by capitalizing on the cost-efficient and environmental qualities of geothermal energy.                                                             | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|                | Pertamina Geothermal Energy, PT  | PT. Pertamina Geothermal Energy is one of the largest geothermal energy resources companies in Indonesia. The Company is a subsidiary of PT Pertamina (Persero) with PT Pertamina Dana Ventura. The company does business in geothermal energy utilizations.                                                                                                                                                                                                                    | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |

|                      |                                                 |                                                                                                                                                                                                                                                                                                                                                                                                |         |                                                                                                                                                                                                                                                                |
|----------------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | Sarulla Operations, Ltd.                        | PLN finally assigned the second lowest bidder (consortium of Medco-Ormat-Itochu) to develop Sarulla project. In April 2013, PLN, PGE and consortium signed the second amendment of ESC/JOC with new tariff agreement. WKP G. Sibual-buali is concession area of Sarulla Project with 440 MW developing plan. Now, Sarulla Operation, Ltd. has been production with a total capacity of 330 MW. | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|                      | Star Energy Geothermal                          | Star Energy is an independent energy company, engages in oil and gas production, and geothermal power generation and heat production. Star Energy acquired a 110 MW Wayang Windu geothermal power facility in November 2004.                                                                                                                                                                   | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
| <b>Civil Society</b> | Indonesian Forum for Living Environment (WALHI) | WALHI is an Indonesian NGO that works on a wide range of issues including natural resource management, indigenous rights, deforestation, and climate change.                                                                                                                                                                                                                                   | Depends | While WALHI is supportive of renewable energy development, its focus on indigenous rights and deforestation could lead to challenges against new geothermal power generation without appropriate environmental and social risk mitigation undertaken.          |
|                      | Yayasan Konservasi Alam Nusantara (YKAN)        | YKAN is an Indonesian environmental non-profit focused on implementing effective natural resource management through advocacy and partnerships.                                                                                                                                                                                                                                                | Resist  | YKAN's focus on community-led approaches to sustainable development could lead to challenges against new geothermal power generation without appropriate environmental and social risk mitigation undertaken.                                                  |
|                      | Local Communities and Indigenous Populations    | Indonesia is home to over 50 million indigenous peoples who tend to live in geographically isolated areas which may be well-suited for geothermal energy production.                                                                                                                                                                                                                           | Resist  | There have been several examples of protest by Indonesian indigenous peoples against geothermal energy development, most recently in November 2023 on the island of Flores against developments from PLN.                                                      |
|                      | Fossil Fuel Workers                             | All workers currently employed in any position within the fossil fuel sector.                                                                                                                                                                                                                                                                                                                  | Resist  | Without adequate workforce training, fossil fuel-related employees will resist widespread transition to clean energy due to uncertainty over employment.                                                                                                       |

## Appendix B

|            | Stakeholder                                    | Stakeholder Description                                                                                                                              | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i>                                                                                                                                  |
|------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Government | Office of the U.S. Trade Representative (USTR) | Part of the Executive Office of the President, USTR coordinates trade policy, resolves disagreements, and frames issues for presidential decision.   | Support                                                                                     | USTR has been a leading advocate for global liberalization of trade in environmental goods and services, including clean energy technologies.                                                                                |
|            | U.S. Trade and Development Agency (USTDA)      | The USTDA helps companies create U.S. jobs through the export of U.S. goods and services for priority infrastructure projects in emerging economies. | Support                                                                                     | This program could support business growth within the geothermal sector, thereby creating domestic employment opportunities. Fossil fuel dominant states may resist due to potential negative business impact.               |
|            | State Governments                              | State-level government officials across states developing renewable and/or fossil fuel energy production technologies.                               | Depends                                                                                     | States with major geothermal technology production would support a program that can boost the state's economy.                                                                                                               |
|            | Export-Import Bank of the United States (EXIM) | The EXIM Bank is the official export credit agency of the U.S.                                                                                       | Support                                                                                     | EXIM has been broadly supportive of existing clean technology export initiatives. Since 1992, EXIM has had a mandate in its congressional charter to increase support for environmental exports, including renewable energy. |
|            | International Trade Administration (ITA)       | The ITA is an agency within the U.S. Department of Commerce focused on export development and competitiveness.                                       | Support                                                                                     | This program would support the ITA's mission of strengthening U.S. global competitiveness and promoting trade and investment opportunities                                                                                   |

|                       |                                             |                                                                                                                                                                                                                                                                           |         |                                                                                                                                                                                                                                                                                                                |
|-----------------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | U.S. Department of Energy (DOE)             | DOE is the executive department of the U.S. that oversees national energy policy and energy production.                                                                                                                                                                   | Support | DOE has already undertaken significant measures to support the global transition to renewable energy. Its Geothermal Technologies Office works to reduce costs and risks associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges. |
|                       | U.S. Energy Association (USEA)              | USEA is an association of public and private energy-related organizations, corporations, nonprofits, educational institutions, think tanks and government agencies.                                                                                                       | Support | USEA works with DOE, DOS, and USAID to improve energy accessibility throughout the world. USEA has industry members who would be interested in participating in geothermal technology development in Indonesia.                                                                                                |
| <b>Academia</b>       | National Renewable Energy Laboratory (NREL) | NREL researches, develops, and demonstrates technologies to advance the use of geothermal energy as a clean, renewable, domestic energy source for the United States.                                                                                                     | Support | This program would benefit the expansion of US geothermal technologies, in line with the interest of NREL                                                                                                                                                                                                      |
| <b>Private Sector</b> | Calpine                                     | Calpine is the largest producer of geothermal power in the US, operating several plants in The Geysers located in north of San Francisco.                                                                                                                                 | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |
|                       | Ormat Technologies                          | Nevada-based Ormat Technologies claims to have developed more than 150 geothermal power plants across the world with a combined capacity of more than 2.1GW.                                                                                                              | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |
|                       | Berkshire Hathaway                          | Berkshire Hathaway's geothermal operations, which comprise 10 geothermal power plants in the Imperial Valley in southern California, are carried out by its subsidiary CalEnergy Operations. The plants are owned by another Berkshire Hathaway subsidiary CE Generation. | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |



|               |                                          |                                                                                                                                                                                                                                                 |         |                                                                                                                                                                                             |
|---------------|------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Northern California Power Agency         | The Northern California Power Agency (NCPA), a California Joint Action Agency, owns and operates two geothermal power plants with a combined generation capacity of 220MW.                                                                      | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                     |
|               | Terra-Gen Power                          | The company operates three geothermal power plants in the US with a combined generation capacity of 86.7MW.<br><br>The firm operates 67MW Dixie Valley Geothermal Power Plant located in Churchill County, Nevada. It was commissioned in 1988. | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                     |
| Civil Society | Natural Resources Defense Council (NRDC) | The NRDC is a U.S.-based non-profit environmental advocacy organization.                                                                                                                                                                        | Depends | The NRDC has published largely positive resources on its website regarding geothermal energy's potential to contribute to fighting the climate crisis.                                      |
|               | The Sierra Club                          | The Sierra Club is U.S.-based non-profit environmental advocacy organization.                                                                                                                                                                   | Resist  | The Sierra Club takes a cautious stance on geothermal, pointing out its adverse environmental impact and that it should be kept to a highly limited segment of renewable energy generation. |
|               | Center for Biological Diversity          | The Center for Biological Diversity is a non-profit membership organization focused on the protection of endangered species.                                                                                                                    | Resist  | The organization has been involved in prior lawsuits against geothermal energy producers over the adverse impact production has on biodiversity.                                            |
|               | Geothermal Rising                        | Geothermal Rising is a U.S.-based international non-profit association of professionals in the field of geothermal energy.                                                                                                                      | Support | Geothermal Rising has industry members who would be interested in participating in geothermal technology deployment in Indonesia                                                            |

## Appendix C

| Country       | Company Name           |
|---------------|------------------------|
| United States | Ormat Technologies Inc |

|                    |                                                |
|--------------------|------------------------------------------------|
|                    | Chevron                                        |
|                    | Calpine                                        |
|                    | Green Mountain Energy                          |
|                    | Haliburton                                     |
|                    | Tetra Tech Inc                                 |
|                    | Fervo Energy                                   |
|                    | Berkshire Hathaway Energy                      |
| <b>Japan</b>       | Toshiba Energy Systems & Solutions Corporation |
|                    | Fuji Electric Co. Lt                           |
|                    | Mitsubishi Power Ltd                           |
|                    | Sumitomo Corporation                           |
| <b>Italy</b>       | Ansaldo Energia SpA                            |
|                    | Enel SpA                                       |
|                    | Turboden SpA                                   |
|                    | Enel Green Power                               |
| <b>Indonesia</b>   | PT Pertamina Geothermal Energy                 |
|                    | Supreme Energy                                 |
| <b>Philippines</b> | Energy Development Corporation                 |
|                    | First Gen Corporation                          |
| <b>Kenya</b>       | Kenya Electricity Generating Company           |
|                    | Sosian Menengai Geothermal Power Ltd.          |
| <b>Iceland</b>     | Geothermal Energy Development Company          |
|                    | Reykjavik Geothermal                           |
| <b>Sweden</b>      | Atlas Copco Ab                                 |
| <b>France</b>      | Engie SA                                       |
| <b>South Korea</b> | Doosan Škoda Power                             |
| <b>Australia</b>   | Macquarie Group Limited                        |



# MEMO I

# Geothermal Energy

## *Philippines*

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March 4, 2024

## Executive Summary

This memo details the opportunities and challenges related to a potential United States (U.S.) public-private partnership (PPP) aimed at promoting geothermal technology exports to the Philippines, currently the third largest geothermal energy producer globally. Our analysis explores stakeholders, market dynamics, relevant policies, export challenges, sectoral growth challenges, key competitors, and public education requirements, along with recommendations for the ITA.

**Key Stakeholders:** Our research identifies various relevant Filipino government entities such as the Department of Energy (DOE), Department of Trade and Industry (DTI), and Department of Environment and Natural Resources (DENR). Private sector stakeholders include the U.S. Philippines Commerce and Industry Agency (USPCIA), Philippine Geothermal Production Company, Inc., and the Energy Development Corporation (EDC), among others. We also introduce the relevant academic institutions and civil society organizations.

**Market Analysis:** The Philippines is actively working to increase its geothermal capacity, aiming to surpass Indonesia as the world's second-largest user of geothermal power. With 2,350 MW currently installed and potential for 27,790 MW, the country has projects under construction and in feasibility studies, supported

by favorable policies for future market growth. Despite a COVID-19-induced downturn, the geothermal market in the Philippines has rebounded.

**Key Codes, Standards, and Regulatory Frameworks:** The Philippines allows 100% foreign ownership in large-scale geothermal projects under the technical or financial assistance regime, as stated in the 1987 Constitution. However, some geothermal projects face local opposition, often due to ecological concerns and indigenous land issues. Monitoring the completion of impact assessments and the implementation of anti-corruption policies is recommended to enhance the country's attractiveness for foreign investment in geothermal technologies.

**Export Challenges:** The Philippines is addressing its energy crisis by prioritizing energy security and climate change initiatives. The country has diversified its energy sector policies, leveraging geothermal technologies for a sustainable and resilient energy supply. The Renewable Energy Act of 2008 and various incentive mechanisms support geothermal development, aligning with national goals. Challenges include bureaucratic hurdles, regulatory uncertainties, and corruption, hindering the sector's growth. The Department of Energy aims to attract foreign investment and

enhance geothermal capacity, allowing 100% foreign ownership in large-scale projects. The Philippines, a significant U.S. trade ally, seeks to boost economic growth through relaxed ownership rules and tax incentives, positioning itself for increased foreign investment. The ITA should monitor policy actions, strengthen public-private partnerships, and support geothermal technology developers to navigate evolving regulations.

**Challenges to Sectoral Growth:** The Philippines faces challenges in the growth of its geothermal energy sector, experiencing slower development since 2007. Issues include technical constraints, economic challenges, regulatory uncertainties, and environmental concerns. Geothermal resources often lie in remote areas, complicating energy transmission and increasing infrastructure costs. The need for skilled professionals in geothermal engineering adds to the challenges. Financial incentives for geothermal projects are diminishing due to perceived risks, lengthy development times, and policy uncertainties. The government's support includes feed-in tariffs, renewable energy prioritization, and priority dispatch, but low financial investment hampers rapid market expansion. Strategic planning, community engagement, and robust risk mitigation are crucial to overcoming social and environmental challenges. The ITA should monitor government actions, support low to medium enthalpy projects, address technical, financial, and regulatory hurdles, and facilitate infrastructure improvements for sustainable geothermal development.

**Main Competitors for US Export:** The global geothermal market features intense competition, with U.S. firms facing challenges from Italian and Japanese companies. Despite this, the U.S. leads with eight key players, showcasing its experience and broad geographical reach. Focusing on the Philippines, rich geothermal resources offer growth opportunities, with key players including the Energy Development Corporation dominating the market. Recent policy changes in the Philippines, allowing full foreign ownership in large-scale geothermal projects, create openings for international investors. The ITA should assist U.S. companies in navigating the Philippine market dynamics, building relationships with local players, and capitalizing on the country's favorable foreign ownership policy.

**Public Education:** In the Philippines, expanding geothermal energy raises concerns about indigenous rights and land conservation, including issues of consultation, displacement, and environmental impact. Public education and social acceptance are crucial for sustainable energy development. Key findings highlight the historical context, the importance of social acceptability, and the need for public participation in the Environmental Impact Assessment (EIA) process. Strategies for a regenerative society, such as educational initiatives, demonstrate corporate social responsibility (CSR). Increasing awareness of national strategies can improve public perception of geothermal projects. Recommendations for the ITA involve monitoring environmental and social impact assessments, providing training for local

administration, and capacity-building for effective geothermal plant project management.

In the Philippines, despite challenges in scaling up the geothermal energy sector, the country's abundant resources, favorable policy environment, and geopolitical incentives make it a **prime candidate** for a geothermal technology export PPP program. Key challenges include technical, economic, regulatory, and sociopolitical factors, requiring transparent

engagement with government agencies. Recommendations include leveraging the strong U.S.-Philippines relationship, assisting companies with market dynamics, and monitoring government actions related to environmental impact assessments and capacity-building efforts. Key areas of focus involve addressing technical challenges, promoting anti-corruption policies, and implementing feed-in tariffs and energy infrastructure improvements.

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## Introduction

This memo discusses the potential for a United States public-private partnership (PPP) focused on promoting geothermal technology exports to the Philippines, the third largest geothermal energy producer in the world with 2,350 MW of current installed capacity. It introduces key domestic and international stakeholders, the current state of the geothermal market, key codes and regulatory frameworks, export challenges, sectoral growth challenges, competitor analysis, and public education requirements. We provide recommendations related to managing stakeholders, sectoral and export growth, and public education that can facilitate the success of a PPP targeted toward the Philippines. The conclusion includes a summary of these recommendations. Finally, the appendices at the end of the report provide further in-depth stakeholder analysis.

## Key Stakeholders

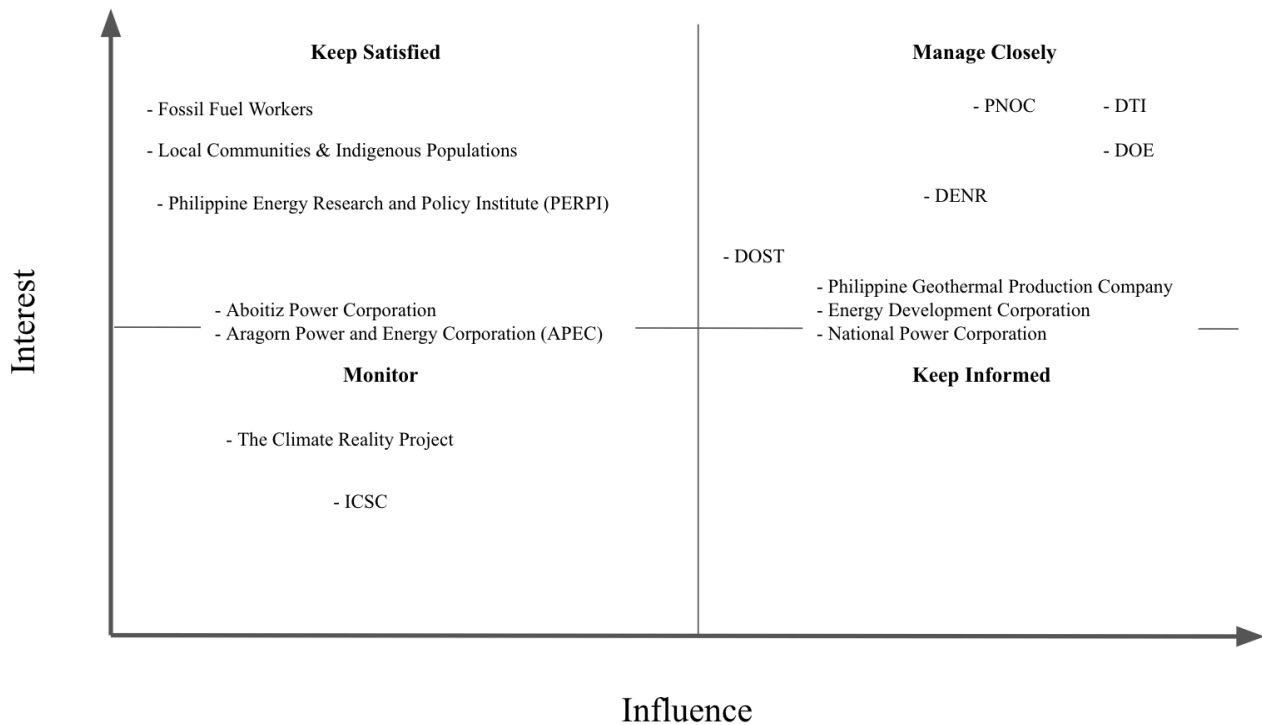
We have identified the following stakeholders across government, the private sector, academia, and civil society in the Philippines. See Appendix A for further analysis on each stakeholder, including whether they are likely to support this program and why or why not. See Appendix B for an analysis of U.S.-based stakeholders.

- *Government:* Department of Energy (DOE), Department of Trade and Industry (DTI), Department of Science and Technology (DOST), Department of Environment and Natural Resources (DENR), Philippine National Oil Company (PNOC)
- *Private Sector:* U.S. Philippines Commerce and Industry Agency (USPCIA), Petron Corporation, Philippine Geothermal Production Company, Inc., Energy Development Corporation, Aboitiz Power Corporation
- *Academia:* Philippine Energy Research and Policy Institute (PERPI - University of Philippines)
- *Civil Society:* The Climate Reality Project Philippines, Institute for Climate and Sustainable Cities (ICSC), Irosin Coalition Against Geothermal (ICAG), Local Communities & Indigenous Populations, Fossil Fuel Workers

### *Recommendation*

The following interest-influence matrix displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely). Interest is a function of the level of impact the program may have on each stakeholder, while influence is a function of how influential the stakeholder is in geothermal energy production and policy within the Philippines.

Figure 1: Philippines Stakeholder Analysis Matrix



## Market Analysis

Current number of geothermal plants: 7

Current geothermal production capacity: 2,350 MW

Estimated geothermal reserves: 27,790 MW

Total installed power capacity: 28,258 MW<sup>104</sup>

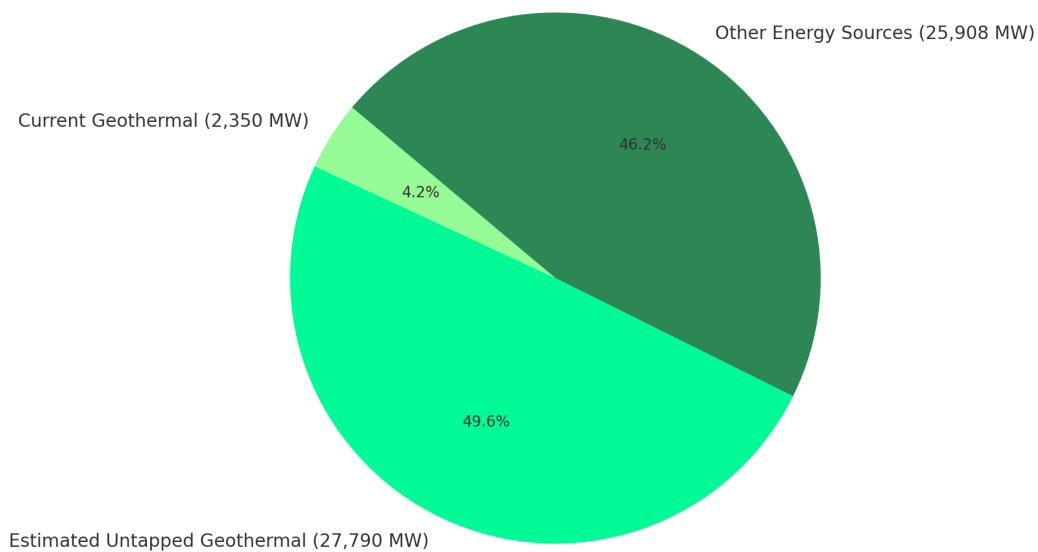
### Outlook

The Philippine government is actively pursuing more geothermal capacity, trying to overtake Indonesia as the second largest global user of geothermal power. The country has a current installed capacity of 2,350 MW, while the estimated geothermal capacity of the entire country is 27,790 MW. As of late 2023, the Philippines has three geothermal energy projects with a combined capacity of 48 MW under construction, with an additional 381 MW capacity for

<sup>104</sup> Philippines: Installed power capacity by plant type 2022. (n.d.). Statista. Retrieved February 26, 2024, from <https://www.statista.com/statistics/1266402/philippines-installed-power-capacity-by-source/>

projects currently undergoing feasibility studies.<sup>105</sup> While the market experienced a downturn during the COVID-19 pandemic it has since rebounded. Although there is currently relatively low domestic investment in geothermal, there are numerous supportive policies and regulations in place which will likely increase market size in the medium to long term as outlined further in this report.<sup>106</sup>

Figure 2: Philippines Total Energy Capacity Distribution



## Key Codes, Standards, and Regulatory Frameworks

### Key Findings

Under the 1987 Constitution, 100% foreign ownership of large-scale geothermal projects is allowed through the technical or financial assistance regime. Section 2, Article XII of the 1987 Constitution provides that the president may enter into agreements with foreign-owned corporations involving either technical or financial assistance for large-scale exploration, development and utilization of minerals, petroleum and other mineral oil. The Renewable Energy Act of 2008 recognizes that geothermal resources are "mineral resources."<sup>107</sup>

<sup>105</sup> Mercurio, R. (2023, September 29). Philippines aims to reclaim spot as 2nd biggest geothermal producer. Retrieved from <https://www.philstar.com/business/2023/09/29/2299750/philippines-aims-reclaim-spot-2nd-biggest-geothermal-producer>

<sup>106</sup> Geothermal energy market in the philippines—Size, share & analysis. (n.d.). Retrieved March 2, 2024, from <https://www.mordorintelligence.com/industry-reports/philippines-geothermal-energy-market>

<sup>107</sup> Philippines: Renewable energy sector is now open to full foreign ownership. (n.d.). Retrieved February 26, 2024, from <https://insightplus.bakermckenzie.com/bm/projects/philippines-renewable-energy-sector-is-now-open-to-full-foreign-ownership>

However, several geothermal plants have run into local opposition due to being located in sensitive ecological and geological areas. In some cases, the Philippine government and/or geothermal plant developers have paid indigenous groups, including through royalty payments, for the ability to construct plants and produce energy on ancestral land.<sup>108</sup>

### *Recommendations*

Monitor the following actions by the Philippines government to identify inflection points for timing a successful PPP program launch for geothermal technologies. These recommendations highlight key improvement areas for the Philippines that would make it a more attractive export destination:

- Completion of environmental and social impact assessments for geothermal production undertaken in the Philippines as a way to track local opposition, particularly from environmental NGOs and indigenous communities.
- Development and implementation of anti-corruption policies that will support the country's efforts to attract higher, and more consistent, levels of foreign direct investment.

## Export Challenges

As the Philippines confronts an imminent energy crisis, bolstering energy security and tackling climate change is increasingly prioritized by its government. Amid the challenges posed by COVID-19, the energy sector has leveraged diverse policy strategies to ensure uninterrupted energy supply to its consumers, sustaining approximately 20% of the electric grid by renewables.<sup>109</sup> The shift towards utilizing geothermal technologies with low to medium enthalpy by key industry players marks a significant step forward in overcoming these challenges.

Geothermal production ownership has transitioned from predominantly public models to incorporate more private and diverse organizations, aiming to enhance competitiveness, efficiency, and attract international capital. Recognizing the importance of unlocking the Philippines' vast but underutilized geothermal resources is crucial. Additionally, the country's geothermal-specific initiatives align with national goals to improve energy reliability, minimize greenhouse gas emissions, and foster sustainable growth by capitalizing on its natural geothermal assets driven by its location within the Ring of Fire.

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<sup>108</sup> *Geothermal energy projects heat up in Philippines and Indonesia*. (n.d.). Nikkei Asia. Retrieved February 26, 2024, from <https://asia.nikkei.com/Business/Energy/Geothermal-energy-projects-heat-up-in-Philippines-and-Indonesia>

<sup>109</sup> Richter, A. (2020, June 18). Geothermal in the Philippines - an urgent revamp of targets and development needed: ThinkGeoEnergy - Geothermal Energy News. ThinkGeoEnergy. <https://www.thinkgeoenergy.com/geothermal-in-the-philippines-an-urgent-revamp-of-targets-and-development-needed/amp/>

## *Policy*

The Renewable Energy Act of 2008, which offers various incentives for renewable energy developers, underpins this development in alternative energy sources.<sup>110</sup> Fiscal and non-fiscal incentive mechanisms such as the Renewable Portfolio Standards (RPS), Net Metering, and the Renewable Energy Market (REM) Trading System have been implemented to accelerate geothermal development.<sup>111</sup> However, the development and utilization of geothermal energy have slowed since 2007, with only 86 MW added to the total installed capacity despite the Renewable Energy Act of 2008.<sup>112</sup> Bureaucratic red tape, regulatory uncertainties, a slow judicial system, inconsistent application of laws, and corruption have been identified as main barriers to potential trade.<sup>113</sup>

## *Regulatory Framework*

The Department of Energy (DOE) is the primary government body responsible for policy formulation, implementation, and coordination of all government activities related to energy projects, including geothermal.<sup>114</sup> The Philippine Energy Plan 2020-2040 aims to develop remaining geothermal resources, attract foreign investment, and enhance geothermal installed capacity by 253MW from 2016 to 2030.<sup>115</sup> Encouraging private domestic and foreign investment is seen as a strategy to reduce dependence on energy imports. The Philippines allows for 100% foreign ownership in large-scale geothermal projects and offers additional incentives under the Risk Mitigation Policy.<sup>116</sup> The DOE also pursues the conduct of Open and Competitive Selection Process (OCSP) to offer prospective geothermal areas to private investors. Nonetheless, governmental red tape, regulatory uncertainties, and a slow judicial system are major challenges that could deter investment and delay projects. Clearer regulations and incentives are necessary to drive further growth in the geothermal energy sector, along with the development of undiscovered high temperature and low to medium temperature geothermal prospect areas.<sup>117</sup>

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<sup>110</sup> Department of Energy Philippines. (2008). Renewable Energy Act of 2008 (Republic Act No. 9513 of 2008). Department of Energy. <https://www.doe.gov.ph/sites/default/files/pdf/issuances/20081216-ra-09513-gma.pdf>

<sup>111</sup> (Philippines Renewable Portfolio Standard (RPS) planning calculator. Greening the Grid. (n.d.). <https://greeningthegrid.org/news/new-resource-philippines-renewable-portfolio-standard-rps-planning-calculator>

<sup>112</sup> Cariaga, C. (2023, October 3). Philippines strives to regain position as 2nd Largest Geothermal Power producer. Think GeoEnergy - Geothermal Energy News.

<https://www.thinkgeoenergy.com/philippines-strives-to-regain-position-as-2nd-largest-geothermal-power-producer/>

<sup>113</sup> Silva Rodríguez de San Miguel, J. A. (2020). Water governance in the USA. *Management of Environmental Quality*, 31(1), 130-145. <https://doi.org/10.1108/MEO-05-2019-0104>

<sup>114</sup> Guidebook on Net-Metering in the Philippines: Department of Energy Philippines. Department of Energy Philippines. (n.d.). <https://www.doe.gov.ph/renewable-energy/guidebook-net-metering-philippines>

<sup>115</sup> Department of Energy Philippines. (2016). Philippine Energy Plan 2016-2030. Retrieved from [https://www.doe.gov.ph/sites/default/files/pdf/pep/2016-2030\\_pep.pdf](https://www.doe.gov.ph/sites/default/files/pdf/pep/2016-2030_pep.pdf)

<sup>116</sup> NDC Partnership. (n.d.). Geothermal Risk Mitigation in the Philippines. Retrieved from <https://ndcpartnership.org/knowledge-portal/good-practice-database/geothermal-risk-mitigation-philippines>

<sup>117</sup> Economic Research Institute for ASEAN and East Asia. (2018). Assessment on Necessary Innovations for Sustainable Use of Conventional and New-Type Geothermal Resources and their Benefits in East Asia. Retrieved from [https://www.eria.org/uploads/media/12.ERIA-RPR-FY2017\\_07\\_Chapter\\_3\\_6.Philippines.pdf](https://www.eria.org/uploads/media/12.ERIA-RPR-FY2017_07_Chapter_3_6.Philippines.pdf)

### *Trade<sup>118</sup>*

The United States is a pivotal trade ally for the Philippines as its largest export destination and the fifth biggest source of imports. In 2022 the Philippines exceeded its economic growth target with 7.6% GDP growth, with another strong year in 2023, attributed to stronger domestic demand and the economic reopening, positioning it among the frontrunners in the ASEAN region and surpassing pre-pandemic levels. However, the country also faced a three-year high inflation rate of 5.8%, propelled by escalated costs in fuel, transport, and food, prompting the implementation of tariff reductions and interest rate adjustments to mitigate inflationary pressures. Despite a 5.9% increase in exports, the nation saw a significant 18.5% rise in imports.<sup>119</sup> Legislative initiatives have been introduced to boost foreign investment through relaxed ownership restrictions and tax incentives.<sup>120</sup> Yet, in comparison to its ASEAN peers, the Philippines lags in attracting foreign direct investment, despite its robust domestic demand post-COVID-19 and various ASEAN and preferential trade agreements with various countries.<sup>121</sup>

### *Recommendations*

Challenges such as governmental red tape, regulatory uncertainties, a slow judicial system, inconsistent application of laws, and corruption have been identified as obstacles to potential trade. However, the implementation of various policies designed to tackle these issues, along with the establishment of flexible taxing and ownership rules and the harnessing of substantial untapped geothermal resources, serves to alleviate these challenges. Fundamentally, the trade ties between the US and the Philippines are poised for growth, grounded in a strong base of food and defense trade. Despite delays in renewable energy development due to COVID-19, significant investments from international institutions and private enterprises are anticipated to boost numerous projects with a potential combined capacity of 381 MW, potentially surpassing Indonesia in global production.

The ITA should monitor the following actions by the Philippine government to identify potential inflection points in the policy and regulatory environment: strengthening public-private partnerships, enhancing the regulatory framework, focusing on research and development, expanding international cooperation, and emphasizing community engagement and environmental stewardship. The ITA should also prioritize the development of policy and financial de-risking mechanisms for energy market investments through multilateral

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<sup>118</sup> The following section, which reviews trade capacities within the Philippines, relies heavily on the insights provided by the U.S. Department of Commerce. (n.d.). Philippines Market Overview. Country Commercial Guides. Retrieved from [https://www.trade.gov/country-commercial-guides/philippines-market-overview#\\_msocom\\_1](https://www.trade.gov/country-commercial-guides/philippines-market-overview#_msocom_1)

<sup>119</sup> Open Economies. (n.d.). Bilateral trade between the USA and Philippines. Retrieved from <https://oec.world/en/profile/bilateral-country/usa/partner/phl>

<sup>120</sup> Department of Energy Philippines. (2008). Renewable Energy Act of 2008 (Republic Act No. 9513 of 2008). Department of Energy. <https://www.doe.gov.ph/sites/default/files/pdf/issuances/20081216-ra-09513-gma.pdf>

<sup>121</sup> Open Economies. (n.d.). Bilateral trade between the USA and Philippines. Retrieved from <https://oec.world/en/profile/bilateral-country/usa/partner/phl>

relationships. It should also extend financial, political, and technical support to geothermal technology developers as appropriate, and perform in-depth analysis of the Philippines' existing and developing geothermal plants and the regulatory framework to identify future changes in support of an inflow of geothermal technology imports.

## Challenges to Sectoral Growth

The market for geothermal power production in the Philippines has experienced slower growth rates since 2007, according to the Department of Energy (DOE).<sup>122</sup> Although multiple infrastructure and plant projects are currently in production, geothermal energy technology experiences some barriers to market development and sectoral growth. The main issues are related to technical development, economic and financial challenges, regulatory and policy frameworks, and environmental issues. DOE's strategy to focus on low to medium enthalpy geothermal resources and aim to assess the viability of small-scale geothermal power initiatives for local energy demands will help to address some of these key issues and reinvigorate the slowing sector.<sup>123</sup>

### *Technology*

In the Philippines, geothermal resources are often located in remote areas, far from urban centers or the main transportation routes, which makes energy transmission difficult and increases cost for energy infrastructure.<sup>124</sup> Further, exploration costs and drilling efforts make geothermal development in remote areas challenging, especially regarding smaller scale projects. Lastly, the country is in need of greater technical expertise and skilled professionals in geothermal engineering, project management and environmental science.<sup>125</sup>

### *Economics*

Financial incentives for geothermal projects are slowing down due to the high perceived risks from lengthy development times, high capital costs, and exploration uncertainties. Additionally, frequent shifts in economic policies and regulations leads to investment uncertainties. In the market the energy source competes with lower upfront cost from fossil fuels and other

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<sup>122</sup> Cariaga, C., et al. (2023, October 3). Philippines strives to regain position as 2nd largest geothermal power producer. Think GeoEnergy - Geothermal Energy News.

<sup>123</sup> Ibid.

Cariaga, C., et al. (2023, March 31). Call for abstracts - 4th Philippine International Geothermal Conference, 27-28 September. Think GeoEnergy - Geothermal Energy News.

<sup>124</sup> Richter, A., et al. (2022, July 8). Philippines DOE endorses four geothermal projects for grid impact study. Think GeoEnergy - Geothermal Energy News.

Geothermal Statistics | Department of Energy Philippines. [www.doe.gov.ph/geothermal-statistics](http://www.doe.gov.ph/geothermal-statistics).

<sup>125</sup> National Geothermal Association of the Philippines. (2023, September 25). Home. Retrieved from [www.ngaphil.com](http://www.ngaphil.com).

conventional energy sources.<sup>126</sup> This can be especially challenging during periods of low foreign direct investment receipts.

### *Policy*

To support geothermal energy development, the government considers feed-in tariff support, prioritizing renewable energy in the energy mix and priority dispatch for geothermal power. The full implementation of the Electric Power Industry Reform Act (EPIRA) and classification of geothermal outputs as priority dispatch could enhance geothermal's role in the energy mix. But low financial investment and economic incentives complicate and slow down the process of rapid market expansion.<sup>127</sup>

### *Environmental and Social*

Large land acquisitions for geothermal projects have caused social tensions and development delays, highlighting the need for strategic planning and better engagement with local communities. For some, geothermal activities pose environmental risks, including contamination of water and soil, air pollution, and potential seismic activities. It is critical for the Philippine government and project developers to implement robust risk mitigation strategies and secure community support.<sup>128</sup>

### *Recommendations*

The ITA should monitor the following actions by the Philippine government to identify inflection points for launching a successful PPP program for geothermal technologies. These recommendations highlight key improvement areas for the Philippines that would make it a more attractive export destination:

- a) Moving towards low to medium enthalpy geothermal resources and evaluating the feasibility of small-scale projects for local energy demands, facilitated by external investment via ITA.
- b) Addressing technical challenges in remote areas, financial risks, ensure regulatory stability, and manage environmental and social impacts to regain market growth in the geothermal space.

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<sup>126</sup> World Bank. (2010, April). A strategic approach to climate change in the Philippines: An assessment of low-carbon interventions in the transport and power sectors (Final report).

Economic Research Institute for ASEAN and East Asia. (2017). Assessment on necessary innovations for sustainable use of conventional and new-type geothermal resources and their benefits.

<sup>127</sup> Asian Development Bank. (2021). Energy policy: Supporting low carbon transition in Asia and the Pacific. Asian Development Bank.

Economic Research Institute for ASEAN and East Asia. (2017). Assessment on necessary innovations for sustainable use of conventional and new-type geothermal resources and their benefits.

<sup>128</sup> Environmental Management Bureau. (2021, March). Philippine Environmental Impact Statement System Brochure. Environmental Management Bureau.



- c) Facilitating the implementation of feed-in tariffs and improvements in infrastructure to support sustainable development of the geothermal market.

## Main Competitors for U.S. Exports

The global geothermal market is characterized by a competitive landscape with 28 key players<sup>129</sup> (Appendix C). This landscape highlights the significant competition U.S. firms face internationally, with Italian and Japanese geothermal companies not only having an expansive global footprint that benefit from supportive government initiatives, such as Japan's Africa Business Education program<sup>130</sup> and the European Investment Bank's \$95 million investment in Eastern Africa's geothermal projects.<sup>131</sup> Despite this stiff competition, the U.S. leads with eight companies (Appendix C), showcasing the experience and a broad geographical reach in the geothermal sector.

Focusing on the Philippines, notable geothermal fields like MakBan and Tongonan highlight the country's rich geothermal resources, approximately half of which remain untapped, presenting significant opportunities for growth and development in the sector.<sup>132</sup> The Philippine geothermal energy market is consolidated around a few key players, including the Philippine Geothermal Production Company, Inc., Energy Development Corporation (EDC), National Power Corporation, Aboitiz Power Corporation, and Aragorn Power and Energy Corporation (APC Group Inc.). Among these, the Energy Development Corporation is the dominant force, with an installed capacity of 1,484 MW, underscoring its pivotal role in the Philippines' geothermal landscape.<sup>133</sup>

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<sup>129</sup> Geothermal energy companies - Top company list. (n.d.). Retrieved from <https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>. Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from <https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721> & Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from <https://www.gminsights.com/industry-analysis/geothermal-energy-market>

<sup>130</sup> Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝. <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>

<sup>131</sup> EIB. (2021, June 17). *East African rift geothermal*. European Investment Bank. <https://www.eib.org/en/projects/pipelines/all/20210194>

<sup>132</sup> GeoEnergy, T. (2024, January 8). *ThinkGeoEnergy's top 10 geothermal countries 2023 – Power generation capacity*. ThinkGeoEnergy - Geothermal Energy News | News from the global geothermal power and large scale direct use industry. <https://www.thinkgeoenergy.com/thinkgeoenergys-top-10-geothermal-countries-2023-power-generation-capacity/>

<sup>133</sup> (2022.). EDC's Integrated Report – Our Annual Integrated Report. <https://integratedreport.energy.com.ph/>

Foreign companies like Toshiba have also made substantial contributions to the Philippine market, installing 510 MW worth of steam turbines for geothermal power plants.<sup>134</sup> This involvement is facilitated by the country's recent policy changes since 2020, which opened up large-scale geothermal projects, with initial investment costs over \$50 million, to full foreign ownership.<sup>135</sup> This policy shift represents a significant opportunity for international investors and companies to participate in the Philippines' geothermal sector.

### *Recommendations*

In conclusion, the situation in the Philippines presents a unique set of opportunities and challenges. The Philippine market is characterized by a few dominant local players and a welcoming stance towards foreign investment in large-scale projects. The ITA should help U.S. companies looking to expand their geothermal technology exports to the Philippines in providing an understanding of the local market dynamics and facilitate the building of relationships with key local players. Taking advantage of the country's open policy towards foreign ownership will be crucial and can benefit from additional diplomatic support by the ITA.

## Public Education

### *Introduction*

In the Philippines, the expansion of geothermal energy plants raises important concerns regarding indigenous rights<sup>136</sup> and land conservation. Some of the social issues raised against geothermal projects in the Philippines include lack of consultation and public participation for the approval of development projects, physical and economic dislocation of settlements, lack of benefits and compensation for social costs, encroachment of ancestral domain of indigenous communities, privatization of the people's forest patrimony, and concerns of environmental degradation and negative health effects.<sup>137</sup> Addressing these concerns is crucial for the sustainable development of the country's energy sector. This section highlights key findings and offers recommendations to improve public education and social acceptance of geothermal energy projects in the Philippines.

### *Key Findings*

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<sup>134</sup> *Delivery records*. (2021). トップページ | 東芝.

<https://www.global.toshiba/ww/products-solutions/renewable-energy/delivery-records/geothermal-power.html#geo><https://www.global.toshiba/ww/company/energy/topics/renewable-energy/toshibas-energy-solutions-in-africa.html>

<sup>135</sup> *Philippines allows 100% foreign ownership in large-scale geothermal projects*. (2020, October 27). RAPPLER.

<https://www.rappler.com/business/philippines-allows-full-foreign-ownership-large-scale-geothermal-projects/>

<sup>136</sup> Sarmiento, B. (2021, December 31). *In round 2 of Philippine geothermal project, tribes dig in for a greater say*. Mongabay.

<https://news.mongabay.com/2021/12/in-round-2-of-philippine-geothermal-project-tribes-dig-in-for-a-greater-say/>

<sup>137</sup> De Jesus, A. (2005). Social Issues Raised and Measures Adopted in Philippine Geothermal Projects. In *Proceedings World Geothermal Congress* (pp. 24–29). <https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2005/0219.pdf>

Historical Context and Importance of Social Acceptability<sup>138</sup>: Presidential Decree 1586 established the Philippines Environmental Impact Statement System (PEISS) in 1978 to balance socioeconomic growth with environmental protection. PEISS mandates projects to address public sentiments and conduct public consultations to resolve issues and conflicts, emphasizing the importance of social acceptability in project implementation.

Public Participation in Environmental Impact Assessment (EIA): Enhancing public engagement in the Environmental Impact Assessment (EIA) process appears to be crucial. Environmental Impact Statements (EIS) should result from informed public participation and meaningful engagement, requiring public involvement throughout the entire scope of the EIA project.

Strategizing for a Regenerative Society<sup>139</sup>: In 2009, Energy Development Corporation (EDC) initiated the Kananga-EDC Institute of Technology Educational Foundation, Inc. (KEITECH) as part of its CSR initiatives in Kananga, Leyte province, Philippines. This program aimed to support underprivileged high school graduates in accessing higher education and acquiring skills for global employability. Supported by the Municipality of Kananga and the Technical Education and Skills Development Authority (TESDA) of the Philippines, KEITECH's educational approach was tailored to local socio-economic conditions and the specific needs of impoverished communities to give back to the host community of the geothermal developer.

Knowledge of National Strategies: Increasing awareness of national strategies and commitments can stimulate citizen engagement and acceptance of renewable energy sources. Drawing lessons from countries like South Korea, public perception can improve when communities understand the regional significance of geothermal projects and their cost-effectiveness and economic benefits.

### *Recommendations*

The ITA should monitor the following public education-related actions by the Philippines government to identify inflection points for launching a successful PPP program for geothermal technologies. These recommendations highlight key improvement areas for the Philippines that would make it a more attractive export destination:

- Completion of environmental and social impact assessments for geothermal production undertaken in the Philippines as a way to track local opposition, particularly from environmental NGOs and indigenous communities.

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<sup>138</sup> Esquivel, C. (2021). *Responsibly Powering the Philippine Islands with Geothermal Energy*. Columbia Academic Commons. <https://doi.org/10.7916/d8-0k68-8c17>

<sup>139</sup> Cariaga, C. (2023, April 25). *How EDC fosters self-reliant host communities in Philippine geothermal sites*. Think Geoenergy. <https://www.thinkgeoenergy.com/how-edc-fosters-self-reliant-host-communities-in-philippine-geothermal-sites/>

- Training and capacity-building sessions for local administration and employees on the exported technologies, facilitating effective management of the geothermal plant projects, thereby promoting operational efficiency and ensuring a smooth transition.

## Conclusion

The Philippines' abundant geothermal primary energy resources combined with an increasingly supportive policy and economic environment and geopolitical incentive to re-invigorate trade relations with the United States under the Marcos Jr. administration make the country **a top candidate** for a geothermal technology export PPP program.

Still, there are several key challenges to scaling up the geothermal energy sector in the country and region as a whole. Technical challenges include the geographic isolation of the most suitable geothermal energy sources and the need for more local expertise across the sector. There are also various economic, regulatory, and sociopolitical challenges, including that geothermal project development requires high capital costs while the country lags Southeast Asian peers in attracting foreign direct investment, a history of conflict between geothermal developers and environment and indigenous rights groups, long standing issues with corruption at all levels of government, and regional competition in geothermal technology exports, particularly from Japan.

Despite these challenges, the Philippine government is actively pursuing more geothermal power, trying to overtake Indonesia as the second largest global user. The country has high potential for geothermal technology imports and infrastructure implementation, should the policy and investment environment remain supportive going forward.

Below is a summary of our key recommendations for ensuring the success of a Philippines-targeted geothermal PPP program:

- Engage regularly and transparently with the appropriate government agency counterparts within the Philippines, in particular the Department of Energy (DOE), Department of Trade and Industry (DTI), Department of Science and Technology (DOST), Department of Environment and Natural Resources (DENR), and Philippine National Oil Company (PNOC), about the country's geothermal technology needs and forward-looking regulatory and economic outlook.
- Leverage the strong historic trade and political relationship between the U.S. and the Philippines, while capitalizing on the Marcos Jr. administration's desire to further

strengthen the relationship. Emphasize the economic, geopolitical, and social benefit that a geothermal technology import program could bring to the Philippines.

- For U.S. companies looking to expand their geothermal exports to the Philippines, assist them with:
  - Better understanding the local market dynamics;
  - Building relationships with key local players described in the stakeholder section of this report;
  - Providing technical assistance to meet the local regulatory requirements;
  - Performing regular in-depth analysis of the Philippines' existing geothermal plants and forward-looking plans for development;
  - Taking advantage of the country's open policy towards foreign ownership of geothermal projects.
- Monitor the following actions by the Philippines government to identify inflection points for timing a successful PPP program launch for geothermal technologies. These recommendations highlight key improvement areas for the Philippines that would make it a more attractive export destination:
  - Completion of environmental and social impact assessments for geothermal production undertaken in the Philippines as a way to track local opposition, particularly from environmental NGOs and indigenous communities.
  - Training and capacity-building sessions for local administration and employees on the exported technologies, facilitating effective management of the geothermal plant projects, thereby promoting operational efficiency and ensuring a smooth transition.
  - Moving towards low to medium enthalpy geothermal resources and evaluating the feasibility of small-scale projects for local energy demands.
  - Addressing technical challenges associated with the strongest geothermal production capacity located in geographically remote areas.
  - Development and implementation of anti-corruption policies that will support the country's efforts to attract higher, and more consistent, levels of foreign direct investment.
  - Implementation of feed-in tariffs and improvements in basic energy infrastructure to support the long-term, sustainable development of the geothermal market.

## Bibliography

1. Asian Development Bank. (2021). Energy policy: Supporting low carbon transition in Asia and the Pacific. Asian Development Bank.
2. Cariaga, C. (2023, April 25). How EDC fosters self-reliant host communities in Philippine geothermal sites. Think Geoenergy.  
<https://www.thinkgeoenergy.com/how-edc-fosters-self-reliant-host-communities-in-philippine-geothermal-sites/>
3. Cariaga, C. (2023, October 3). Philippines strives to regain position as 2nd Largest Geothermal Power producer. Think GeoEnergy - Geothermal Energy News.  
<https://www.thinkgeoenergy.com/philippines-strives-to-regain-position-as-2nd-largest-geothermal-power-producer/>
4. Cariaga, C., et al. (2023, March 31). Call for abstracts - 4th Philippine International Geothermal Conference, 27-28 September. Think GeoEnergy - Geothermal Energy News.
5. Cariaga, C., et al. (2023, October 3). Philippines strives to regain position as 2nd largest geothermal power producer. Think GeoEnergy - Geothermal Energy News.
6. De Jesus, A. (2005). Social Issues Raised and Measures Adopted in Philippine Geothermal Projects. In Proceedings World Geothermal Congress (pp. 24–29).  
<https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2005/0219.pdf>
7. Department of Energy Philippines. (2008). Renewable Energy Act of 2008 (Republic Act No. 9513 of 2008). Department of Energy.  
<https://www.doe.gov.ph/sites/default/files/pdf/issuances/20081216-ra-09513-gma.pdf>
8. Department of Energy Philippines. (2016). Philippine Energy Plan 2016-2030. Retrieved from  
[https://www.doe.gov.ph/sites/default/files/pdf/pep/2016-2030\\_pep.pdf](https://www.doe.gov.ph/sites/default/files/pdf/pep/2016-2030_pep.pdf)
9. EDC's Integrated Report – Our Annual Integrated Report. 2022.  
<https://integratedreport.energy.com.ph/>
10. Economic Research Institute for ASEAN and East Asia. (2017). Assessment on necessary innovations for sustainable use of conventional and new-type geothermal resources and their benefits.

11. Economic Research Institute for ASEAN and East Asia. (2018). Assessment on Necessary Innovations for Sustainable Use of Conventional and New-Type Geothermal Resources and their Benefits in East Asia. Retrieved from [https://www.eria.org/uploads/media/12.ERIA-RPR-FY2017\\_07\\_Chapter\\_3\\_6.Philippines.pdf](https://www.eria.org/uploads/media/12.ERIA-RPR-FY2017_07_Chapter_3_6.Philippines.pdf)
12. EIB. (2021, June 17). East African rift geothermal. European Investment Bank. <https://www.eib.org/en/projects/pipelines/all/20210194>
13. Environmental Management Bureau. (2021, March). Philippine Environmental Impact Statement System Brochure. Environmental Management Bureau.
14. Esquivel, C. (2021). Responsibly Powering the Philippine Islands with Geothermal Energy. Columbia Academic Commons. <https://doi.org/10.7916/d8-0k68-8c17>
15. Geothermal energy companies - Top company list. (n.d.). Retrieved from <https://www.mordorintelligence.com/industry-reports/geothermal-energy-market/companies>, Top 9 geothermal energy companies in the world [2022]. (n.d.). Retrieved from <https://www.fortunebusinessinsights.com/blog/top-geothermal-energy-companies-10721> & Geothermal energy market size | Analysis report 2024-2032. (2023, March 28). Retrieved from <https://www.gminsights.com/industry-analysis/geothermal-energy-market>
16. Geothermal energy market in the philippines—Size, share & analysis. (n.d.). Retrieved March 2, 2024, from <https://www.mordorintelligence.com/industry-reports/philippines-geothermal-energy-market>
17. Geothermal energy projects heat up in Philippines and Indonesia. (n.d.). Nikkei Asia. Retrieved February 26, 2024, from <https://asia.nikkei.com/Business/Energy/Geothermal-energy-projects-heat-up-in-Philippines-and-Indonesia>
18. Geothermal Statistics | Department of Energy Philippines. [www.doe.gov.ph/geothermal-statistics](http://www.doe.gov.ph/geothermal-statistics).
19. Guidebook on Net-Metering in the Philippines: Department of Energy Philippines. Department of Energy Philippines. (n.d.). <https://www.doe.gov.ph/renewable-energy/guidebook-net-metering-philippines>
20. Mercurio, R. (2023, September 29). Philippines aims to reclaim spot as 2nd biggest geothermal producer. Retrieved from <https://www.philstar.com/business/2023/09/29/2299750/philippines-aims-reclaim-spot-2nd-biggest-geothermal-producer>

21. National Geothermal Association of the Philippines. (2023, September 25). Home. Retrieved from [www.ngaphil.com](http://www.ngaphil.com).
22. NDC Partnership. (n.d.). Geothermal Risk Mitigation in the Philippines. Retrieved from <https://ndcpartnership.org/knowledge-portal/good-practice-database/geothermal-risk-mitigation-philippines>
23. Open Economies. (n.d.). Bilateral trade between the USA and Philippines. Retrieved from <https://oec.world/en/profile/bilateral-country/usa/partner/phl>
24. Philippines allows 100% foreign ownership in large-scale geothermal projects. (2020, October 27). RAPPLER. <https://www.rappler.com/business/philippines-allows-full-foreign-ownership-large-scale-geothermal-projects/>
25. Philippines: Installed power capacity by plant type 2022. (n.d.). Statista. Retrieved February 26, 2024, from <https://www.statista.com/statistics/1266402/philippines-installed-power-capacity-by-source/>
26. Philippines: Renewable energy sector is now open to full foreign ownership. (n.d.). Retrieved February 26, 2024, from <https://insightplus.bakermckenzie.com/bm/projects/philippines-renewable-energy-sector-is-now-open-to-full-foreign-ownership>
27. Philippines Renewable Portfolio Standard (RPS) planning calculator. Greening the Grid. (n.d.). <https://greeningthegrid.org/news/new-resource-philippines-renewable-portfolio-standard-rps-planning-calculator>
28. Richter, A. (2020, June 18). Geothermal in the Philippines - an urgent revamp of targets and development needed: ThinkGeoEnergy - Geothermal Energy News. ThinkGeoEnergy. <https://www.thinkgeoenergy.com/geothermal-in-the-philippines-an-urgent-revamp-of-targets-and-development-needed/amp/>
29. Richter, A., et al. (2022, July 8). Philippines DOE endorses four geothermal projects for grid impact study. Think GeoEnergy - Geothermal Energy News.
30. Sarmiento, B. (2021, December 31). In round 2 of Philippine geothermal project, tribes dig in for a greater say. Mongabay. <https://news.mongabay.com/2021/12/in-round-2-of-philippine-geothermal-project-tribes-dig-in-for-a-greater-say/>



31. Silva Rodríguez de San Miguel, J. A. (2020). Water governance in the USA. *Management of Environmental Quality*, 31(1), 130-145. <https://doi.org/10.1108/MEQ-05-2019-0104>

32. The following section, which reviews trade capacities within the Philippines, relies heavily on the insights provided by the U.S. Department of Commerce. (n.d.). *Philippines Market Overview*. Country Commercial Guides. Retrieved from [https://www.trade.gov/country-commercial-guides/philippines-market-overview#\\_msocom\\_1](https://www.trade.gov/country-commercial-guides/philippines-market-overview#_msocom_1)

33. Toshiba and KenGen conclude memorandum of understanding on O&M services for geothermal power plants | News release | Toshiba energy systems & solutions. (2023, August 31). トップページ | 東芝. <https://www.global.toshiba/ww/news/energy/2022/08/news-20220831-01.html>

34. World Bank. (2010, April). *A strategic approach to climate change in the Philippines: An assessment of low-carbon interventions in the transport and power sectors (Final report)*.

## Appendix A

|            | Stakeholder                            | Stakeholder Description                                                                                                                                                                                                                                                                                                           | Level of Support<br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><i>Why would the stakeholder resist or support?</i>                                                                                |
|------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Government | Department of Energy (DOE)             | DOE is the executive department of the Philippine government responsible for preparing, integrating, manipulating, organizing, coordinating, supervising, and controlling all plans, programs, projects and activities of the Government relative to energy exploration, development, utilization, distribution and conservation. | Support                                                                                 | The Philippines is a global leader in geothermal energy production and given the country's abundant resources, DOE is highly invested in exploring further production. |
|            | Department of Trade and Industry (DTI) | DTI is the executive department of the Philippine government responsible for the advancement, promotion, governance, regulation, management and growth of industry and trade.                                                                                                                                                     | Support                                                                                 | DTI would likely support this initiative as it would stimulate trade and business in the geothermal industry.                                                          |

|                       |                                                         |                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                                                                                |
|-----------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | Department of Science and Technology (DOST)             | DOST is the executive department of the Philippine government responsible for the coordination of science and technology-related projects in the Philippines and to formulate policies and projects in the fields of science and technology in support of national development.                        | Neutral | DOST plays a role in supporting the technical development in the Philippines' energy production and distribution infrastructure. It is also involved with the adaptation of imported technology into existing infrastructure.                                  |
|                       | Department of Environment and Natural Resources (DENR)  | DENR is the primary agency responsible for the conservation, management, development, and proper use of the country's environment and natural resources, specifically forest and grazing lands, mineral resources, including those in reservation and watershed areas, and lands of the public domain, | Depends | While this program would not directly conflict with DENR's mandate, the agency would require any new geothermal plant development to undergo a robust environmental impact assessment to mitigate any potential harm to the country's natural resources.       |
|                       | Philippine National Oil Company (PNOC)                  | PNOC is a government-owned and controlled energy corporation that is involved in exploration, exploitation and development of all energy resources in the country.                                                                                                                                     | Resist  | PNOC Renewables Corporation is a fully owned subsidiary of PNOC focused on renewable energy development, however given the parent company's focus on fossil fuels it may resist rapid changes in the country's energy mix.                                     |
| <b>Academia</b>       | Philippine Energy Research and Policy Institute (PERPI) | PERPI is an independent energy research institute attached to the University of Philippines. It will study recent developments and scientific breakthroughs in energy.                                                                                                                                 | Support | PERPI's mission is development and breakthrough in geothermal technologies in Philippines                                                                                                                                                                      |
| <b>Private Sector</b> | Philippine Geothermal Production Company                | Philippine Geothermal Production Company, Inc. (PGPC) is a Filipino corporation operating the geothermal steam fields located in Tiwi, Albay and Mak-Ban which straddles the provinces of Laguna and Batangas. It is owned by the SM Investments Corporation.                                          | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |

|               |                                                     |                                                                                                                                                                                                                                                                                                                                              |         |                                                                                                                                                                                                                                                                |
|---------------|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|               | Energy Development Corporation                      | EDC is the Philippines' leading 100% renewable energy producer, and has been primarily exploring, developing, operating, and utilizing geothermal energy since 1976.                                                                                                                                                                         | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|               | National Power Corporation                          | The National Power Corporation (Filipino: Pambansang Korporasyon sa Elektrisidad, also known as Napocor, NPC or National Power) is a Philippine government-owned and controlled corporation that is mandated to provide electricity to all rural areas of the Philippines by 2025                                                            | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|               | Aboitiz Power Corporation                           | AboitizPower is an energy solutions company that provides dependable power across the country – and with 49 power generation facilities and nine electric distribution sites – we provide our customers with reliable and affordable power.                                                                                                  | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
|               | Aragorn Power and Energy Corporation (APEC)         | The APC Group has investments in energy, mining and manpower outsourcing businesses and telecommunications. APEC and partner Guidance Management Corp. owns the geothermal service contract in the province of Kalinga covering an area of around 26,000 hectares with an estimated power generation potential of between 120 MW and 200 MW. | Neutral | May resist with the program if this company already has a exclusive contract with a specific technology company which has a conflict with the U.S. supplier, but could potentially benefit from downward technology price pressures from increased competition |
| Civil Society | The Climate Reality Project Philippines             | Climate Reality is a global environmental advocacy organization focused on demanding immediate action on the climate crisis.                                                                                                                                                                                                                 | Support | Climate Reality is broadly supportive of geothermal energy production, though notes the need for further assessment of adverse environmental impacts from EGS.                                                                                                 |
|               | Institute for Climate and Sustainable Cities (ICSC) | ICSC is an international NGO advancing fair climate policy and low-carbon, climate-resilient development. It is based in the Philippines.                                                                                                                                                                                                    | Support | ICSC is broadly supportive of geothermal energy production in the Philippines.                                                                                                                                                                                 |

|  |                                            |                                                                                                                                                                            |        |                                                                                                                                                                                                  |
|--|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Fossil Fuel Workers                        | All workers currently employed in any position within the fossil fuel sector.                                                                                              | Resist | Without adequate workforce training, fossil fuel-related employees will resist widespread transition to clean energy due to uncertainty over employment.                                         |
|  | Local Communities & Indigenous Populations | The Philippines is home to over 17 million indigenous peoples who tend to live in geographically isolated areas which may be well-suited for geothermal energy production. | Resist | In 2019, Energy Development Corporation (EDC) agreed to pay royalties to a local tribe for production within their ancestral lands, setting a precedent for future geothermal plant development. |

## Appendix B

|            | Stakeholder                                    | Stakeholder Description                                                                                                                              | Level of Support<br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><i>Why would the stakeholder resist or support?</i>                                                                                                                        |
|------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Government | Office of the U.S. Trade Representative (USTR) | Part of the Executive Office of the President, USTR coordinates trade policy, resolves disagreements, and frames issues for presidential decision.   | Support                                                                                 | USTR has been a leading advocate for global liberalization of trade in environmental goods and services, including clean energy technologies.                                                                  |
|            | U.S. Trade and Development Agency (USTDA)      | The USTDA helps companies create U.S. jobs through the export of U.S. goods and services for priority infrastructure projects in emerging economies. | Support                                                                                 | This program could support business growth within the geothermal sector, thereby creating domestic employment opportunities. Fossil fuel dominant states may resist due to potential negative business impact. |
|            | State Governments                              | State-level government officials across states developing renewable and/or fossil fuel energy production technologies.                               | Depends                                                                                 | States with major geothermal technology production would support a program that can boost the state's economy.                                                                                                 |

|                       |                                                |                                                                                                                                                                                                                                                               |         |                                                                                                                                                                                                                                                                                                                |
|-----------------------|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | Export-Import Bank of the United States (EXIM) | The EXIM Bank is the official export credit agency of the U.S.                                                                                                                                                                                                | Support | EXIM has been broadly supportive of existing clean technology export initiatives. Since 1992, EXIM has had a mandate in its congressional charter to increase support for environmental exports, including renewable energy.                                                                                   |
|                       | International Trade Administration (ITA)       | The ITA is an agency within the U.S. Department of Commerce focused on export development and competitiveness.                                                                                                                                                | Support | This program would support the ITA's mission of strengthening U.S. global competitiveness and promoting trade and investment opportunities                                                                                                                                                                     |
|                       | U.S. Department of Energy (DOE)                | DOE is the executive department of the U.S. that oversees national energy policy and energy production.                                                                                                                                                       | Support | DOE has already undertaken significant measures to support the global transition to renewable energy. Its Geothermal Technologies Office works to reduce costs and risks associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges. |
| <b>Academia</b>       | National Renewable Energy Laboratory (NREL)    | NREL researches, develops, and demonstrates technologies to advance the use of geothermal energy as a clean, renewable, domestic energy source for the United States.                                                                                         | Support | This program would benefit the expansion of US geothermal technologies, in line with the interest of NREL                                                                                                                                                                                                      |
| <b>Private Sector</b> | Calpine                                        | Calpine is the largest producer of geothermal power in the US, operating several plants in The Geysers located north of San Francisco.                                                                                                                        | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |
|                       | Ormat Technologies                             | Nevada-based Ormat Technologies claims to have developed more than 150 geothermal power plants across the world with a combined capacity of more than 2.1GW.                                                                                                  | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |
|                       | Berkshire Hathaway                             | Berkshire Hathaway's geothermal operations, which comprise 10 geothermal power plants in the Imperial Valley in southern California, are carried out by its subsidiary CalEnergy Operations. The plants are owned by another Berkshire Hathaway subsidiary CE | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                                                                                                                                        |

|                      |                                          |                                                                                                                                                                                                                                                     |         |                                                                                                                                                                                             |
|----------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      |                                          | Generation.                                                                                                                                                                                                                                         |         |                                                                                                                                                                                             |
|                      | Northern California Power Agency         | The Northern California Power Agency (NCPA), a California Joint Action Agency, owns and operates two geothermal power plants with a combined generation capacity of 220MW.                                                                          | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                     |
|                      | Terra-Gen Power                          | The company operates three geothermal power plants in the US with a combined generation capacity of 86.7MW.<br><br>The firm operates the 67MW Dixie Valley Geothermal Power Plant located in Churchill County, Nevada. It was commissioned in 1988. | Support | This program would support its business expansion within the geothermal sector beyond the United States                                                                                     |
| <b>Civil Society</b> | Natural Resources Defense Council (NRDC) | The NRDC is a U.S.-based non-profit environmental advocacy organization.                                                                                                                                                                            | Depends | The NRDC has published largely positive resources on its website regarding geothermal energy's potential to contribute to fighting the climate crisis.                                      |
|                      | The Sierra Club                          | The Sierra Club is U.S.-based non-profit environmental advocacy organization.                                                                                                                                                                       | Resist  | The Sierra Club takes a cautious stance on geothermal, pointing out its adverse environmental impact and that it should be kept to a highly limited segment of renewable energy generation. |
|                      | Center for Biological Diversity          | The Center for Biological Diversity is a non-profit membership organization focused on the protection of endangered species.                                                                                                                        | Resist  | The organization has been involved in prior lawsuits against geothermal energy producers over the adverse impact production has on biodiversity.                                            |

## Appendix C

| Country       | Company Name                                   |
|---------------|------------------------------------------------|
| United States | Ormat Technologies Inc                         |
|               | Chevron                                        |
|               | Calpine                                        |
|               | Green Mountain Energy                          |
|               | Haliburton                                     |
|               | Tetra Tech Inc                                 |
|               | Fervo Energy                                   |
|               | Berkshire Hathaway Energy                      |
| Japan         | Toshiba Energy Systems & Solutions Corporation |
|               | Fuji Electric Co. Lt                           |
|               | Mitsubishi Power Ltd                           |
|               | Sumitomo Corporation                           |
| Italy         | Ansaldo Energia SpA                            |
|               | Enel SpA                                       |
|               | Turboden SpA                                   |
|               | Enel Green Power                               |
| Indonesia     | PT Pertamina Geothermal Energy                 |
|               | Supreme Energy                                 |
| Philippines   | Energy Development Corporation                 |
|               | First Gen Corporation                          |
| Kenya         | Kenya Electricity Generating Company           |
|               | Sosian Menengai Geothermal Power Ltd.          |
| Iceland       | Geothermal Energy Development Company          |
|               | Reykjavik Geothermal                           |
| Sweden        | Atlas Copco Ab                                 |
| France        | Engie SA                                       |

|                    |                         |
|--------------------|-------------------------|
| <b>South Korea</b> | Doosan Škoda Power      |
| <b>Australia</b>   | Macquarie Group Limited |





# MEMO II

# Green Hydrogen

## *Chile*

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April 5, 2024

## Executive Summary

This memo details the opportunities and challenges related to a potential United States government led public-private program initiative aimed at promoting green hydrogen technology exports to Chile. Our analysis explores stakeholders, market dynamics, relevant policies, export challenges, sectoral growth challenges, key competitors, and public education requirements, along with recommendations for the ITA.

**Key Stakeholders:** To achieve its green hydrogen goals, the Chilean government has engaged numerous stakeholders ranging from the Inter-American Development Bank to numerous private sector entities. The development of renewable energy and hydrogen infrastructure will also require input from indigenous communities.

**Market Analysis:** Chile has ambitious goals for exporting green hydrogen, targeting \$50 billion in exports by 2050. However, it is still very early on in this process, and whether or not it can achieve these goals remains to be seen.

**Key Codes, Standards, and Regulatory Frameworks:** Chile's electricity has distinctly lineated roles outlined by DFL No. 4/2007, which favors renewable energy generation. Despite a lack of specific legislation for green hydrogen, discussions in the Chilean Congress indicate progress toward its inclusion in gas pipelines. The country's roadmap to green hydrogen emphasizes a phased approach, starting with domestic usage, particularly in sectors with significant energy demand. Plans

include replacing imported ammonia and gray hydrogen in oil refineries and transitioning heavy transportation fleets to green hydrogen. Public-private partnerships and investment initiatives, including a US\$1 billion fund managed by Corfo, are driving Chile's green hydrogen ambitions. The fund aims to catalyze private investment and reduce financial risks associated with green hydrogen projects.

**Export Challenges:** Evaluation of investments in Chile's green hydrogen industry highlights substantial environmental and social risks, hindering industry expansion. Regulatory gaps, including the absence of regulations for safe management and transparency issues, impede sectoral growth. Specific regions chosen for green hydrogen development face environmental and social resistance, with concerns about biodiversity impacts. Recommendations include incentivizing exports to companies with comprehensive environmental assessments to promote environmentally safe and equitable oversight in green hydrogen projects.

**Challenges to Sectoral Growth:** Despite Chile's strong support for expanding hydrogen technology and its advantageous position for green hydrogen production, significant barriers hinder growth. Environmental stresses such as water scarcity, political instability under a new left-wing government, a lack of domestic demand, and the need for massive infrastructure investment are all barriers to sectoral growth. Recommendations include supporting outreach to local communities, continuing long-term

projects like the Green Hydrogen Fund, and insulating green hydrogen development from political fluctuations. Collaboration with Chile to navigate these challenges and foster sustainable growth in the hydrogen sector is essential.

**Main Competitors for U.S. Export:** Chile's ambitious green hydrogen goals have already attracted significant international interest. Major players like Enel, Air Liquide, Engie, GNL Quintero, and Linde are investing in various green hydrogen projects across the country. U.S. companies face competition from countries like Germany, China, and Australia in the green hydrogen market. Notable foreign investors in Chile's green hydrogen sector include Siemens Energy, Linde, ENGIE, and Fortescue Metals Group. To address competition, collaboration with European counterparts can explore joint ventures and partnerships in Chile's green hydrogen sector, ensuring opportunities for U.S. companies.

**Public Education:** The National Green Hydrogen Strategy emphasizes the importance of initiatives for national employment and

capability development, especially in key sectors such as mining and commodities. Challenges include re-educating the existing workforce and identifying technical skills needed for the green hydrogen value chain. Chile has engaged in knowledge-sharing initiatives with countries like Germany and Norway, facilitating technology transfer and business cooperation to support its green hydrogen sector. Recommendations include expanding international cooperation in green hydrogen education, encouraging specialized workforce training programs, updating relevant curriculums, and monitoring progress in technical training by state-owned utility companies.

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## Introduction

This memo discusses our research team's findings and recommendations for a United States government led public-private program initiative focused on promoting green hydrogen exports to Chile. It addresses questions related to the regulatory environment, market analysis, barriers to growth, foreign competition, and public education. We conducted research through expert interviews and publicly available news reports, peer-reviewed papers, and government documents to answer them and develop recommendations.

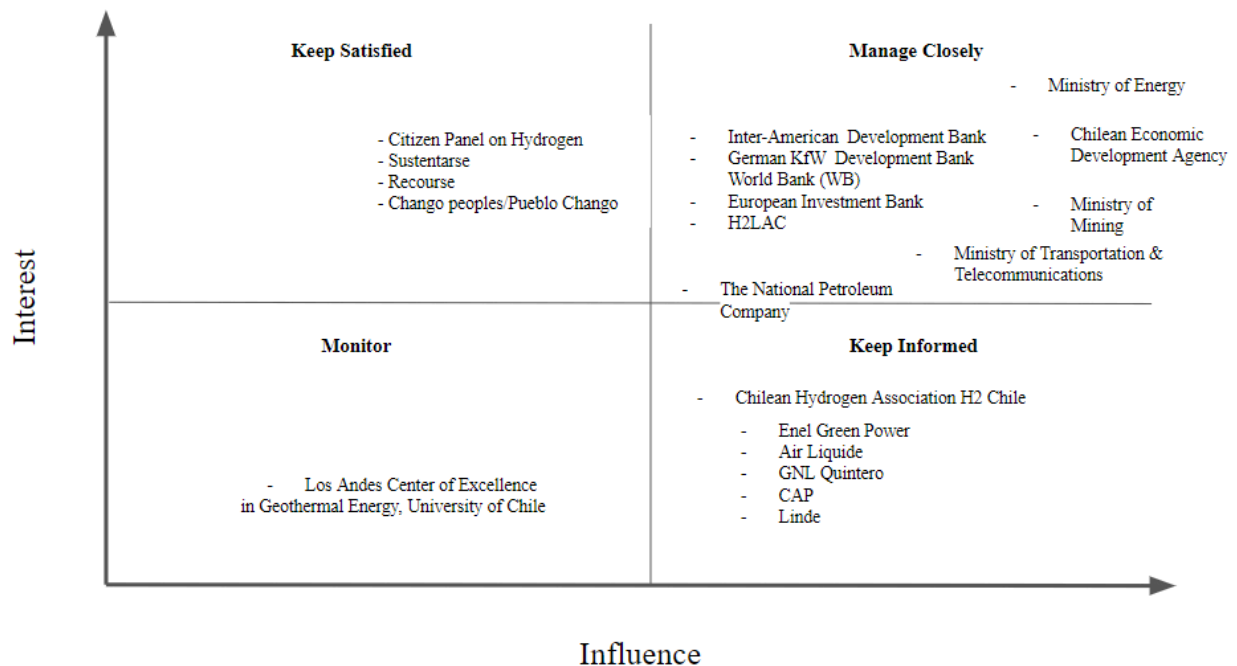
## Key Stakeholders

Identifying and understanding the various stakeholders involved in the implementation of a green hydrogen Public-Private Partnership (PPP) is vital for strategic alignment, risk management, and resource allocation. Stakeholder analysis, in the context of Chile's hydrogen landscape, can be effective in building relationships, enhancing legitimacy, and ensuring accountability within a complex system. Likewise, we have identified the following stakeholders working at international and regional levels across government, the private sector, academic, and civil society in Chile.

- *International /Regional Entity*: Inter-American Development Bank (IDB), German KfW Development Bank (KfW), World Bank (WB), European Investment Bank (EIB) and H2LAC
- *Government*: Ministry of Energy (MOE), Ministry of Transportation and Telecommunications (MTT), Ministry of Mining (MOM), Chilean Economic Development Agency (CORFO) Inter-Ministerial Committee and The National Petroleum Company (ENAP)
- *Private Sector*: Enel Green Power, Air Liquide (ALC), GNL Quintero, CAP and Linde
- *Academia*: Los Andes Center of Excellence in Geothermal Energy (CEGA), University of Chile
- *Civil Society*: Chilean Hydrogen Association, Citizen Panel on Hydrogen in Magallanes, Chango peoples/Pueblo Chango, Chilean NGO Sustentarse, Recourse

## Recommendation

The following interest-influence matrix displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely).



**Figure 1:** Chile Green Hydrogen Stakeholder Analysis Matrix

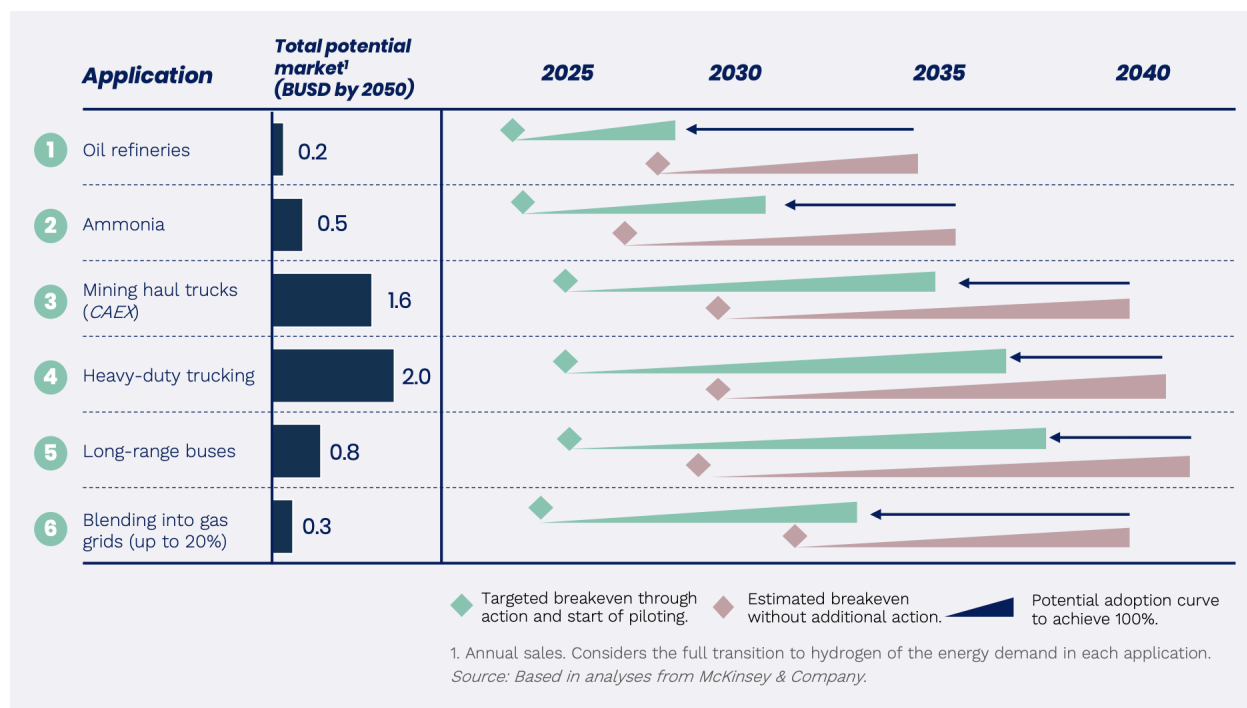
## Market Analysis

### Overview

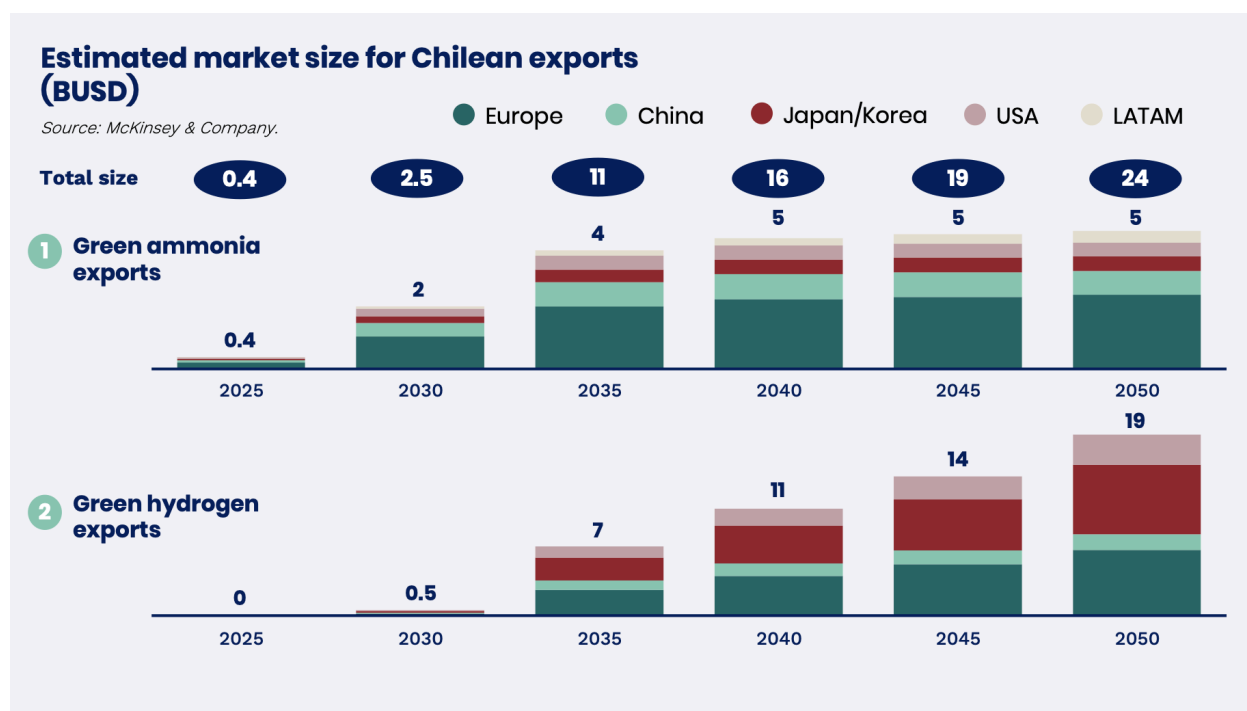
Chile's green hydrogen strategy centers around its ability to produce more green energy than it uses and plans to export the excess hydrogen. Chile has the potential to produce more than 1800 GW of renewable energy, 70 times the country's need for internal consumption, allowing it to produce green hydrogen at the lowest cost worldwide at \$1.5 per kg by 2030<sup>140</sup>. According to the government's 2020 Green Hydrogen strategy, it targets the production of 1 million tonnes of green hydrogen by 2030. It has also set targets for electrolyzer capacity of 5 GW by 205 and 25 GW by 2030. In dollar terms, this equates to around \$330 billion in private investment opportunities leading to \$50 billion in exports by 2050.<sup>141</sup> Throughout this expansion, Chile views the EU as its largest customer for the importation of both ammonia and green hydrogen.

<sup>140</sup>Chile | green hydrogen organisation. (n.d.). Retrieved April 5, 2024, from <http://gh2.org/countries/chile>

<sup>141</sup> *Chile to accelerate its green hydrogen industry with world bank support*. (2023, June 29). World Bank. <https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support>



**Figure 2:** Prioritized applications to build up supply chains



**Figure 3:** Estimated market size for Chilean GH exports



However, these projections must be balanced against expectations for the growth of the technology. While it is still in its early stages, projections from Deloitte predict that worldwide hydrogen demand will reach \$1.4 trillion by 2050, making the government's goal of \$50 billion well within the range of the global market.<sup>142</sup> Presently there is no large-scale hydrogen production in Chile so progress towards these goals will need to be closely monitored, as will the development of large-scale renewable energy projects to support hydrogen production.<sup>143</sup>

### *Recommendations*

- Continue to monitor the development of renewable energy and hydrogen production and associated infrastructure as well as government support for these developments

## Key Codes, Standards, and Regulatory Frameworks

In Chile, the regulatory framework for renewable energy, primarily governed by [DFL No. 4/2007](#) and its amendments, outlines a clear division among participants in the electricity market. Generation, transmission, and distribution activities are distinct, preventing a single entity from engaging in multiple roles simultaneously. Consequently, developers of renewable energy focus solely on generation. The National Electrical Coordinator determines which power generators operate based on marginal costs, favoring renewable energy plants due to their lower costs. Transmission and distribution companies, however, do not differentiate between energy from renewable or conventional sources.<sup>144</sup>

There is currently no specific legal framework governing green hydrogen projects. However, a bill is under consideration in the Chilean Congress (Bulletin No. 391-369 of 2021) that would mandate gas distribution companies to include a percentage of hydrogen in their pipelines. Additionally, discussions among Congress members have indicated potential legislation dedicated to green hydrogen, although it has not yet materialized.<sup>145</sup>

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<sup>142</sup> Truby, J., Philip, P., & Lorentz, B. (2023, June 19). Green hydrogen: Energizing the path to net zero. <https://www.deloitte.com/global/en/issues/climate/green-hydrogen.html>

<sup>143</sup> Mcfarlane, C. (2023, November 11). *Hydrogen in chile—Where does the industry stand today?* <https://www.linkedin.com/pulse/hydrogen-chile-where-does-industry-stand-today-cody-mcfarlane-ak6ne>

<sup>144</sup> Eyzaguirre, N., & Garnham, J. (2023, 9). Renewable energy laws and regulations report 2024 Chile. Retrieved from <https://iclg.com/practice-areas/renewable-energy-laws-and-regulations/chile>

<sup>145</sup> Eyzaguirre, N., & Garnham, J. (2023, 9). Renewable energy laws and regulations report 2024 Chile. Retrieved from <https://iclg.com/practice-areas/renewable-energy-laws-and-regulations/chile>

Nevertheless, Chile is strategically positioning itself to become a dominant force in the global green hydrogen market, leveraging its abundant renewable resources and favorable economic conditions. The country's ambitious roadmap outlines a phased approach to capitalize on the declining costs of electrolyzers and renewable power, which are expected to drive highly competitive green hydrogen production.<sup>146</sup>

In the initial phase, Chile focuses on domestic usage, targeting sectors with significant energy or hydrogen demand. This includes replacing imported ammonia and gray hydrogen in oil refineries and transitioning heavy transportation fleets and machinery to green hydrogen. By concentrating efforts in these areas, Chile aims to establish local supply chains and gain valuable experience, supported by public initiatives incentivizing production and creating tangible demand.<sup>147</sup>

As production scales up, Chile plans to expand its activities to include exportation, particularly targeting green ammonia and hydrogen. The country's favorable conditions, including the abundance of renewable resources in regions like the Atacama Desert and the Magallanes Region, coupled with technological advancements, are expected to enable large-scale and cost-effective production. This strategic positioning underscores Chile's potential to achieve the lowest levelized cost of production globally by 2030.<sup>148</sup>

In subsequent waves of development, Chile will leverage its domestic base to establish itself as a major player in export markets. This involves developing a robust industry for green ammonia production and exportation, supported by gigawatt-scale consortiums and secured commitments through offtake agreements and investments. By capitalizing on synergies and economies of scale, Chile aims to position itself as a global supplier of clean fuels, tapping into emerging opportunities such as using ammonia in shipping and synfuels in aviation.<sup>149</sup>

In addition, the Chilean Economic Development Agency (Corfo) will manage a US\$1 billion fund aimed at catalyzing private investment in green hydrogen projects. This fund is expected to reduce costs and mitigate risks associated with investing in the nascent green hydrogen industry. The fund will not provide subsidies or finance research and development but will instead support "real projects," aiming to reduce financial and technical risks. It will operate as a second-tier

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<sup>146</sup> Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

<sup>147</sup> Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

<sup>148</sup> Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

<sup>149</sup> Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

lender, making favorable loans or guarantees available to commercial banks for qualifying projects. Funding for the program will come primarily from sovereign loans from several development banks, including the Inter-American Development Bank, the World Bank, the European Investment Bank, and Germany's KfW Development Bank, among others.<sup>150</sup>

Green hydrogen projects in Chile are expected to range from small-scale solutions to larger projects at gigawatt scale, with potential applications in sectors such as mining, transportation, and industry. Collaborations between companies like Enaex and ENGIE aim to produce green ammonia using renewable energy, reducing carbon footprints and creating export opportunities. Additionally, there are discussions about the possibility of manufacturing electrolysis equipment in Chile to support local projects and create high-quality jobs.<sup>151</sup>

Despite policy initiatives, private investment remains the primary source of financing for green hydrogen projects in Chile.<sup>152</sup> Marcos Kulka, CEO of H2Chile, emphasized the significant investment required for Chile to achieve its green hydrogen goals, estimating a need for US\$60 billion by 2050.<sup>153</sup>

Chile's pursuit of green hydrogen investments appears to be heavily focused on Europe. In 2022, the European Union and Chile concluded negotiations on the EU-Chile Advanced Framework Agreement, marking a significant milestone in their partnership aimed at strengthening political dialogue, cooperation, and trade and investment opportunities. This agreement is expected to deepen trade relations, with nearly all EU exports to Chile becoming tariff-free, facilitating increased exports and investments between the two economies. Furthermore, the agreement prioritizes sustainability and innovation, with commitments to democratic principles, human rights, and environmental standards, as well as initiatives to support small and medium enterprises.<sup>154</sup>

Chile is fostering public-private partnerships to boost the green hydrogen trade. A Public-Private Agreement for Hydrogen in Mining and Transportation is being established, involving key

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<sup>150</sup> ECPA. (2023, July 28). Chile launches major fund to Kickstart green hydrogen projects. Retrieved from <https://ecpamericas.org/newsletters/chile-launches-major-fund-to-kickstart-green-hydrogen-projects/>

<sup>151</sup> ECPA. (2023, July 28). Chile launches major fund to Kickstart green hydrogen projects. Retrieved from <https://ecpamericas.org/newsletters/chile-launches-major-fund-to-kickstart-green-hydrogen-projects/>

<sup>152</sup> ECPA. (2023, July 28). Chile launches major fund to Kickstart green hydrogen projects. Retrieved from <https://ecpamericas.org/newsletters/chile-launches-major-fund-to-kickstart-green-hydrogen-projects/>

<sup>153</sup> AFP. (2024, February 12). Chile on green hydrogen investment hunt in Europe. Retrieved from <https://www.france24.com/en/live-news/20240212-chile-on-green-hydrogen-investment-hunt-in-europe>

<sup>154</sup> Public Affairs Bruxelles. (2022, December 9). EU and Chile strengthen a comprehensive political and trade partnership. Retrieved from <https://www.pubaffairsbruxelles.eu/eu-institution-news/eu-and-chile-strengthen-a-comprehensive-political-and-trade-partnership/>

stakeholders to address barriers and accelerate hydrogen adoption in these sectors. To facilitate permitting and piloting processes for green hydrogen projects, a task force is being formed by the Chilean Ministry of Energy in partnership with Germany. The task force aims to support developers and held its inaugural meeting in November 2021. Subsequent meetings have covered topics such as hydrogen certification schemes and consumer perceptions of sustainability criteria. Additionally, the Chilean National Development Agency has selected six green hydrogen production projects for development, slated to commence operations by 2025.<sup>155</sup>

Generally speaking, Chile maintains relatively few barriers to imports and investments, offering foreign firms similar protections and operating conditions as local companies. This openness encourages international trade and investment, fostering a favorable environment for business engagement.<sup>156</sup> Despite the intention to localize supply chains, the sector relies on imports for equipment and parts, with the United States already supplying over 7%.

#### *Recommendations*

- Chile aims to localize its supply chain for green hydrogen projects, reducing dependency on imports. However, the sector currently relies on imports for equipment and parts, posing a challenge to achieving this goal. The ITA can assist by facilitating technology transfer and collaboration between U.S. and Chilean companies to develop domestic manufacturing capabilities. This could involve joint ventures, technology licensing agreements, and knowledge exchange programs to support the localization process.
- Despite Chile's ambitious plans for green hydrogen production, significant investments are still required to scale up capacity. The ITA can support U.S. companies in accessing financing and investment opportunities in Chile through export financing programs, investment promotion activities, and partnerships with financial institutions.
- While Chile aims to localize its supply chain, the sector currently relies on imports for equipment and parts. To address this challenge, the ITA can promote U.S.-made products, provide export financing support, and advocate for policies that create a level playing field for U.S. suppliers.

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<sup>155</sup> Green Hydrogen Organisation. (n.d.). Chile. Retrieved from <https://gh2.org/countries/chile>

<sup>156</sup> ITA. (2023, December 7). Chile - Trade barriers. Retrieved from <https://www.trade.gov/country-commercial-guides/chile-trade-barriers>

## Export Challenges

### Overview

Despite the attempt to create unifying frameworks and standards, the bases of what defines “sustainable green hydrogen” are lacking and overlook vital social and environmental criteria needed to allow for the scaling up of projects. “Many of the relevant sustainability criteria are not currently covered by hydrogen certification schemes such as water supply, social impact, community development, etc. This could imply a negative impact in the implementation and/or operation of green hydrogen projects”.<sup>157</sup> In an interview with RMI International Policy Analyst Natalie Janzow, she discussed the criticality of agreeing on the emissions intensity of products.<sup>158</sup> “Standards being adopted around the world risk validating hydrogen produced with unacceptably high emissions.”<sup>159</sup>

A report by Recourse evaluates the role of The World Bank in GH development in Chile. They state that “The World Bank’s GH investment in Chile is flagged as having ‘considerable or substantial environmental and social risk’ due to the ‘wide range of potential environmental, health and safety impacts.’” Such an evaluation of Chile’s GH industry establishment creates barriers to expansion. It is imperative that rising energy projects be built on a foundation of equitable and environmentally safe oversight and regulation.

The report further lists other gaps in regulation impeding sectoral growth for GH. It mentions that “regulations for the safe management of GH, storage, transport, and use remain in the drafting process and are only expected to be enacted by 2025, despite GH production already taking place as early as 2017.” Further, the Chilean government lacks a typology for assessing GH projects, the way it does for other sectors and industries, and lacks transparency in the process of handing out concessions in the production of GH. Lastly, in the specific regions the Chilean government has chosen for GH development, such as the Antofagasta Region, the communes of Tocopilla and Mejillones are environmental sacrifice zones. There has already been resistance from Indigenous communities for fear that new developments will create new environmental and social sacrifice zones.

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<sup>157</sup> GIZ, ILF Ingeniería Chile Limitada, Ludwig-Bölkow Systemtechnik LBST. *Requirements for the production and export of green-sustainable hydrogen*. (2021). Energy Partnership Chile - Alemania. [https://www.energypartnership.cl/fileadmin/user\\_upload/chile/media\\_elements/Studies/EP\\_CHL\\_Production\\_of\\_green\\_sustainable\\_hydrogen\\_final\\_ISBN.pdf](https://www.energypartnership.cl/fileadmin/user_upload/chile/media_elements/Studies/EP_CHL_Production_of_green_sustainable_hydrogen_final_ISBN.pdf)

<sup>158</sup> Janzow, N. (2024, Mar 20). Personal communication [Personal interview].

<sup>159</sup> Moberg, J. (2023, March 31). *Hydrogen standards should only lend credibility to truly emissions-busting projects*. Green Hydrogen Organisation. <https://gh2.org/blog/hydrogen-standards-should-only-lend-credibility-truly-emissions-busting-projects>

A publication in the journal *Science* warned of the serious potential impacts on biodiversity from the development of GH megaprojects in the Magallanes Region, another environmentally sensitive region in the south near Patagonia. Despite the recently increasing utilization of a legal loophole known as Request of Relevance (“Consulta de Pertinencia”) as an administrative mechanism aiming to circumvent projects' environmental assessment approvals, such development mechanisms might face backlash and resistance from the global communities.<sup>160</sup>

### Recommendations

- Incentivize exports to companies and subprojects demonstrating comprehensive environmental impact assessments, and not simply impact statements. This will ensure the support and scaling up of entities that won't be stalled by regulatory barriers.

## Challenges to Sectoral Growth

### Overview

Although the Chilean government publicly supports expanding hydrogen technology and the country is well positioned to do this, significant barriers to growth remain. Chile is well suited to green hydrogen production due to its abundant wind and solar resources.<sup>161</sup> Because it has a relatively low demand for power compared to other industrialized nations, this means that Chile will require technology that will allow for the export of the hydrogen it produces.

To spur this development, Chile crafted a National Green Hydrogen Strategy in 2020. Produced by the Chilean Department of Energy, it listed the main barriers to further development as:

- Asymmetries of information
- Lack of coordination between supply and demand sides
- Technological and financial risks
- Cost gaps in relation to fossil-powered solutions

The report does mention that technical working groups have been formed to address these challenges and find solutions.

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<sup>160</sup> Seeger, M. (2023). *The New 'Energy El Dorado'? The World Bank's Role in Promoting Green Hydrogen in Chile*. Recourse, Sustentarse.

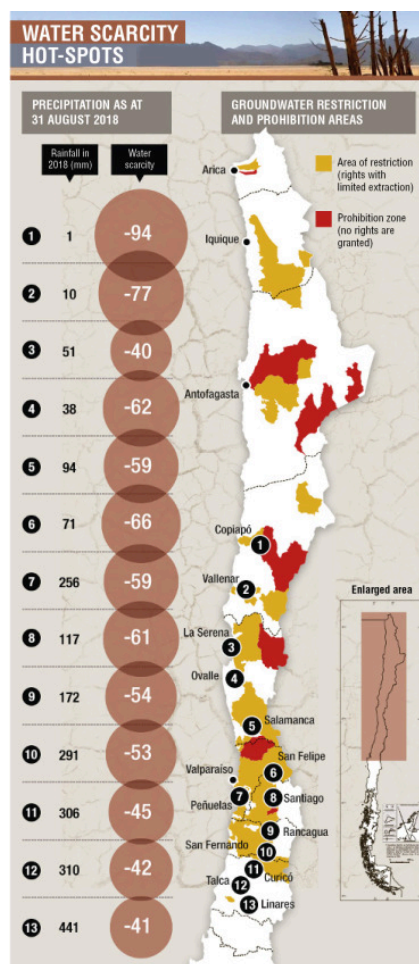
<https://re-course.org/wp-content/uploads/2023/09/The-World-Bank-role-in-promoting-Green-Hydrogen-in-Chile.pdf>

<sup>161</sup> Isidoro Losada, A. M. (2022). Green hydrogen: Chances and barriers for the energiewende in chile. *Science Talks*, 4, 100088. <https://doi.org/10.1016/j.sctalk.2022.100088>

## Environmental Stresses

Another key barrier to sectoral growth includes the environmental costs associated with shifting energy production towards the global south.

Chile has a centralized government based in the capital Santiago, but large-scale energy projects for solar and wind will be built in the far north or south of the country, marginalizing those communities even more.<sup>162</sup> If hydrogen facilities are to be colocated to reduce transmission loss,



**Figure 4:** Water stress hotspots in Chile

this will only exacerbate the issue. For example, water scarcity is a key concern in northern Chile, as demonstrated in Figure 4. Water is needed to supply electrolyzers to create hydrogen,

<sup>162</sup> Isidoro Losada, A. M. (2022). Green hydrogen: Chances and barriers for the energiewende in chile. *Science Talks*, 4, 100088. <https://doi.org/10.1016/j.sctalk.2022.100088>



and although it is needed at lower levels than more intensive industries such as mining, it is still a considerable draw on resources. However, this also presents an opportunity. Water for electrolysis is typically drawn from desalination plants.<sup>163</sup> Water from these plants could also be used for drinking, helping to alleviate local water stress. Desalination plants do bring their own set of challenges including environmental and energy concerns.

### *Political Instability*

Chile recently elected a left-wing government under President Gabriel Boric, which can present a challenge. While the government is highly supportive of hydrogen and green energy, the development of these technologies can have negative effects on the environment due to mining or water usage that could lead to opposition from the same movement. Additionally, the current administration is experiencing low approval ratings, leading to political instability which could hamper further hydrogen development. Chile is also in the process of attempting to write and then ratify a new constitution to replace its previous one, written during a military dictatorship. A 2022 referendum to ratify a new constitution failed, and while it did contain main references to the environment, this was not listed as a cause of its failure in post-referendum analysis.<sup>164</sup> To drive industry growth in an infrastructure-dependent technology such as hydrogen, there needs to be trust in the government body overseeing the development and policy.<sup>165</sup> While Chile is a stable country from a democratic perspective, administration changes could make large-scale projects that require continued support difficult to plan. However, this should be mitigated as hydrogen becomes a more valuable export and job creator within the country, making it a positive item to support for any administration.

Experts have said there has been a lack of domestic demand for hydrogen. One of those sources of demand could be the mining industry, which is under pressure to create more green operations.<sup>166</sup> However, new support for indigenous and local water rights threatens the ability of the mining industry to operate at scale, creating a paradox when it comes to hydrogen demand which is challenging for the government to navigate.

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<sup>163</sup> Collins (l\_collins), L. (2021, September 20). “Vast majority” of green hydrogen projects may require water desalination, potentially driving up costs. Recharge | Latest Renewable Energy News. <https://www.rechargenews.com/energy-transition/vast-majority-of-green-hydrogen-projects-may-require-water-desalination-potentially-driving-up-costs/2-1-1070183>

<sup>164</sup> Motamedi, M. (2023, December 18.). *Why Chileans rejected conservative constitution, and what's next?* Al Jazeera. Retrieved March 28, 2024, from <https://www.aljazeera.com/news/2023/12/18/why-chileans-rejected-conservative-constitution-and-whats-next>

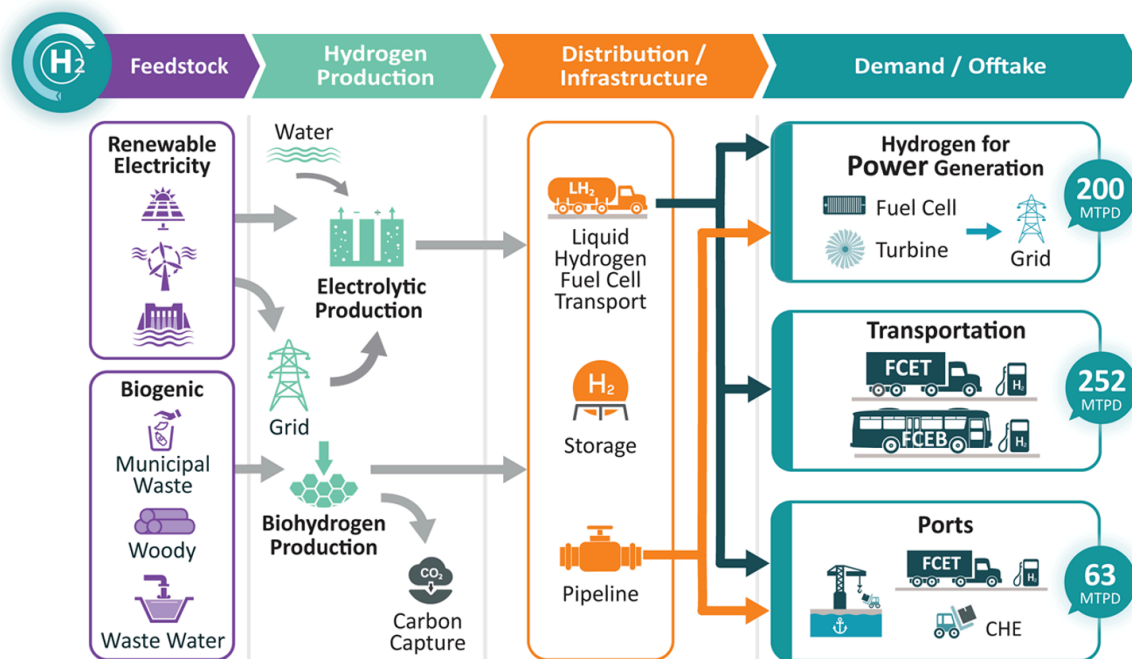
<sup>165</sup> Janzow, N. (2024, Mar 20). Personal communication [Personal interview].

<sup>166</sup> Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)



## Long-Term Infrastructure Investments

The principal issue cited by Natalie Janzow of the Rocky Mountain Institute was the need to build infrastructure in order to facilitate the export of hydrogen. The production and transmission of hydrogen requires “electricity transmission lines, roads, pipelines in ports and water desalination plants” for domestic use and even more complicated infrastructure for international export, as demonstrated in Figure 2.<sup>167</sup> By focusing on international exports, the Chilean government has been accused of not creating sufficient levels of domestic demand from the private sector.<sup>168</sup> This could be especially problematic as the private sector will need to play a large role in the development of the industry. Additionally, as a highly flammable fuel, safety is a major concern and the continued upkeep of infrastructure will be expensive. In comparison to the existing fossil fuel industry, hydrogen faces an uphill battle with both private industry and government to receive financial investment to achieve similar levels of infrastructure.



**Figure 5: Infrastructure required for Hydrogen<sup>169</sup>**

<sup>167</sup>Janzow, N. (2024, Mar 20). Personal communication [Personal interview].

<sup>168</sup> Chile's push to enter global green hydrogen market faces obstacles. (2022, December 6). *Dialogo Chino*. <https://dialogochino.net/en/climate-energy/361364-chile-green-hydrogen-market-obstacles/>

<sup>169</sup> Renewable, clean hydrogen power is coming to California. Here's what you need to know. (2023, December 4). University of California. <https://www.universityofcalifornia.edu/news/renewable-clean-hydrogen-power-coming-california-heres-what-you-need-know>

## *Recommendations*

- Assist Chile in outreach to local communities near renewable energy and hydrogen production facilities to prevent local opposition
- Support Chile's long-term projects such as the Green Hydrogen fund to allow U.S. companies to make the long-term infrastructure investments needed in the country.
- Work with Chile to insulate green hydrogen development from politics, either through appointed councils with longer terms or mechanisms to prevent administration or governance changes from affecting infrastructure development and usage.

## Main Competitors for U.S. Exports

With Chile's ambitious goals being publicly announced, it has already attracted prominent international interest for exports. By 2025, the Chilean development agency Corfo plans to implement six hydrogen projects, supported by public subsidies totaling US\$50 million and a combined electrolyzer capacity of 396MW. The projects, selected for funding, include initiatives by international organizations with investments ranging from US\$2.4 million to US\$16.9 million, targeting electrolyzer capacities between 10MW and 240MW.<sup>170</sup>

- **Enel Green Power** (US\$16.9 million for 240MW of electrolyzer capacity)  
Alongside AME and potential partners like ENAP, Siemens Energy, and Porsche, Enel launched Chile's first pilot project for green hydrogen production in the Magallanes Region by 2022. Utilizing an electrolyzer powered by wind energy in Cabo Negro, north of Punta Arenas, highlights Patagonia's exceptional wind conditions for green hydrogen production. With over 7,200 MW of installed capacity in Chile, Enel is a major contributor to the country's renewable energy sector, aiming to enhance its green hydrogen production capacity in line with global demand and competitive pricing projections.<sup>171</sup>
- **Air Liquide** (US\$11.7 million for 80MW)  
Corfo has partnered with Air Liquide, among others, to increase green hydrogen production. Air Liquide receives \$11.7 million to produce green methanol. Utilizing captured CO<sub>2</sub>, renewable energy, and green hydrogen, the project targets an annual

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<sup>170</sup> GH2. (n.d.). Countries: Chile. Retrieved from <https://gh2.org/countries/chile>

<sup>171</sup> Enel. (2020, October 2). Enel Green Power together with AME announces plans for first pilot project for green hydrogen production in Chile. Retrieved from <https://www.enel.com/media/explore/search-press-releases/press/2020/10/enel-green-power-together-with-ame-announces-plans-for-first-pilot-project-for-green-hydrogen-production-in-chile>

output of 60,000 tonnes of green methanol, with operations expected to start in December 2025.<sup>172</sup>

- **Engie** (US\$9.5 million for 26MW)

This includes developing 2 GW of renewable energy capacity and ceasing coal-fired power generation by 2025, thereby eliminating nearly 1.5 GW of coal capacity. The plan, which involves a €1.5 billion investment by 2025, will cut ENGIE's CO<sub>2</sub> emissions in Chile by 80% by 2026. It includes shutting down six coal units, converting three to gas or biomass, and significantly expanding its renewable portfolio. Additionally, ENGIE is pioneering green hydrogen in Chile with three pilot projects.<sup>173</sup>

- **GNL Quintero** (US\$5.7 million for 10MW)

The "Green Hydrogen Quintero Bay" project, a project between GNL Quintero, ACCIONA Energía, and Enagás, represents a \$30 million investment in Chile's Valparaíso Region to construct an electrolysis plant for green hydrogen production using renewable electricity. Aiming to produce 500 tons annually at the outset, it is offering a sustainable energy alternative to support the industrial, mining, and transportation sectors.<sup>174</sup>

- **Linde** (US\$2.4 million for 20MW)

The "Power-to-MEDME" project, supported by over 11 million euros from the German Federal Ministry of Education and Research, involves several Fraunhofer institutes, including ISE and IEE, aiming to establish large-scale green hydrogen production in Chile. This focuses on exploring the potential for hydrogen and liquid fuels production from solar energy and includes constructing a pilot plant for climate-neutral methanol and dimethyl ether in Chile. Linde GmbH is set to build a pilot facility in northern Chile for green methanol or DME production, utilizing CO<sub>2</sub> captured from a local cement factory. The project aligns with the EU's REPowerEU goal to import renewable hydrogen,

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<sup>172</sup> Reuters. (2022, May 26). Chile signs agreements for green hydrogen production. Retrieved from <https://www.reuters.com/business/sustainable-business/chile-signs-agreements-green-hydrogen-production-2022-05-26/>

<sup>173</sup> ENGIE. (n.d.). ENGIE announces transformation plan in Chile. Retrieved from <https://www.engie.com/sites/default/files/assets/documents/2021-04/CP%20chili%20EN.pdf>

<sup>174</sup> GNL Quintero. (2021, September 2). GNL Quintero, ACCIONA Energía and Enagás to implement joint Green Hydrogen project on Quintero Bay. Retrieved from <https://www.gnlquintero.com/en/2021/09/02/gnl-quintero-acciona-energia-and-enagas-to-implement-joint-green-hydrogen-project-on-quintero-bay/>

positioning Chile as a vital supplier of CO<sub>2</sub>-neutral energy sources to Europe and promoting green hydrogen use in heavy-duty mining vehicles and other sectors.<sup>175</sup>

These projects are anticipated to draw an additional US\$1 billion in investments and are expected to produce over 45,000 tons of green hydrogen annually. The Chilean government's acceptance rate of 50% for proposed projects underscores its commitment to having these six green hydrogen projects operational by 2025.<sup>176</sup>

Major competitors for the green hydrogen technology and investment space in Chile include Germany, China, and Australia, which have made considerable announcements investing in green hydrogen technologies and projects in the country. Germany's national strategy to become a global leader in hydrogen technologies, China's rapid scale-up in green hydrogen production as part of its carbon emission reduction efforts, and Australia's investments in enforcing renewable resources for hydrogen production position them as competitors focusing on Chile. Additionally, the European Union, with countries such as France, the Netherlands, and Spain investing heavily in hydrogen as part of the European Green Deal, represents a collective competitor in the global hydrogen market.<sup>177</sup>

Several foreign companies play significant roles in Chile's green hydrogen sector, especially due to the country's renewable energy potential. Notable entities include Siemens Energy and Linde from Germany, ENGIE from France, and Fortescue Metals Group from Australia, all of which have an interest in renewable energy projects in combination with hydrogen production.

### *Recommendation*

- Chile's green hydrogen sector has attracted interest from major international players, including European energy giants. Competition from European investors could pose a challenge for U.S. companies seeking to export green hydrogen-related products and technologies to Chile. To address this challenge, the ITA can collaborate with European

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<sup>175</sup> Fraunhofer Institute for Solar Energy Systems ISE. (2023). Research on large-scale production of green hydrogen carriers in Chile. Retrieved from <https://www.ise.fraunhofer.de/en/press-media/news/2023/research-on-large-scale-production-of-green-hydrogen-carriers-in-Chile.html>

<sup>176</sup> Switzerland Global Enterprise. (2022). Green Hydrogen Projects Chile. Retrieved from <https://www.s-ge.com/zh/system/files?file=event/downloads/20220525%20Green%20Hydrogen%20projects%20Chile.pdf&ct>

<sup>177</sup> International Monetary Fund. (2022). Chile's Big Bet on Green Hydrogen. Retrieved from <https://www.imf.org/en/Publications/fandd/issues/2022/12/country-case-chile-bet-on-green-hydrogen-Bartlett>

counterparts to explore opportunities for joint ventures, partnerships, and co-investment in Chile's green hydrogen sector.

## Public Education

### *Introduction*

As Chile strives to become a global leader in the renewable energy sector, including through the development of the green hydrogen sector, there is a need to better align its public education and workforce capabilities with the technical demands of this industry. Chile's National Green Hydrogen Strategy notes the importance of initiatives that create opportunities for national employment and capability development.<sup>178</sup> Additionally, given the country's official commitment to decarbonizing its highly economically important mining and commodity sectors using green hydrogen, a comprehensive re-education and skill development strategy for these specific workforces is especially imperative. While Chile's preparedness for further green hydrogen development is generally strong relative to peers, this section identifies gaps in the country's public education and offers recommendations for the ITA's involvement in future improvements.

### *Findings*

The transition to a green hydrogen economy requires significant re-education of the existing workforce, especially in the mining and commodity sectors which make up a significant portion of Chile's economy. This training will be crucial for Chile to both meet its decarbonization targets effectively and sustain its long-term economic growth. The National Green Hydrogen Strategy specifically notes that: "Industry, academia, and technical centers will work together to identify gaps and prepare national capabilities to supply a new, burgeoning industry. Competencies and technical skills required along the value chain of green hydrogen will be identified jointly by public and private stakeholders. A coordinated preparation of those capabilities by national educational institutions will be articulated. A timely preparation in this regard will improve the projections for sophisticated, satisfactory, and good quality work positions."<sup>179</sup>

Thus far, Chile has engaged in several knowledge-sharing initiatives with countries with advanced green hydrogen capabilities. Notably, the Energy Partnership between Chile and

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<sup>178</sup> Ministry of Energy, Government of Chile. (2020, November). *National Green Hydrogen Strategy*. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

<sup>179</sup> Ministry of Energy, Government of Chile. (2020, November). *National Green Hydrogen Strategy*. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)

Germany facilitates knowledge exchange, training sessions, and renewable energy agreements.<sup>180</sup> Additionally, the Norway trade mission and the Team Europe Initiative (TEI) on Green Hydrogen development in Chile demonstrate concerted efforts to support Chile's green hydrogen sector through technology transfer, business cooperation, and the procurement of investment opportunities.<sup>181 182</sup>

These initiatives demonstrate an acknowledgment of the increasing demand for a skilled workforce capable of supporting the green hydrogen economy and seamlessly adopting potential technology imports from countries like the United States. By better addressing the educational and training needs associated with the development of this sector, Chile can not only meet its environmental and economic goals but also position itself as a global leader in green hydrogen.

### *Recommendations*

- Expand international cooperation in green hydrogen education by modeling Chile's existing partnerships, like those with Germany and Norway, to establish joint educational exchanges and training programs. This could involve planning facilitated trips for U.S.-based hydrogen technology companies, joint workshops, and collaborative R&D projects between the United States and Chile. These programs would also allow U.S. hydrogen technology companies to develop market relationships and sales leads in Chile.
- Encourage Chile to implement specialized workforce training and educational programs focused on green hydrogen technologies and applications.
- Encourage Chile to update existing engineering, environmental science, and other relevant curriculums to include specific content on green hydrogen technologies. This approach will ensure a longer-term base of knowledge among future green professionals.
- Monitor Chile's state-owned utility companies, such as Colbún, for progress on the technical training front, as public funding will likely flow to these entities which have demonstrated prior development and/or interest in green hydrogen production.

## Conclusion

Chile's current government is highly supportive of green hydrogen and the country can produce far more green energy than it uses. However, because it is still in such an early stage of

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<sup>180</sup>How Chile is becoming a leader in renewable energy. (2023, January 4). Retrieved from <https://www.weforum.org/agenda/2023/01/how-chile-is-becoming-a-leader-in-renewable-energy/>

<sup>181</sup>Trade mission Chile - green hydrogen. (n.d.). Retrieved from <https://www.innovasjon Norge.no/tjeneste/trade-mission-chile-green-hydrogen>

<sup>182</sup> Team Europe Initiative. (n.d.). *Green Hydrogen Cooperation with Chile: Fast Forward to Carbon-Neutrality*. Retrieved from <https://www.eeas.europa.eu/sites/default/files/documents/2023/TEI%20RH2%20Brochure%20%28ENG%29.pdf>

development, **Chile is not an optimal candidate** for green hydrogen exports at this time. This does not mean that Chile will not become a high-level producer in the future and there could be benefits realized by being an early investor in the country. More established relationships could make it easier for U.S. companies to do business in the future or to potentially receive Chilean exports as well. At present time there are too many barriers to further development that must be overcome before the industry can take off. These should be closely monitored because if the Chilean government is able to navigate them, it could produce the world's cheapest green hydrogen.

Below is a summary of our key recommendations

- Continue to monitor the development of renewable energy and hydrogen production and associated infrastructure as well as government support for these developments
- Chile aims to localize its supply chain for green hydrogen projects, reducing dependency on imports. However, the sector currently relies on imports for equipment and parts, posing a challenge to achieving this goal. The ITA can assist by facilitating technology transfer and collaboration between U.S. and Chilean companies to develop domestic manufacturing capabilities. This could involve joint ventures, technology licensing agreements, and knowledge exchange programs to support the localization process.
- Despite Chile's ambitious plans for green hydrogen production, significant investments are still required to scale up capacity. The ITA can support U.S. companies in accessing financing and investment opportunities in Chile through export financing programs, investment promotion activities, and partnerships with financial institutions.
- While Chile aims to localize its supply chain, the sector currently relies on imports for equipment and parts. To address this challenge, the ITA can promote U.S.-made products, provide export financing support, and advocate for policies that create a level playing field for U.S. suppliers.
- Incentivize exports to companies and subprojects demonstrating comprehensive environmental impact assessments, and not simply impact statements. This will ensure the support and scaling up of entities that won't be stalled by regulatory barriers.
- Assist Chile in outreach to local communities near renewable energy and hydrogen production facilities to prevent local opposition
- Support Chile's long-term projects such as the Green Hydrogen fund to allow U.S. companies to make the long-term infrastructure investments needed in the country.
- Work with Chile to insulate green hydrogen development from politics, either through appointed councils with longer terms or mechanisms to prevent administration or governance changes from affecting infrastructure development and usage.
- Chile's green hydrogen sector has attracted interest from major international players, including European energy giants. Competition from European investors could pose a



challenge for U.S. companies seeking to export green hydrogen-related products and technologies to Chile. To address this challenge, the ITA can collaborate with European counterparts to explore opportunities for joint ventures, partnerships, and co-investment in Chile's green hydrogen sector.

- Expand international cooperation in green hydrogen education by modeling Chile's existing partnerships, like those with Germany and Norway, to establish joint educational exchanges and training programs. This could involve planning facilitated trips for U.S.-based hydrogen technology companies, joint workshops, and collaborative R&D projects between the United States and Chile. These programs would also allow US hydrogen technology companies to develop market relationships and sales leads in Chile.
- Encourage Chile to implement specialized workforce training and educational programs focused on green hydrogen technologies and applications.
- Encourage Chile to update existing engineering, environmental science, and other relevant curriculums to include specific content on green hydrogen technologies. This approach will ensure a longer-term base of knowledge among future green professionals.
- Monitor Chile's state-owned utility companies, such as Colbún, for progress on the technical training front, as public funding will likely flow to these entities which have demonstrated prior development and/or interest in green hydrogen production.



## Bibliography

1. Chile | green hydrogen organisation. (n.d.). Retrieved April 5, 2024, from <http://gh2.org/countries/chile>
2. Chile to accelerate its green hydrogen industry with world bank support. (2023, June 29). World Bank. <https://www.worldbank.org/en/news/press-release/2023/06/29/chile-to-accelerate-its-green-hydrogen-industry-with-world-bank-support>
3. Truby, J., Philip, P., & Lorentz, B. (2023, June 19). Green hydrogen: Energizing the path to net zero. <https://www.deloitte.com/global/en/issues/climate/green-hydrogen.html>
4. Mcfarlane, C. (2023, November 11). Hydrogen in chile—Where does the industry stand today? <https://www.linkedin.com/pulse/hydrogen-chile-where-does-industry-stand-today-cody-mcfarlane-ak6ne>
5. Eyzaguirre, N., & Garnham, J. (2023, 9). Renewable energy laws and regulations report 2024 Chile. Retrieved from <https://iclg.com/practice-areas/renewable-energy-laws-and-regulations/chile>
6. Ministry of Energy, Government of Chile. (2020, November). National Green Hydrogen Strategy. Retrieved from [https://energia.gob.cl/sites/default/files/national\\_green\\_hydrogen\\_strategy\\_-\\_chile.pdf](https://energia.gob.cl/sites/default/files/national_green_hydrogen_strategy_-_chile.pdf)
7. ECPA. (2023, July 28). Chile launches major fund to Kickstart green hydrogen projects. Retrieved from <https://ecpamericas.org/newsletters/chile-launches-major-fund-to-kickstart-green-hydrogen-projects/>
8. AFP. (2024, February 12). Chile on green hydrogen investment hunt in Europe. Retrieved from <https://www.france24.com/en/live-news/20240212-chile-on-green-hydrogen-investment-hunt-in-europe>
9. Public Affairs Bruxelles. (2022, December 9). EU and Chile strengthen a comprehensive political and trade partnership. Retrieved from <https://www.pubaffairsbruxelles.eu/eu-institution-news/eu-and-chile-strengthen-a-comprehensive-political-and-trade-partnership/>
10. ITA. (2023, December 7). Chile - Trade barriers. Retrieved from <https://www.trade.gov/country-commercial-guides/chile-trade-barriers>

11. GIZ, ILF Ingeniería Chile Limitada, Ludwig-Bölkow Systemtechnik LBST. Requirements for the production and export of green-sustainable hydrogen. (2021). Energy Partnership Chile - Alemania.
12. [https://www.energypartnership.cl/fileadmin/user\\_upload/chile/media\\_elements/Studies/E\\_P\\_CHL\\_Production\\_of\\_green\\_sustainable\\_hydrogen\\_final\\_ISBN.pdf](https://www.energypartnership.cl/fileadmin/user_upload/chile/media_elements/Studies/E_P_CHL_Production_of_green_sustainable_hydrogen_final_ISBN.pdf)
13. Janzow, N. (2024, Mar 20). Personal communication [Personal interview].
14. Moberg, J. (2023, March 31). Hydrogen standards should only lend credibility to truly emissions-busting projects. Green Hydrogen Organisation.  
<https://gh2.org/blog/hydrogen-standards-should-only-lend-credibility-truly-emissions-busting-projects>
15. Seeger, M. (2023). The New ‘Energy El Dorado’? The World Bank’s Role in Promoting Green Hydrogen in Chile. Recourse, Sustentarse.  
<https://re-course.org/wp-content/uploads/2023/09/The-World-Bank-role-in-promoting-Green-Hydrogen-in-Chile.pdf>
16. Isidoro Losada, A. M. (2022). Green hydrogen: Chances and barriers for the energiewende in chile. Science Talks, 4, 100088.  
<https://doi.org/10.1016/j.sctalk.2022.100088>
17. Collins (l\_collins), L. (2021, September 20). “Vast majority” of green hydrogen projects may require water desalination, potentially driving up costs. Recharge | Latest Renewable Energy News.  
<https://www.rechargenews.com/energy-transition/vast-majority-of-green-hydrogen-projects-may-require-water-desalination-potentially-driving-up-costs/2-1-1070183>
18. Motamedi, M. (2023, December 18). Why Chileans rejected conservative constitution, and what’s next? Al Jazeera. Retrieved March 28, 2024, from  
<https://www.aljazeera.com/news/2023/12/18/why-chileans-rejected-conservative-constitution-and-whats-next>
19. Chile’s push to enter global green hydrogen market faces obstacles. (2022, December 6). Dialogo Chino.  
<https://dialogochino.net/en/climate-energy/361364-chile-green-hydrogen-market-obstacles/>
20. Renewable, clean hydrogen power is coming to California. Here’s what you need to know. (2023, December 4). University of California.  
<https://www.universityofcalifornia.edu/news/renewable-clean-hydrogen-power-coming-california-heres-what-you-need-know>

21. Enel. (2020, October 2). Enel Green Power together with AME announces plans for first pilot project for green hydrogen production in Chile. Retrieved from <https://www.enel.com/media/explore/search-press-releases/press/2020/10/enel-green-power-together-with-ame-announces-plans-for-first-pilot-project-for-green-hydrogen-production-in-chile>
22. Reuters. (2022, May 26). Chile signs agreements for green hydrogen production. Retrieved from <https://www.reuters.com/business/sustainable-business/chile-signs-agreements-green-hydrogen-production-2022-05-26/>
23. ENGIE. (n.d.). ENGIE announces transformation plan in Chile. Retrieved from <https://www.engie.com/sites/default/files/assets/documents/2021-04/CP%20chili%20EN.pdf>
24. GNL Quintero. (2021, September 2). GNL Quintero, ACCIONA Energía and Enagás to implement joint Green Hydrogen project on Quintero Bay. Retrieved from <https://www.gnlquintero.com/en/2021/09/02/gnl-quintero-acciona-energia-and-enagas-to-implement-joint-green-hydrogen-project-on-quintero-bay/>
25. Fraunhofer Institute for Solar Energy Systems ISE. (2023). Research on large-scale production of green hydrogen carriers in Chile. Retrieved from <https://www.ise.fraunhofer.de/en/press-media/news/2023/research-on-large-scale-production-of-green-hydrogen-carriers-in-Chile.html>
26. Switzerland Global Enterprise. (2022). Green Hydrogen Projects Chile. Retrieved from <https://www.s-ge.com/zh/system/files?file=event/downloads/20220525%20Green%20Hydrogen%20projects%20Chile.pdf&ct>
27. International Monetary Fund. (2022). Chile's Big Bet on Green Hydrogen. Retrieved from <https://www.imf.org/en/Publications/fandd/issues/2022/12/country-case-chile-bet-on-green-hydrogen-Bartlett>
28. How Chile is becoming a leader in renewable energy. (2023, January 4). Retrieved from <https://www.weforum.org/agenda/2023/01/how-chile-is-becoming-a-leader-in-renewable-energy/>
29. Trade mission Chile - green hydrogen. (n.d.). Retrieved from <https://www.innovasjon Norge.no/tjeneste/trade-mission-chile-green-hydrogen>
30. Team Europe Initiative. (n.d.). Green Hydrogen Cooperation with Chile: Fast Forward to Carbon-Neutrality. Retrieved from

## Appendix A - Stakeholder Table U.S.

|                   | Stakeholder                                      | Stakeholder Description                                                                                                                                                                                                                                                    | Level of Support | Reason for Resistance or Support                                                                                                                                                                                                                                                                                                                |
|-------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Government</b> | U.S. Department of Energy (DOE)                  | Oversees national energy policy and energy production                                                                                                                                                                                                                      | Support          | DOE is leading many federal initiatives: Energy Earthshots Initiative: Hydrogen Shot, Regional Clean Hydrogen Hubs: Hydrogen Hub Matchmaker, Clean Hydrogen Electrolysis Program, Clean Hydrogen Manufacturing, and Recycling RD&D Activities that will enable/enhance U.S. competitiveness. It also has several offices dedicated to hydrogen. |
|                   | International Trade Administration (ITA)         | An agency within the U.S. Department of Commerce focused on export development and competitiveness                                                                                                                                                                         | Support          | /                                                                                                                                                                                                                                                                                                                                               |
|                   | DOE National Energy Technology Laboratory (NETL) | Under the DOE Office of Fossil Energy, focuses on applied research for clean production and use of domestic energy resources. R&D on the supply, efficiency, and environmental constraints of producing and using fossil energy resources while maintaining affordability. | Support          | This program complements NETL's mission.                                                                                                                                                                                                                                                                                                        |
|                   | DOE Loan Programs Office (LPO)                   | ~ \$300 billion in loan authority to finance projects that support clean energy deployment and energy                                                                                                                                                                      | Support          | This program could benefit from LPO's support which could advance its remit.                                                                                                                                                                                                                                                                    |

|                 |                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                   |                                                                           |
|-----------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------|
|                 |                                                            | infrastructure reinvestment to reduce emissions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                   |                                                                           |
|                 | DOE Hydrogen and Fuel Cell Technologies Office (HFTO)      | Conducts comprehensive efforts to overcome the technological, economic, and institutional barriers to the development of hydrogen and fuel cells.                                                                                                                                                                                                                                                                                                                                                                                                      | Support           | This program complements HTFO's mandate                                   |
|                 | Hydrogen Interagency Task Force (HIT)                      | A collaboration among U.S. federal agencies to advance a whole-of-government approach to executing the national clean hydrogen strategy, including the development of a robust market supported by domestic supply chains and sustainable jobs. The Departments of Agriculture, Commerce, Defense, Interior, Labor, Transportation, Treasury, and State as well as the Environmental Protection Agency, National Aeronautics and Space Administration, Small Business Administration, and U.S. Special Presidential Envoy for Climate are represented. | Support           | With a whole government approach HIT would likely support ITA's program   |
| <b>Academia</b> | Hydrogen Initiative, Stanford University                   | A collaboration of researchers, industry leaders & governments to enable the use of hydrogen to achieve deep decarbonization. It focuses on the hydrogen value chain of hydrogen generation, transportation, storage, applications, and the policies that govern hydrogen markets.                                                                                                                                                                                                                                                                     | Support           | Hydrogen Initiative would support this program which advances its mission |
|                 | Center on Global Energy Policy (CGEP), Columbia University | Fosters dialogue on energy and climate problems and solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Support / Neutral | CGEP would likely support efforts to decarbonize with green hydrogen.     |

|                       |                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                    |
|-----------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------|
| <b>Private Sector</b> | Linde PLC                        | A global multinational chemical company. It's the world's largest industrial gas company by market share and revenue. Globally, Linde has more than 500 hydrogen production plants. Through its ITM Linde Electrolys is a joint venture, Linde has become one of the world's leading suppliers of green hydrogen produced using proton exchange membrane electrolyzer technologies. Market cap 2023: \$226.42 billion.                        | Support | This program would support its business expansion within Chile and Japan           |
|                       | Air Products and Chemicals (APC) | APC sells industrial gases and chemicals and provides related equipment and expertise. APC operates more than 100 hydrogen plants and maintains the world's largest hydrogen distribution network. Air Products has an extensive hydrogen-dispensing technology patent portfolio and has been involved in more than 250 hydrogen-fueling projects worldwide. Market cap: US\$55.1 billion.                                                    | Support | This program would support its business expansion within the green hydrogen sector |
|                       | Cummins                          | Cummins designs, manufactures, and distributes engines, filtration, and power-generation products with a specialization in diesel and alternative fuel engines and generators. Their brand Accelera, features "a diverse portfolio of zero-emissions solutions, including battery systems, fuel cells, ePowertrain systems, and electrolyzers." Accelera started electrolyzer production in Minnesota, US. The company is set to showcase its | Support | This program would support its business expansion within the green hydrogen sector |

|  |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                            |
|--|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                 | next-generation hydrogen engine in mid-2024.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |         |                                                                                                                                                                                                            |
|  | AES Corporation | <p>An independent power producer that stands to supply the renewable power needed to run electrolysis for green-hydrogen production.</p> <p>AES previously stated it would build a \$4 billion renewables-powered hydrogen facility with Air Products by 2027, turning 1.4 GW of renewable generation into 200 metric tons per day of green hydrogen, far bigger than anything like it in the U.S. today, and a step toward the DOE's goal of producing 10 million metric tons of clean hydrogen annually by 2030.</p> | Support | AES Corporation is a beneficiary of the DOE's Regional Clean Hydrogen Hubs                                                                                                                                 |
|  | Air Liquide     | A French multinational company and the second-largest supplier of industrial gases by revenues globally.                                                                                                                                                                                                                                                                                                                                                                                                               | Support | Air Liquide is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Amazon          | <p>Amazon invested early in hydrogen to power forklifts at its warehouses. As of 2022, Amazon was running 15,000 forklifts at 70 fulfillment centers on green hydrogen with help from partner Plug Power, while scoping out the fuel for decarbonizing its delivery fleet. California and the Pacific Northwest hubs aim to remake the West Coast heavy-duty trucking network in a cleaner,</p>                                                                                                                        | Support | Amazon is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector      |

|  |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |                                                                                                                                                                                                |
|--|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |              | hydrogen-powered image. Amazon has explicitly said it is testing hydrogen trucks for shipping and fuel cells for powering its buildings, and it wants to use its bulk purchasing power to expand the market for cleanly produced hydrogen.                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                |
|  | Bloom Energy | This long-running and perennially unprofitable cleantech player has sold solid-oxide fuel cells to give customers 24/7 onsite power production without any combustion. Those fuel cells historically have run on fossil gas, but more recently Bloom has played up its hydrogen competency so its purported climate solutions don't depend on a steady supply of fossil fuels. It recently tested its high-temperature solid-oxide electrolyzer at government research centers, and it claims it produces hydrogen more efficiently than other leading electrolyzer technologies. | Support | As a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Chevron      | Chevron makes 1 million metric tons of hydrogen gas per year from fossil fuels, much of which is used to refine oil. Clean hydrogen wise Chevron owns a majority stake in the electrolysis and storage venture in Delta, Utah known as ACES; it also is working on Gulf Coast hydrogen production with Air Liquide and other partners.                                                                                                                                                                                                                                            | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector    |
|  | ExxonMobil   | Exxon's base of infrastructure in the Gulf and know-how for making and selling liquid fuels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested                                                                                                         |



|  |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |         |                                                                                                                                                                                                                                |
|--|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                           | <p>may give it an edge in the emerging clean-hydrogen economy. Piping gases around and flushing them underground is one of Exxon's strong suits. If the existing carbon pipelines around Houston can't support competitive blue-hydrogen production, it's hard to imagine anywhere else that could.</p>                                                                                            |         | <p>and aware of this program that would support its business expansion within the green hydrogen sector</p>                                                                                                                    |
|  | Holtec                    | <p>Holtec is participating in two of the hubs that will tap existing nuclear fleets to supply carbon-free power for electrolysis. The 24/7 industrial demand for hydrogen production would make for welcome commercial demand at legacy nuclear plants that have struggled to keep their doors open.</p>                                                                                           | Support | <p>Holtec is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>                   |
|  | Mitsubishi Power Americas | <p>Mitsubishi got in early on green hydrogen and is working on the fully integrated hydrogen project in Delta, Utah, which will combine production, underground storage and use for power and other needs. That experience, plus a big balance sheet and a trusted brand in heavy power equipment, made Mitsubishi Power a sought-after partner for the Gulf Coast and Pacific Northwest hubs.</p> | Support | <p>Mitsubishi Power America is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p> |
|  | Plug Power                | <p>Plug Power started off making fuel cells but hit its commercial stride by selling thousands of fuel-cell forklifts to Amazon. Now it is building its own green-hydrogen production with electrolyzer technology.</p>                                                                                                                                                                            | Support | <p>Plug Power is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>               |

|                      |                                                   |                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                                                                                                                                          |
|----------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | TC Energy                                         | TC Energy is developing 10 blue and green hydrogen hubs across North America.                                                                                                                                                                                                                                                                                                                 | Support | TC Energy is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|                      | CF Industries                                     | A U.S. Manufacturer and distributor of agricultural fertilizers, including ammonia, urea, and ammonium nitrate products, based in Deerfield, Illinois. CF Industries is constructing North America's first commercial-scale green ammonia production capability at its Donaldsonville Complex in Louisiana.<br><br>Green ammonia is ammonia produced using hydrogen from carbon-free sources. | Support | This program would support its business expansion within the green hydrogen sector                                                                                                                       |
|                      | Hydrogen Forward                                  | Hydrogen Forward is a coalition of companies and organizations across the hydrogen value chain that are working to ensure hydrogen is a key contributing solution in the energy transition. .                                                                                                                                                                                                 | Support | This program would support the business expansion of its members within the green hydrogen sector                                                                                                        |
|                      | Fuel Cell and Hydrogen Energy Association (FCHEA) | The FCHEA is the leading industry association in the U.S. representing more than 100 leading organizations advancing production, distribution, and use of innovative, clean, safe, and reliable hydrogen energy.                                                                                                                                                                              | Support | This program would support the business expansion of its members within the green hydrogen sector                                                                                                        |
| <b>Civil Society</b> | Green Hydrogen Coalition (GHC)                    | The GHC is an educational non-profit. It focuses on building top-down momentum for scalable green hydrogen projects that leverage multi-sector opportunities to simultaneously scale supply and                                                                                                                                                                                               | Support | This program would support the business expansion of its members within the green hydrogen sector                                                                                                        |

|  |                                          |                                                                                                                                                                                                                                                                                |                     |                                                                                                                                                |
|--|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                          | demand.                                                                                                                                                                                                                                                                        |                     |                                                                                                                                                |
|  | Clean Air Task Force (CATF)              | CATF is a non-profit that aims to build momentum for solutions based on scientific evidence, and intellectual integrity, and pragmatism. Its mission is to push the technology and policy changes needed to achieve a zero-emissions, high-energy planet at an affordable cost | Support             | This program aligns with CATF's mission                                                                                                        |
|  | Natural Resources Defense Council (NRDC) | The NRDC is a U.S. non-profit international environmental advocacy group.                                                                                                                                                                                                      | Support conditional | While this program aligns with CATF's mission, NRDC may be aware and supportive of grass root resistance in Chile, Indonesia and other markets |
|  | Rocky Mountain Institute (RMI)           | RMI is an independent, non-partisan, nonprofit that aims to transform global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all.                                                           | Support             | This program aligns with RMI's mission                                                                                                         |
|  | Bipartisan Policy Center (BPC)           | The BPC is a not-for-profit organization that ensures policymakers work across party lines to craft bipartisan solutions                                                                                                                                                       | Support             | This program aligns with PBC's mission                                                                                                         |
|  | GTI Energy                               | GTI is a non-profit “focused on developing, scaling, and deploying energy transition solutions that improve lives, economies, and the environment.                                                                                                                             | Support             | As an administer for Multiple regional clean Hydrogen Hubs GTI would be well placed to benefit and support this program                        |

## Appendix B - Stakeholder Table Chile

|                                  | Stakeholder                           | Stakeholder Description                                                                                                                                                                                                                                                                     | Level of Support<br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><i>Why would the stakeholder resist or support?</i>                                                                                                                                                                                                                  |
|----------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| International / Regional Entity: | Inter-American Development Bank (IDB) | The main source of development financing for Latin America and the Caribbean.<br>The IDB has 48 member countries of which 26 are borrowers.<br>It provides financial and technical support to national and sub-national governments and other entities in the region and conducts research. | Support                                                                                 | Mid -2023 the IDB approved a \$400 million loan to support the development of the green hydrogen industry and its derivatives in Chile. This is the second credit operation under the \$1 billion Conditional Credit Line for Investment Projects for productivity and sustainable development in Chile. |
|                                  | German KfW Development Bank (KfW)     | The German KfW Development Bank finances and supports programmes and projects that involve public sector players in developing countries and emerging economies                                                                                                                             | Support                                                                                 | The KfW is providing the Green Hydrogen Finance Programme (PFCH2V) fund with \$110m. This fund is aligned with this programs aims.                                                                                                                                                                       |
|                                  | World Bank (WB)                       | The WB is an international financial institution that provides loans and grants to the governments of low- and middle-income countries for the purpose of pursuing capital projects.                                                                                                        | Support                                                                                 | The WB is providing an initial \$150m towards the PFCH2V fund and is expted to further provide \$200m at a future stage. This fund is alligned with this programs aims.                                                                                                                                  |
|                                  | European Investment Bank (EIB)        | The EIBis the European Union's (EU) investment bank and is owned by its member states.<br>The EIB finances and invests both through equity and debt solutions                                                                                                                               | Support                                                                                 | The EIB is providing the(PFCH2V fund with \$110m. This fund is alligned with this programs aims.                                                                                                                                                                                                         |

|                   |                                                       |                                                                                                                                                                                                                                                                                                            |         |                                              |
|-------------------|-------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------|
|                   |                                                       | companies and projects that achieve the policy aims of the EU through loans, equity and guarantees.                                                                                                                                                                                                        |         |                                              |
|                   | H2LAC                                                 | H2LAC is a collaborative platform whose objective is to promote the development of green hydrogen and its derivatives in Latin America and the Caribbean in order to promote its production, use and export.                                                                                               | Support | H2LAC's aims align with this program's aims. |
| <b>Government</b> | Ministry of Energy (MOE)                              | MOE is responsible for developing and coordinating, the plans, policies and regulations for the development of Chile's energy sector, and ensuring that all Chileans can access energy safely and at reasonable prices                                                                                     | Support | This program aligns with MOE's mandate       |
|                   | Ministry of Transportation & Telecommunications (MTT) | The MTT's main functions are to propose national policies on transport and telecommunications, in accordance with Chile's Government's directives and exercise the direction and control of its implementation.                                                                                            | Support | This program aligns with MTT's mandate       |
|                   | Ministry of Mining (MOM)                              | MOM designs, executes and evaluates public mining policies, aimed at raising and disseminating the contribution of the mining sector to national development, promoting innovation, productivity and sustainability, to take advantage of the available mining resources in socially inclusive conditions. | Support | This program aligns with MOM's mandate       |
|                   | The National Petroleum                                | Empresa Nacional del Petróleo s a state-owned company in Chile.                                                                                                                                                                                                                                            | Support | This program could replicate/build on an MOU |

|                 |                                                                                             |                                                                                                                                                                                                                                                                                                          |         |                                                                                                                                 |
|-----------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------|
|                 | Company (ENAP)                                                                              | The company is engaged in the exploration, production, refining, and marketing of hydrocarbons and their derivatives.                                                                                                                                                                                    |         | between ENAP and HIF Global to accelerate the use of eFuels ( eGasoline produced from green hydrogen) in Chile                  |
|                 | Chilean Economic Development Agency (CORFO), Ministry of Economy, Development, and Tourism. | Works to improve the competitiveness and the productive diversification of the country by encouraging investment, innovation and entrepreneurship.                                                                                                                                                       | Support | This program aligns with CORFO's mandate                                                                                        |
| <b>Academia</b> | Los Andes Center of Excellence in Geothermal Energy (CEGA), University of Chile             | CEGA work's to generate and improve geothermal knowledge in Chile.<br>Its mission is to develop geothermal energy as a sustainable, environmentally friendly and economically competitive resource in order to contribute to the energy requirements in Chile and the Andean countries.                  | Support | This program could advance CEGA's mission                                                                                       |
|                 | Enel Green Power (Chile)                                                                    | A subsidiary of Italian energy giant Enel is using Chile as a proving ground for green hydrogen technology                                                                                                                                                                                               | Resist  | As a foreign competitor this company would likely oppose this program                                                           |
|                 | Air Liquide (Chile) (ALC)                                                                   | ALC produces and markets industrial and medical gases and related services. It serves a wide array of sectors including industrial and healthcare activities. It operates 4 production units and has 8 retail and filling centers across the country, complemented by an important distribution network. | Support | As a company with a presence in the U.S.<br>This program would support its business expansions within the green hydrogen sector |

|               |                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                                                                                                                                    |
|---------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------|
|               | GNL Quintero                          | <p>GNL Quintero is the southern hemisphere's first terminal for the reception, unloading, storage and regasification of liquefied natural gas. It is owned by EIG, an institutional investor to the global energy sector, specialized in private investments in energy and energy-related infrastructure, FLUXYS a fully independent energy infrastructure group focused on gas transmission &amp; storage and liquefied natural gas terminaling (80%) and ENAP (20%)</p> | Support Conditional | As a public private program initiative GNL Quintero could be both an example to and beneficiary of this program                    |
|               | CAP                                   | <p>CAP is a Chilean holding company of the mining and steel sectors. These sectors are represented by different affiliates.</p>                                                                                                                                                                                                                                                                                                                                           | Support Conditional | Depending on how CAP is included in this program it could support                                                                  |
|               | Linde (Chile)                         | <p>Linde plc is a global multinational chemical company founded in Germany and, since 2018, domiciled in Ireland and headquartered in the UK. Linde is the world's largest industrial gas company by market share and revenue. Market cap 2023: \$226.42 billion.</p>                                                                                                                                                                                                     | Support             | <p>As a company with a presence in the U.S. This program would support its business expansion within the green hydrogen sector</p> |
| Civil Society | Chilean Hydrogen Association H2 Chile | <p>The objective of H2 Chile is to promote the use of hydrogen as a sustainable energy vector, fostering its research, development and use in industrial, commercial, residential and mobility applications. H2 Chile has two types of memberships, individuals and companies. H2 Chile is composed</p>                                                                                                                                                                   | Support             | This program supports H2 Chile's aims and helps its members reach their goals.                                                     |

|  |                                         |                                                                                                                                                                                                                                                                                                                  |        |                                                                                                                                                                                                                                                          |
|--|-----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                         | of individuals who work in different companies involved in the hydrogen value chain (Air Liquide, Engie, Copec, Codelco, AChEE, GIZ, etc.) and Academic Institutions (UdeC, UTFSM, UDT).                                                                                                                         |        |                                                                                                                                                                                                                                                          |
|  | Citizen Panel on Hydrogen in Magallanes | Is a network of socio-environmental and scientific organizations focused on the impact of public policy associated with the industrialization process of hydrogen.                                                                                                                                               | Resist | In August 2023 the Citizen Panel on Hydrogen in Magallanes, declared that the hydrogen industry's plans amount to extractivism that would transform the region into a "big new zone of sacrifice to satisfy the needs and urgencies of the first world." |
|  | Sustentarse                             | Sustentarse advocates for Human Rights, sustainable development, and good socio-environmental governance at the local level. It supports communities and, especially the most vulnerable groups - such as women and indigenous peoples - in the defense of their rights, their territories, and the environment. | Resist | This NGO supports the Chango's rights to a healthy environment and would be aware of the affected community's concerns and fears                                                                                                                         |
|  | Recourse                                | An International NGO collaborating with Sustentarse on ecological justice and Human rights                                                                                                                                                                                                                       | Resist | This NGO supports the Chango's rights to a healthy environment and would be aware of the affected community's concerns and fears                                                                                                                         |
|  | Chango peoples/Pueblo Chango            | The Changos, also known as Camanchacos or Camanchangos are an indigenous people or group of peoples who inhabited a long stretch of the Pacific coast from southern Peru to north-central Chile, including the coast of the Atacama desert.                                                                      | Resist | The Pueblo Chango have raised several concerns and are actively opposing green hydrogen development in their area                                                                                                                                        |





# MEMO II

# Green Hydrogen

## *Indonesia*

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## Executive Summary

This memo details the opportunities and challenges related to a potential United States (U.S.) public-private program (PPP) aimed at promoting green hydrogen technology exports to Indonesia. Our analysis explores stakeholders, market dynamics, relevant policies, export challenges, sectoral growth challenges, key competitors, and public education requirements, along with recommendations for the ITA.

**Key Stakeholders:** The stakeholders range from international and regional entities like the Asia Development Bank (ADB) and the Just Energy Transition Partnership (JETP), to pivotal government bodies including the Ministry of Energy and Mineral Resources (ESDM) and the Ministry of Environment and Forestry (KLHK). The private sector plays a crucial role, with companies such as TotalEnergies, HDF Energy, and Pertamina leading initiatives, while academic institutions like the Indonesia Institute for Essential Service Reform (IESR) and the Singapore University of Technology and Design (SUTD) provide research and development insights. Civil society organizations, including METI and the Indonesian Renewable Energy Society, contribute to the discourse on sustainable energy practices.

**Market Analysis:** Indonesia aims to scale its green hydrogen production from a nascent stage to a significant global market presence by 2060, leveraging its substantial renewable energy potential. The National Hydrogen Strategy underscores ambitions to replace fossil fuels across key sectors, with projections indicating a robust demand increase. Strategic investments

and projects, such as PT PLN (Persero)'s production facilities and the Garuda Hidrogen Hijau initiative, mark early financial successes. However, regulatory and infrastructural challenges persist, necessitating focused investment in renewables and strategic partnerships. The ITA is encouraged to collaborate with key local entities to foster industry growth, however, investing towards the untapped potential of the renewable energy market seems more promising at the current stage.

**Key Codes, Standards, and Regulatory Frameworks:** Indonesia is navigating its green hydrogen journey amidst a complex regulatory and policy landscape, with ambitions to catalyze a low-carbon economy transition using its abundant renewable resources. Key policies, such as Law 30/2007, Government Regulation No.79/2014, Presidential Regulation No.22/2017, and the forthcoming New and Renewable Energy Bill, frame Indonesia's roadmap towards reducing reliance on imported energy, enhancing energy security, and incorporating renewable sources into the national energy mix. The National Hydrogen Strategy, published in December 2023, crystallizes Indonesia's vision for becoming a green hydrogen hub, supported by pilot projects and international partnerships.

Despite these strategic initiatives, Indonesia confronts challenges including regulatory ambiguities, insufficient infrastructure investments, and the need for more robust policy

reforms to attract the necessary capital for a successful energy transition. The ITA should leverage the U.S. Clean Energy Working Group to enhance engagement with Indonesian authorities, promote technology transfer, and advocate for regulatory environments conducive to green hydrogen development.

**Export Challenges:** Indonesia's green hydrogen sector faces significant export challenges stemming from the absence of a comprehensive national green hydrogen strategy, uncompetitive renewable energy prices, high electrolyzer costs, and underdeveloped infrastructure. Currently, the cost of green hydrogen production remains high, with the lowest achievable price at \$2.6/kg—non-competitive without government subsidies, contrasting sharply with the existing fossil fuel subsidization. To reach an efficient price point by 2030, a subsidy of at least \$0.5/kg for green hydrogen is deemed necessary by BUMN and Pertamina. Moreover, the development of dedicated green hydrogen production and ammonia transportation infrastructure, alongside an import duty exemption for power plant developers, are critical steps for integrating green hydrogen into the national market and supply chain effectively.

**Challenges to Sectoral Growth:** Indonesia's green hydrogen economy faces hurdles from regulatory gaps, technological and infrastructural inadequacies, and uncertain market development. The absence of a tailored regulatory framework and the need for substantial investment in technology and infrastructure, especially for transport across its archipelago, impede sector growth. Market readiness is further delayed by regulatory

ambiguities, with significant growth not expected until post-2030. Despite Indonesia's advantage as a leading nickel exporter, essential for electrolyzer production, the lack of targeted policies for electrolyzer manufacturing hinders competitive positioning. The recommendation for the ITA is to monitor Indonesia's progress, considering potential future opportunities as the regulatory and market landscape evolves.

**Main Competitors for U.S. Export:** Japan, Singapore, and the European Union are key competitors for the United States in the green hydrogen technology export market. Japan is deeply involved in Indonesia's green hydrogen development, focusing on production and utilization, including co-firing ammonia in coal power plants through collaborations with companies like JERA, Mitsubishi Heavy Industries, and Mitsubishi Corporation. Singapore aims to become a green hydrogen shipping hub, partnering with Indonesia to explore production for export. The EU is increasing its renewable energy investments in Southeast Asia, with Germany's Augustus Global Investment announcing a significant green hydrogen plant investment in Aceh, Indonesia beginning in 2024.

For the United States to effectively compete, the ITA should foster partnerships with Indonesian state-owned enterprises and alignment with local standards and development processes are crucial. Identifying specific value chain segments for technology exports and investing in supporting infrastructure are recommended strategies to strengthen the U.S. presence in Indonesia's evolving green hydrogen sector.

**Public Education:** Indonesia's green hydrogen sector's success hinges on addressing the workforce's green skill gaps and enhancing public education on renewable energy. With ambitious renewable energy goals, the country partners with international entities, like the German government's ISED project, to innovate training for green jobs. State-owned and private companies are urged to develop comprehensive training programs. Additionally, leveraging online media to inform and engage the public on green hydrogen's benefits is crucial. We recommend the ITA foster U.S.-Indonesia partnerships for workforce development and public awareness campaigns.

In Indonesia, establishing a green hydrogen economy faces multifaceted challenges, including regulatory uncertainties, technological and infrastructural gaps, financial constraints, and the need for enhanced public education and workforce development. Despite these obstacles, the country's strategic initiatives, such as the National Hydrogen Strategy and collaborations with international partners, underscore its potential in the green hydrogen sector. However, current limitations—ranging from the lack of a cohesive policy framework and skilled workforce to inadequate infrastructure and market readiness—suggest that Indonesia may currently represent **a suboptimal candidate** for a green hydrogen export PPP initiative.

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## Introduction

This memo discusses the potential for a United States public-private program (PPP) initiative focused on promoting green hydrogen technology exports to Indonesia. It introduces key domestic and international stakeholders, the current state of the green hydrogen market, key codes and regulatory frameworks, export challenges, sectoral growth challenges, competitor analysis, and public education requirements. We provide recommendations related to managing stakeholders, sectoral and export growth, and public education that can facilitate the success of a PPP initiative targeted toward Indonesia. The conclusion includes a summary of these recommendations. Finally, the appendices provide further in-depth stakeholder analysis.

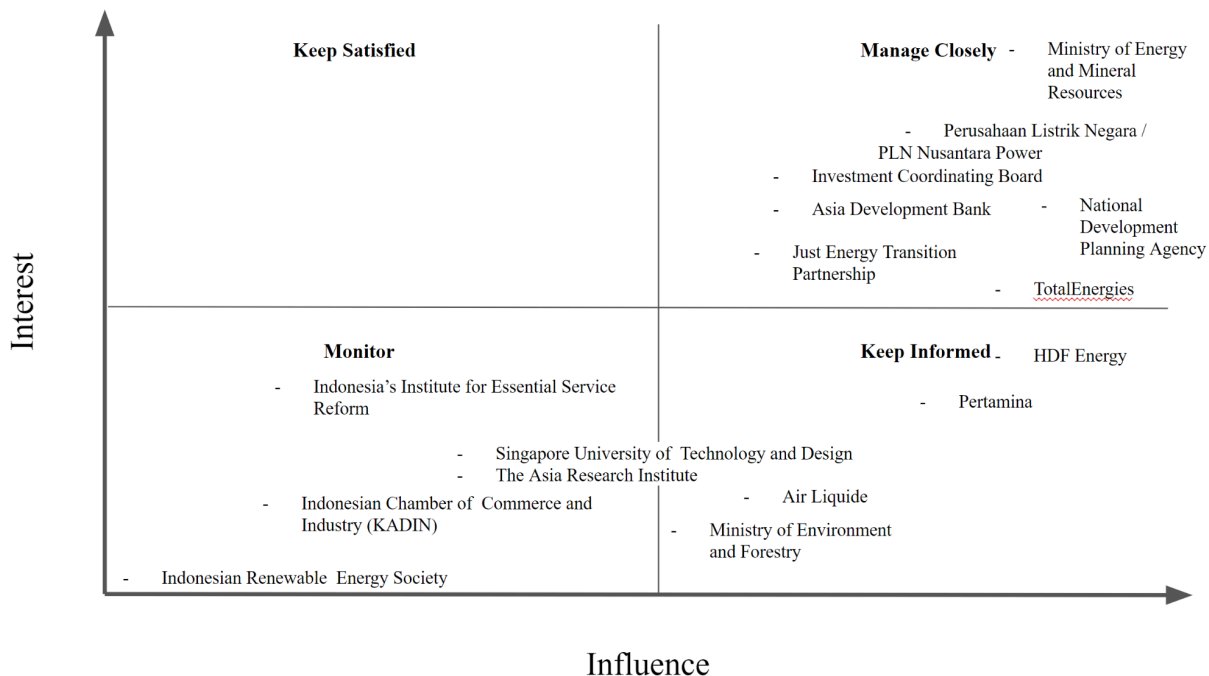
## Key Stakeholders

Identifying and understanding the various stakeholders involved in the implementation of a green hydrogen (GH) Public-Private Program (PPP) initiative is vital for strategic alignment, risk management, and resource allocation. Stakeholder analysis of Indonesia's hydrogen landscape can be effective in building relationships, enhancing legitimacy, and ensuring accountability within a complex system. We have identified the following stakeholders working at international, regional levels across government, the private sector, academic, and civil society in Indonesia:

- *International /Regional Entity:* Asia Development Bank (ADB) and the Just Energy Transition Partnership (JETP)
- *Government:* Ministry of Energy and Mineral Resources (ESDM), Ministry of Environment and Forestry (KLHK), Investment Coordinating Board (BKPM), Perusahaan Listrik Negara (PLN)/ PLN Nusantara Power (PLN NP), and the National Development Planning Agency (Bappenas)
- *Private Sector:* TotalEnergies, HDF Energy, Pertamina and Air Liquide
- *Academia:* Indonesia's Institute for Essential Service Reform (IESR), Singapore University of Technology and Design (SUTD), The Asia Research Institute (ARI), and The National Research and Innovation Agency (BRIN)
- *Civil Society:* The Institute for Essential Services Reform (IESR), Indonesian Chamber of Commerce and Industry (KADIN), and the Indonesian Renewable Energy Society (METI).

## Recommendations

The following interest-influence matrix (Fig. 1) displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely).



**Figure 1:** Indonesia Green Hydrogen Stakeholder Analysis Matrix

## Market Analysis

### Overview

The Ministry of Energy demand for low-carbon hydrogen is predicted to increase from around 0.2 petajoules PJ (equivalent to 26,000 barrels of oil) in 2031 to peak at 609 PJ in 2060.<sup>183</sup> Regulatory challenges Indonesia is facing regarding scaling up green hydrogen (GH) revolve around the foundational strategy and infrastructure needed to promote GH, including national policy and standardization, and renewable energy supply. Indonesia still has ways to go in the

<sup>183</sup> IBP. (2023, December 28). *Indonesia anticipates significant growth in green hydrogen demand*. Indonesia Business Post. Retrieved from <https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>



expansion of its GH potential, and it will require intensive strategizing and execution on all fronts.

#### *Expected growth of green hydrogen market*

Indonesia's green hydrogen market is set for remarkable expansion, backed by the country's National Hydrogen Strategy from 2023. This strategy delineates a future where Indonesia transitions to a more sustainable energy mix by 2060, leveraging its vast renewable energy potential of approximately 3,689 GW—of which a mere 0.3% has been tapped into—to produce green hydrogen. With the Directorate General of New, Renewable Energy and Energy Conservation at the helm, Indonesia aims to become a significant player in the global hydrogen scene, focusing initially on low-carbon hydrogen with a gradual shift to green hydrogen as it becomes economically feasible.<sup>184</sup>

Key to this strategy is the ambition to replace fossil fuels with low-carbon hydrogen across industries and power generation by 2060, making hydrogen a primary fuel in transportation, alongside electric vehicles powered by low-carbon electricity. The demand for low-carbon hydrogen is anticipated to surge post-2030, particularly in transportation, industry, power generation, and energy storage sectors. Notably, the transportation sector is expected to embrace green hydrogen by 2031, with the industrial sector to follow by 2041, transitioning from natural and fossil gas for high-temperature heating processes.<sup>185</sup>

Market projections are robust, with Indonesia's state-owned Pertamina forecasting hydrogen demand to range between 2.1 MTPA (million tonnes per annum) to 8.7 MTPA by 2040, depending on the adoption scenario. The International Energy Agency (IEA) further supports this optimistic outlook, projecting Indonesia's low-carbon hydrogen needs to exceed 208.3 Terawatt hours (TWh) by 2060, spotlighting the power generation, transportation, and industrial sectors as key demand drivers.<sup>186</sup>

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<sup>184</sup>Singh, A. N. and R. (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects*, *New Investment*. S&P Global Commodity Insights.  
<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>

<sup>185</sup>IBP, J. (2023, December 28). *Indonesia anticipates significant growth in green hydrogen demand: Risk & OPP*. Indonesia Business Post.  
<https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>

<sup>186</sup>IBP, J. (2023, December 28). *Indonesia anticipates significant growth in green hydrogen demand: Risk & OPP*. Indonesia Business Post.  
<https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>

Investment in production capacity underscores this growth trajectory. The government PT PLN (Persero) has already operationalized 21 green hydrogen production facilities, demonstrating a significant stride in infrastructure development. Large-scale investments, such as the U.S.\$1 billion Garuda Hidrogen Hijau (GH2) project and the U.S.D\$500 million green hydrogen project in the Arun Special Economic Zone, are tangible markers of the capital flow towards enhancing Indonesia's hydrogen production capabilities.<sup>187</sup>

Strategic initiatives further this development, with PT Pupuk Indonesia committing to produce and/or consume 2.3 MTPA of green and blue hydrogen. Additionally, PT Kilang Pertamina Internasional's plan to establish a blue ammonia facility by 2030, with a capacity of approximately 150,000 TPA of blue hydrogen, exemplifies strategic advancements in production capabilities.<sup>188</sup>

In summary, Indonesia's hydrogen market is poised for substantial growth, supported by ambitious national strategies, substantial investments, and strategic initiatives aimed at overcoming current challenges in infrastructure, regulatory clarity, and investment. These efforts are crucial for Indonesia not only to achieve its 2060 goals of energy security and decarbonization but also to secure its position as a significant hydrogen exporter on the global stage.

### *Recommendations*

- ITA should begin with primarily investing in other renewables besides GH, given that Indonesia's renewable energy capacity is not yet sufficient to support the affordable production of GH.
- If ITA chooses to support GH, it should engage with local stakeholders to promote the expansion of green technology industries, opportunities include involvement in ongoing project development and engagement with state-owned PLN, Pertamina or Pupuk Indonesia, which have shown an interest in green hydrogen development.<sup>189</sup>

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<sup>187</sup> Jhanesta, W. (2023, December 28). *Indonesian hydrogen outlook 2024*. petromindo28. <https://www.petromindo.com/news/article/indonesian-hydrogen-outlook-2024>

<sup>188</sup> Jhanesta, W. (2023, December 28). *Indonesian hydrogen outlook 2024*. petromindo28. <https://www.petromindo.com/news/article/indonesian-hydrogen-outlook-2024>

<sup>189</sup> *Hydrogen in Indonesia*. (n.d.). Business-Indonesia. March 26, 2024. Retrieved from <https://business-indonesia.org/hydrogen>

## Key Codes, Standards, and Regulatory Frameworks

### *The regulatory and policy landscape*

For countries with abundant low-cost renewable energy resources, green hydrogen has an immense potential to accelerate the transition to a low-carbon economy and ultimately reduce carbon emissions. Developing countries, including Indonesia, have now started exploring these opportunities by studying its low-carbon hydrogen potential and gaining experience in using ammonia-based and methanol-based fuel cell systems.<sup>190</sup> Consequently, Indonesia aims to diversify exports and use domestically sourced renewables for international trade. In 2022, Indonesia imported \$5.4 billion of energy equipment, with about 15% of that from the United States, along with supplies from other major suppliers like China, Singapore, Japan, Korea, Malaysia, France, and Germany.<sup>191</sup>

Indonesia's energy transition strategy involves initially adopting low-carbon hydrogen and gradually transitioning to green hydrogen to compete economically with other energy sources. The goal is to establish a hydrogen economy, replacing fossil fuels across industries and power generation by 2060, alongside the rise of electric vehicles powered by low-carbon electricity. Various pilot projects are underway in Indonesia with a view of tapping and developing Indonesia's green (and blue) hydrogen potential, with involvement largely from Indonesia's state-owned companies. For instance, Indonesia's state-owned electricity company Persero and France's HDF Energy, in May 2023, signed a Memorandum of Understanding to develop projects that combine renewable energy generation with on-site green hydrogen generation, that would help Indonesia overcome the "unique constraints due to its archipelago geography" while becoming a green hydrogen frontrunner in Asia.<sup>192</sup> Saudi Arabian power generation company ACWA has also signed an agreement with Indonesian state-owned chemical manufacturing company Pupuk Indonesia to develop a giga-scale green hydrogen project in the country, hinting at an increase in foreign competition for any country interested in trading clean technology components with Indonesia.<sup>193</sup> Pertamina Geothermal Energy (a subsidiary of the national oil company Pertamina) is also conducting a green hydrogen pilot in the Ulubelu geothermal region of Lampung.

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<sup>190</sup> World Trade Organization. (2023). International trade and green hydrogen: Supporting the global transition to a low-carbon economy. Retrieved from [https://www.wto.org/english/res\\_e/booksp\\_e/green\\_hydrogen\\_e.pdf](https://www.wto.org/english/res_e/booksp_e/green_hydrogen_e.pdf)

<sup>191</sup> (2024). Indonesia - Country Commercial Guide. International Trade Administration. <https://www.trade.gov/country-commercial-guides/indonesia-energy>

<sup>192</sup> Wood, J. (2023, May 25). *HDF Energy signs MoUs for green hydrogen on two continents*. Windpower Monthly. Retrieved from

<https://www.windpowermonthly.com/article/1824053/hdf-energy-signs-mous-green-hydrogen-two-continents>

<sup>193</sup> Power, A. (2023, December 6). *ACWA Power signs deal to develop the largest green hydrogen project in Indonesia*. ACWA Power. Retrieved from <https://www.acwapower.com/news/acwa-power-signs-deal-to-develop-the-largest-green-hydrogen-project-in-indonesia/>

A few significant policy and regulatory frameworks in place in Indonesia that could potentially help boost the country's green hydrogen market include:<sup>194</sup>

- **Law 30/2007 (Energy Law):** Aims to reduce Indonesia's dependence on imported refined oil and enhance energy security while boosting the use of other energy sources, including natural gas, biofuels, and geothermal resources.
- **Government Regulation No.79/2014: National Energy Policy (KEN):** Aims to provide a set of directions for national energy management to achieve energy independence and security, support sustainable development and increase the share of New and Renewable Energy (NRE) in the primary energy mix to be at least 23% by 2025 and at least 31% by 2050.
- **Presidential Regulation No.22/2017: National Energy Plan (RUEN):** Establishes a comprehensive plan for NRE development until 2050, including specific actions for hydrogen development such as regulatory frameworks, technological advancement, manufacturing capacity enhancement, and incentives provision.
- **Law No. 30/2009: Electricity Law:** Governs the planning and administration of the electricity sector, with a focus on new and renewable energy sources.
- **New and Renewable Energy Bill:** This pending legislation regulates the development of new and renewable energy sources, addresses prices and incentives, and in its latest draft, includes provisions for hydrogen as a new energy source.
- **National Hydrogen Strategy (Dec 2023):** Outlines Indonesia's approach to hydrogen industry development, emphasizes support for new and renewable energy, decarbonization initiatives aligned with global climate change mitigation, and positions Indonesia as a potential hydrogen hub, with plans indicating research and pilot projects in progress and anticipated growth in hydrogen utilization post-2030, particularly in mobility, electricity generation, energy storage, and decarbonization efforts in challenging sectors.<sup>195</sup>

Despite these promising policies, challenges such as regulatory ambiguity and the absence of formal regulations hinder the widespread adoption of low-carbon hydrogen, and establishing hydrogen storage infrastructure is crucial to balance supply and demand, so inadequate investment may impede hydrogen development.<sup>196</sup>

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<sup>194</sup> Global Center of Excellence for Green Hydrogen. (n.d.). Global Center of Excellence for Green Hydrogen. Retrieved March 29, 2024, from

<https://isa-ghic.org/countries/indonesia#:~:text=Green%20hydrogen%20development%20in%20the>

<sup>195</sup> Ministry of Energy and Mineral Resources (2023). *National Hydrogen Strategy* [Review of *National Hydrogen Strategy*]. . <https://ebtke.esdm.go.id/post/2023/12/15/3680/strategi.hidrogen.nasional>

<sup>196</sup> Nugraha, A. (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects, new investment*. Spglobal.com; S&P Global Commodity Insights. Retrieved from

### *Policy, Trade, and Regulatory Challenges*

- **Policy Ambiguity and Strategic Deficits:** While the above policies and regulations outline ambitious targets for renewable energy integration into Indonesia's energy mix by 2025 and 2050, the absence of concrete implementation policies hinders the realization of these goals. Apart from the annual ratification of the Electricity Business Plan (RUPTL) by the Ministry of Energy and Mineral Resources (MEMR), there is a lack of strategic directions for achieving energy transition and meeting renewable energy targets. The RUPTL, typically spanning 10 years, primarily outlines PT Perusahaan Listrik Negara (PLN)'s (Indonesia's government-owned electricity company) plans for power plant development. According to the latest RUPTL (2021–2030), PLN intends to incorporate 10.6 GW of renewable energy capacity by 2025.<sup>197</sup>
- **Financial Hurdles and Project Bankability Issues:** Despite considerable interest from investors in climate ventures, challenges persist in making projects financially viable. Factors such as the inability to efficiently scale remote off-grid clean energy initiatives and generate adequate returns pose significant hurdles. A major concern is a lack of bankable renewable energy projects—those deemed financially viable enough for bank support. As of 2020, the Indonesian government could only secure 34% of the total investment required to fulfill its commitments under the Paris Climate Accord. According to experts, bridging Indonesia's climate finance gap necessitates substantial private sector involvement, with the bulk of required capital expected to come from private sources.<sup>198</sup>
- **Low Infrastructure Investments and Need for Policy Reform:** Another key challenge is the investment cost required to build the appropriate infrastructure for producing green hydrogen. In Indonesia, hydrogen transport is particularly challenging due to its geographical conditions.<sup>199</sup> Historically, Indonesia has invested around USD 20 billion per year in its energy sector. As decarbonization becomes more capital intensive, the International Energy Agency projects that, by 2030, the investment is expected to be around USD 8 billion higher per year, with investment in renewables generation and grids (USD 25 billion) than the current investment in the entire energy sector. Mobilizing

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<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>

<sup>197</sup> Mahiddin, F. et al. (2023, February 24). *Indonesia: Renewable Energy Laws And Regulations 2023*. Mondaq.

<https://www.mondaq.com/renewables/1286536/renewable-energy-laws-and-regulations-2023>

<sup>198</sup> Eco-Business. (2023, September 2). *Lack of “bankable” climate projects hurting Indonesia’s energy transition*. Eco-Business.

<https://www.eco-business.com/news/lack-of-bankable-climate-projects-hurting-indonesias-energy-transition/>

<sup>199</sup> Gunawan, D. (2022). *Unlocking the Potential of Hydrogen in Indonesia*. <https://doi.org/10.55981/brin.562.c11>

this level of investment, however, requires significant policy reforms in Indonesia as well as international support.<sup>200</sup>

- **Regulatory Ambiguity and Local Government Engagement:** A study conducted by Indonesia's Center of Economic and Law Studies (CELIOS), noted that the challenges posed by regulatory ambiguity and limited involvement of local government in the national energy transition strategies are multifaceted. Many local government entities lack awareness and understanding of government policies, and the absence of a regulatory framework at the local level for implementing national policies adds further complexity to the transition process. Regional governments have expressed concerns that the current policy framework does not adequately address the requirements for a seamless energy transition, leaving gaps and uncertainties. Addressing these challenges requires improved communication and collaboration among central and local government bodies, along with the development of robust regulatory frameworks that prioritize community welfare and facilitate a smoother transition to cleaner energy sources.<sup>201</sup>
- **Technology Transfer:** Technical knowledge and expertise to handle, install, and maintain hydrogen and related systems is one of the most important factors determining a country's existing capacity to implement green hydrogen solutions. Ensuring the availability and use of appropriate equipment to handle hydrogen is key when trading key components required to build Indonesia's green hydrogen potential.<sup>202</sup>
- **Tariffs and Fiscal Incentives:** The existing tariff and subsidy structures in Indonesia present challenges for the development of hydrogen energy cleantech initiatives. Current estimates lack specificity and fail to fully account for various non-price barriers impacting renewable energy project costs. These barriers include local content requirements, potential delays, and limitations on foreign investment. President Regulation (Peraturan Presiden, PERPRES) 44/2016, commonly referred to as the "negative investment list," imposes restrictions on foreign investments in different sectors, including power generation projects, which encompasses renewable energy ventures. Challenges to green hydrogen development in Indonesia also include the

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<sup>200</sup> IEA (n.d.). *Executive summary – An Energy Sector Roadmap to Net Zero Emissions in Indonesia – Analysis*. <https://www.iea.org/reports/an-energy-sector-roadmap-to-net-zero-emissions-in-indonesia/executive-summary>

<sup>201</sup> CELIOS (2023). *Accelerating the Just Energy Transition: Challenges and Opportunities for Regions*, July 2023. Retrieved from <https://celios.co.id/wp-content/uploads/2023/10/CELIOS-Accelerating-the-Just-Energy-Transition-Challenges-and-Opportunities-for-Regions.pdf>

<sup>202</sup> ESMAP (2020). *Green Hydrogen in Developing Countries*. Washington, DC: World Bank. <https://documents1.worldbank.org/curated/en/953571597951239276/pdf/Green-Hydrogen-in-Developing-Countries.pdf>



absence of explicit inclusion in pioneer industry lists for tax holidays,<sup>203</sup> alongside the need for continued regulatory alignment and awareness-building efforts to facilitate its integration into national energy strategies. The regulation stipulates maximum levels of foreign ownership allowed in various projects. These regulations create uncertainties and constraints for foreign investors interested in participating in hydrogen energy cleantech initiatives, potentially impeding the sector's growth and innovation in Indonesia.<sup>204</sup>

### *Recommendations*

- **Engage with the U.S. Clean Energy Working Group for Indonesia established by the U.S. Embassy in Jakarta in partnership with Indonesia's Ministry of Energy and Mineral Resources (MEMR):** The Clean Energy Working Group was established on March 2023 as a platform to support and showcase U.S. firms in the decarbonization and climate change technology spaces, including green hydrogen development. This platform can be used to facilitate better engagement with the local government and to increase awareness of the significance of regulatory frameworks in balancing government policies and strategies.
- **Technology Transfer and Capacity Building:** Establish partnerships with Indonesian institutions and industry stakeholders to facilitate technology transfer and knowledge exchange in green hydrogen production and related technologies. Develop training programs and workshops to enhance the technical capacity of the local workforce in handling, installing, and maintaining hydrogen systems.
- **Facilitate international cooperation:** Explore avenues for international cooperation and financial assistance to mobilize additional investment for renewable energy projects, focused on technology deployment and infrastructure development. Advocate for transparent and predictable pricing mechanisms that account for non-price barriers and promote investment in clean energy technologies.<sup>205</sup>

## Export Challenges

Indonesia is currently preparing a national green hydrogen roadmap to increase capacity and investment around the market<sup>206</sup>. Establishing a national strategy is vital for propelling

<sup>203</sup> Global Center of Excellence for Green Hydrogen (n.d.). *Indonesia*. (n.d.). Retrieved March 29, 2024, from <https://isa-ghic.org/countries/indonesia>

<sup>204</sup> Asian Development Bank (n.d.). *Renewable Energy Tariffs and Incentives in Indonesia: Review and Recommendations* [Review of *Renewable Energy Tariffs and Incentives in Indonesia: Review and Recommendations*]. <http://dx.doi.org/10.22617/TCS200254>

<sup>205</sup> Iphe (n.d.). *Working Groups and Task Forces*. <https://www.iphe.net/working-groups-task-forces>

<sup>206</sup> Green Hydrogen Organisation (n.d.). *GH2 Country Portal - Indonesia*. Retrieved March 26, 2024, from <https://gh2.org/countries/indonesia>

Indonesia's GH regulatory frameworks forward to encourage GH development. This is the overarching regulatory piece of the puzzle necessary to make way for any further development within codes and frameworks for GH.

The uncompetitive price of renewable energy in Indonesia, and the high cost of electrolyzers, make it difficult to scale up production at this point. Maintaining GH development is not feasible without subsidies in place. Currently, the cheapest GH that can be produced is at \$2.6/kg. This price can't compete against the subsidized fossil fuel industry. At least \$0.5/kg of subsidy would be required to achieve the desired efficient price by 2030, and lowering this cost is a vital step for increasing the adoption of GH.

Further, the infrastructure dedicated to hydrogen production, ammonia transportation, and GH utilization still needs significant development in order to integrate the energy source into the market and supply chain.<sup>207</sup> The industry could also benefit from import duty exemptions for capital goods for power plant developers.<sup>208</sup>

## Challenges to Sectoral Growth

Indonesia faces a spectrum of challenges across regulatory, financial, technological, and market domains. A key barrier to the growth of the green hydrogen sector in Indonesia is a lack of a cohesive regulatory and policy framework designed to support the development of green hydrogen. While the country has set ambitious targets for green energy, the absence of a holistic package of policies and regulations that encourage investment, ensure safety and provide clear operational guidelines significantly hinders the sector's development.<sup>209</sup> <sup>210</sup> The recently released Indonesia Hydrogen Strategy (Dec 2023) could be the missing building block, and its execution and impact should be closely monitored.

The technological and infrastructure readiness in Indonesia also presents a significant hurdle. The development of a green hydrogen economy requires access to advanced technologies for efficient hydrogen production, storage, and transportation. Indonesia currently faces challenges in adopting these technologies at scale, which is essential for the successful establishment of a

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<sup>207</sup>EKONID AHK Indonesia (2023, October 10). *Green Hydrogen in Indonesia: How to Move Forward* [Webinar]. BUMN, Pertamina. <https://www.youtube.com/watch?v=qISTzrR08S4>

<sup>208</sup> Global Center of Excellence for Green Hydrogen (2024, March 30). *Indonesia*. <https://isa-ghic.org/countries/indonesia>

<sup>209</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>210</sup> Green Hydrogen Organisation (n.d.). *GH2 Country Portal - Indonesia*. Retrieved March 26, 2024, from <https://gh2.org/countries/indonesia>



green hydrogen economy.<sup>211 212</sup> One significant hurdle is the substantial investment cost needed to establish the necessary infrastructure, a challenge exacerbated by the country's geographical characteristics. While hydrogen can typically be transported economically over short distances using trucks and trains, longer distances spanning islands or for international export magnify costs due to transportation via ships or pipelines.<sup>213</sup> Additionally, the country struggles with market development and demand creation for green hydrogen. The lack of a developed market within and outside Indonesia limits the incentive for increasing production. The Ministry of Energy and Mineral Resources notes in their hydrogen strategy that the main obstacles are the unpredictable supply-demand and the usage of low-carbon hydrogen still being restricted due to regulatory ambiguity.<sup>214</sup> The rapid development of low-carbon hydrogen in Indonesia will occur after 2030, making current investments more challenging.<sup>215</sup>

Besides that, the renewable energy infrastructure is not as advanced as it would need to be and the current targets regarding renewable energy make green hydrogen production challenging.<sup>216</sup> The slow pace of development is attributed to several factors, including the country's archipelagic nature and varied economic development across its islands. The majority of industrial activities and, consequently, energy demand are concentrated on the island of Java, which is responsible for 60% of the national GDP and 80% of the energy demand, making it a primary target for future green hydrogen demand. However, the regions with the highest potential for renewable energy generation, such as East Nusa Tenggara for solar power and South Sulawesi and East Nusa Tenggara for onshore wind, are located outside Java.<sup>217</sup> Green hydrogen also faces stiff competition from established energy sources, including fossil fuels and other

<sup>211</sup> SEADS (n.d.) *Can green hydrogen help Indonesia meet its net-zero goals?*

<https://seads.adb.org/solutions/can-green-hydrogen-help-indonesia-meet-its-net-zero-goals>

<sup>212</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>213</sup> Gunawan, D. (2022). *Unlocking the potential of hydrogen in Indonesia*. In H. Ardiansyah, & P. Ekadewi (Eds.), *Indonesia post-pandemic outlook: Strategy towards net-zero emissions by 2060 from the renewables and carbon-neutral energy perspectives* (209–235). BRIN Publishing.

<https://penerbit.brin.go.id/press/catalog/download/562/480/11501?inline=1>

<sup>214</sup> Nugraha, A. (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects, new investment*. Spglobal.com; S&P Global Commodity Insights.

<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>

<sup>215</sup> IBP (2023, December 28). *Indonesia anticipates significant growth in green hydrogen demand*. Indonesia Business Post.

<https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>

<sup>216</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>217</sup> Business-Indonesia (n.d.). *Hydrogen in Indonesia*. The first comprehensive online investor guide to Indonesia's Prime Businesses. <https://business-indonesia.org/hydrogen>

renewables such as solar and wind energy. This competition is exacerbated by subsidies for fossil fuels and the decreasing costs of other renewable technologies.<sup>218</sup>

Comparing Indonesia to other countries in South and Southeast Asia (see Fig. 2) shows that the current renewable energy capacity and targets are not as strong as for other players.<sup>219</sup>

| Country           | 2022 Energy Capacity |               |              | Energy Projection and Targets for 2030–2035 |               |               |
|-------------------|----------------------|---------------|--------------|---------------------------------------------|---------------|---------------|
|                   | Total, GW            | Renewable, GW | Renewable, % | Total, GW                                   | Renewable, GW | Renewable, %  |
| India             | 420 GW               | 100 GW        | 24%          | 1,175 GW                                    | 450 GW        | 40% by 2030   |
| Malaysia          | 117.6 GW             | 7.6 GW        | 7.2%         | 108.4 GW                                    | 18.4 GW       | 17% by 2030   |
| Thailand          | 60.6 GW              | 9 GW          | 14.9%        | 62.2 GW                                     | 18.6 GW       | 30% by 2037   |
| Philippines       | 29.9 GW              | 5.4GW         | 22%          | 30.6 GW                                     | 15.3 GW       | 50% by 2030   |
| Viet Nam          | 76 GW                | 20 GW         | 26%          | 146 GW                                      | 46 GW         | 31.5% by 2030 |
| Brunei Darussalam | 889 MW               | 0.45 MW       | 0.05%        | n/a                                         | n/a           | 10% by 2035   |
| Indonesia         | 64.4 GW              | 9.6 GW        | 13%          | 83.7 GW                                     | 25 GW         | 23% by 2025   |

**Figure 2:** Renewable energy outlook in gigawatt (GW) for selected countries in the region<sup>220</sup>

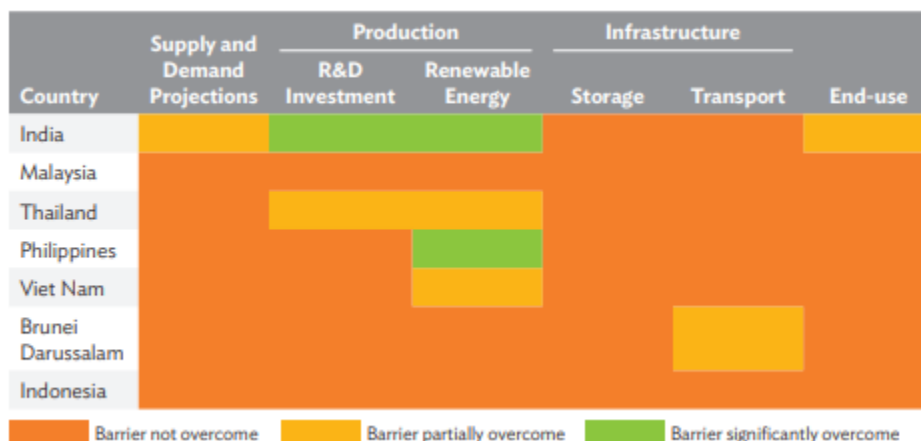
Furthermore, the hydrogen infrastructure itself functions as a barrier as Indonesia cannot build on a strong network of hydrogen pipelines and as an archipelago it faces additional challenges to build it.<sup>221</sup> The following figure (see Fig. 3) serves as a good summary of many of the challenges Indonesia faces and compares it to other countries in the region:

<sup>218</sup>The Diplomat – Asia-Pacific Current Affairs Magazine (n.d.). *Indonesia's fossil fuel subsidies threaten its energy transition*. (2024, February 16).  
<https://thediplomat.com/2024/02/indonesias-fossil-fuel-subsidies-threaten-its-energy-transition/>

<sup>219</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

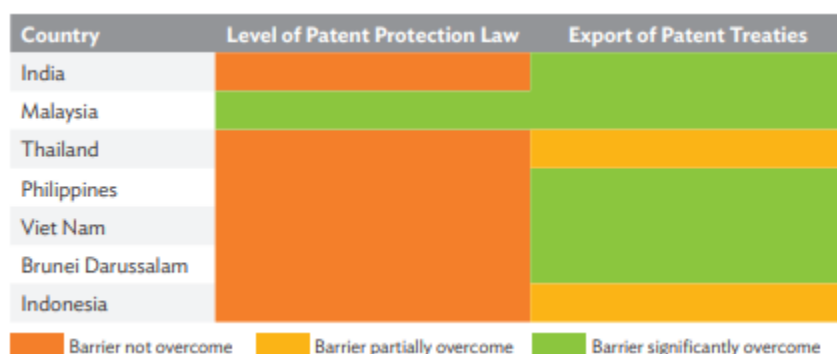
<sup>220</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>221</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>



**Figure 3:** Extent of overcoming barriers of selected countries in the region<sup>222</sup>

Another hurdle to overcome is legal barriers. National patent law and international mechanisms of patent sharing must be supportive of development. Countries with supportive intellectual property arrangements will benefit more from their innovations and attract foreign investors.<sup>223</sup> Indonesia performs below average (see Fig. 4) compared to its peers in the region when it comes to legal barriers:



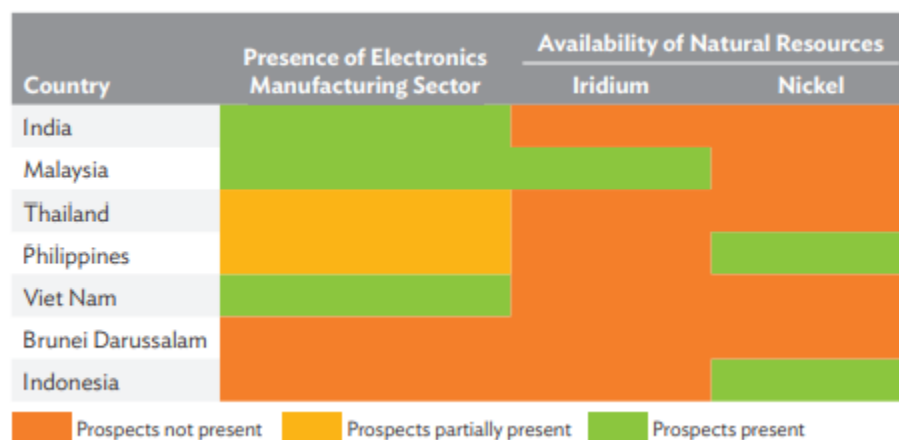
**Figure 4:** Legal barriers regarding patents of selected countries in the region<sup>224</sup>

<sup>222</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). Hydrogen in Decarbonization Strategies in Asia and the Pacific. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>223</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). Hydrogen in Decarbonization Strategies in Asia and the Pacific. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>224</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). Hydrogen in Decarbonization Strategies in Asia and the Pacific. Asian Development Bank Institute.  
<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

Additional barriers lie in the field of manufacturing and abundance of important critical minerals. Balance of plant (BoP) in engineering refers to all the supporting components and auxiliary systems of a power plant needed to deliver energy. BoP components play a crucial role in the hydrogen sector, especially in the manufacturing and operation of electrolyzers, which are devices used to produce green hydrogen by splitting water into hydrogen and oxygen, using electricity. The manufacturing industry, particularly the electronics manufacturing sector, is vital in the production of these BoP components. The abundance of specific natural resources like nickel and iridium further complements this scenario. Nickel, used in alkaline electrolyzers, and iridium, used as a catalyst in Proton Exchange Membrane (PEM) electrolyzers, are critical materials that impact the efficiency and cost-effectiveness of hydrogen production. Indonesia emerged as a significant player as the world's leading nickel exporter, and it can contribute to the green hydrogen market, either through the direct export of nickel or by leveraging this resource to manufacture and export alkaline electrolyzers. Despite these strengths, Indonesia lacks targeted policies and incentives for the domestic production of electrolyzers. This lack of enabling policy puts Indonesia at a competitive disadvantage compared to regions with more developed hydrogen policies, such as the European Union, which has set ambitious targets for electrolyzer capacity. In addition, Indonesia does not have a significant abundance of iridium which is a crucial element for PEM electrolyzers.<sup>225</sup> (see Fig. 5)



**Figure 5:** Manufacturing prospects and natural resources for selected countries in the region<sup>226</sup>

<sup>225</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). Hydrogen in Decarbonization Strategies in Asia and the Pacific. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>226</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). Hydrogen in Decarbonization Strategies in Asia and the Pacific. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

## Recommendations

Given the barriers and challenges discussed above, we recommend that the ITA closely monitors Indonesia in the upcoming years to assess the maturity of its hydrogen market. Their increasing regulatory framework and more ambitious targets are moving in the right direction for the hydrogen economy to take off in the near future, especially in the 2030s, but the conditions are not yet sufficient.

## Main Competitors for U.S. Exports

Indonesia's Ministry of Energy and Mineral Resources (ESDM) developed the National Hydrogen Strategy, which forecasts a significant rise in the demand for low-carbon or green hydrogen between 2031 and 2060.<sup>227</sup> To facilitate this growth, Indonesia has started collaboration with other countries to secure a long-term supply of green hydrogen as well as gain support for its own technological development in green hydrogen sectors. These countries, especially Japan, Singapore, and the EU may be potential competitors for the United States in exporting green hydrogen technologies to Indonesia.

**Japan.** Japan has a significant stake in Indonesia's green hydrogen development. To secure a long-term supply of cost-competitive green hydrogen, the Japanese Government and many Japanese companies are actively in collaboration with Indonesia on green hydrogen/ammonia production, power production, and co-firing of ammonia in coal power plants. Key examples include:

- **JERA/Mitsubishi Heavy Industry.** Both are actively involved in the advancement of co-firing ammonia in coal-fired power plants. Mitsubishi Heavy Industry and PLN are conducting feasibility studies on co-firing with hydrogen and ammonia in Indonesia.<sup>228</sup>
- **Mitsubishi Corporation.** PT Pertamina (Persero), PT Pupuk Indonesia (Persero), and Mitsubishi Corporation agreed to develop the green hydrogen and green ammonia value chain and Carbon Capture Utilization and Storage (CCUS) businesses. This agreement aligns with the Indonesian government's target of reducing emissions by 29% by 2030.<sup>229</sup>

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<sup>227</sup> Indonesia Business Post (2023 December). *Indonesia anticipates significant growth in green hydrogen demand.* <https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>.

<sup>228</sup> Center on Global Energy Policy at Columbia SIPA (2023, August). *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia.* <https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>.

<sup>229</sup> Pertamina (2022 March). *Pertamina, PT Pupuk Indonesia, and Mitsubishi Corporation Agree to Develop Blue/Green Hydrogen and Ammonia Business.*

**Singapore** is also advancing its green hydrogen initiative to become the green hydrogen shipping hub in Asia. To support its decarbonization strategy, Singapore is facilitating technological development of green hydrogen production in Southeast Asia, through a partnership with Indonesia.

- **Sembcorp Utilities Pte Ltd**, a subsidiary of Sembcorp Industries, and PT PLN (Persero), an Indonesian state-owned utility company, have signed an agreement to conduct a joint study on the viability of producing green hydrogen in Indonesia for export to Singapore.<sup>230</sup>
- **Keppel (Singapore). Chevron**. On November 11, 2022, Pertamina Power Indonesia (Pertamina NRE), Keppel Infrastructure (through Keppel New Energy Pte. Ltd.), and Chevron Corporation (through Chevron New Energies International Pte. Ltd.) entered into a Joint Study Agreement (JSA) to investigate the potential for developing green hydrogen and green ammonia projects using renewable energy sources, primarily in Sumatra, Indonesia.<sup>231</sup>

**The EU.** Many states of the European Union are assessing the export of hydrogen technologies to Indonesia and neighboring countries. The European Investment Bank and European External Action Service have laid out infrastructure and investment plans to increase its focus on renewable energy projects across the region, including green hydrogen.<sup>232</sup>

- **Augustus Global Investment** from Germany has announced a \$500 million investment in a green hydrogen plant in Aceh province, Indonesia, beginning construction in 2024. The proposed plant aims for an annual production of 35,000 metric tons of green hydrogen. An initial agreement has been signed with Indonesian state-owned enterprises, including fertilizer manufacturers PT Pupuk Indonesia and PT Pupuk Iskandar Muda, as

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<https://www.pertamina.com/en/news-room/news-release/pertamina-pt-pupuk-indonesia-and-mitsubishi-corporation-agree-to-develop-blue-green-hydrogen-and-ammonia-business>.

<sup>230</sup> Semicorp (2023 October). *Sembcorp and PT PLN (Persero) Sign Joint Development Study Agreement on Green Hydrogen Production and Export*.

<https://www.sembcorp.com/sg/news-and-insights/news/2023/sembcorp-and-pt-pln-persero-sign-joint-development-study-agreement-on-green-hydrogen-production-and-export/>.

<sup>231</sup> Chevron (2022 November). *Pertamina, keppel infrastructure, and chevron sign agreement to explore development of green hydrogen and ammonia projects*.

<https://www.chevron.com/newsroom/2022/q4/pertamina-keppel-and-chevron-sign-agreement>.

<sup>232</sup> EIB (March 2024) *Indonesia: EIB Global Agrees to Support PT SMI on Sustainable Infrastructure Development*. European Investment Bank

[www.eib.org/en/press/all/2024-084-eib-global-agrees-to-support-pt-smi-on-sustainable-infrastructure-development-in-indonesia](https://www.eib.org/en/press/all/2024-084-eib-global-agrees-to-support-pt-smi-on-sustainable-infrastructure-development-in-indonesia)

EEAS (2023) *European Union Trade and Investment with Indonesia Report*

<https://www.eeas.europa.eu/sites/default/files/documents/2023/EU%20Trade%20and%20Investment%20with%20Indonesia%202023.pdf>

well as the state utility firm PT Perusahaan Listrik Negara, to secure power supply and a construction site for the investment.<sup>233</sup>

### *Recommendations*

To tap into the Indonesian green hydrogen market, the ITA should foster partnerships with Indonesian state-owned enterprises (SOEs) and the government to provide local support, facilitate participation in the development process, and ensure compliance with local green hydrogen standards. Additionally, it could help identify the specific focus of the U.S. within the value chain for exporting its technologies. Finally, supporting infrastructure development, including investments in port facilities, storage infrastructure, and transportation networks, will be crucial for a successful presence in Indonesia's green hydrogen sector.

## Public Education

The government of Indonesia aims to become a global supplier of green hydrogen energy, and though still in the early stages of developing this sector, is in the process of building its first green hydrogen plant.<sup>234</sup> The country has one of the fastest-growing energy consumption requirements globally, illustrating the need for more energy infrastructure to meet these needs.<sup>235</sup> Indonesia will need to focus on its workforce and public education on renewable energies, including green hydrogen, to meet the country's growing renewable energy ambitions.

Indonesia faces significant green skill gaps in its current workforce, including within the more developed solar, wind, hydro, and geothermal technology sectors, illustrating a need for more targeted educational policies to narrow this gap.<sup>236</sup> The Indonesian government has taken steps to increase training for green jobs in partnership with the German government through an initiative called the Innovation and Investment for Inclusive Sustainable Economic Development (ISED) project.<sup>237</sup> The goal of ISED is to innovate training courses on renewable energy and create

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<sup>233</sup> Reuters. (2023, August 28). *Germany's Augustus Global Investment plans to build hydrogen plant in Indonesia*. <https://www.reuters.com/sustainability/climate-energy/germanys-august-global-investment-plans-build-hydrogen-plant-indonesia-2023-08-28>

<sup>234</sup> Reccessary (2023, October). *Indonesia launches first green hydrogen plant, aims to become global supplier*. Retrieved from <https://www.reccessary.com/en/news/id-announcement/Indonesia-launches-first-green-hydrogen-plant-aims-become-global-supplier>.

<sup>235</sup> Promoting green employment

<sup>236</sup> Energy Tracker Asia. (2024, February) *Indonesia to Experience a Green Jobs Boom, But Policy Changes Integral*. retrieved from <https://energytracker.asia/indonesia-to-experience-a-green-jobs-boom-but-policy-changes-integral/>.

<sup>237</sup> Promoting green employment



systems that promote employment in green jobs.<sup>238</sup> Indonesian state-owned electricity companies, such as PT PLN, have established training programs and education centers to educate the workforce about green hydrogen.<sup>239</sup> Monitoring the development of similar programs within privately owned companies will be critical going forward.

Indonesia's push towards decarbonizing its mining sector, which accounts for approximately 9% of its GDP, presents a potential opportunity for the use of green hydrogen. However, this transition will require a comprehensive re-education and skill development program for the mining workforce.<sup>240</sup> Employees at all levels will need to be trained on new technologies and processes related to green hydrogen production, storage, and utilization within mining operations. This includes understanding the environmental benefits, operational changes, safety protocols, and maintenance of green hydrogen systems.

The media also plays a role in influencing public perception of green hydrogen energy in Indonesia. According to a research study conducted by the University of Indonesia and University of Dharma Persada, researchers discovered that most of the public received knowledge about renewable energy from online media.<sup>241</sup>

### *Recommendations*

- 1) Encourage the Indonesian government to partner with private companies across relevant industries to create green hydrogen training programs.
- 2) Foster a targeted partnership with the Indonesian government on furthering green hydrogen technology workforce skills, similar to ISED developed by the German government. This can include webinars, workshops, joint curriculum development, and university partnerships.

## Conclusion

Indonesia's endeavor to position itself as a global leader in green hydrogen production is both ambitious and reflective of its commitment to sustainable energy transformation. However, the

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<sup>238</sup> Promoting green employment

<sup>239</sup> Indonesia Business Post (2024, February). *Indonesia's First! PLN Launches Green Hydrogen Refueling Station*. Retrieved from

<https://indonesiabusinesspost.com/risks-opportunities/indonesias-first-pln-launches-green-hydrogen-refueling-station/>.

<sup>240</sup> SP Global (n.d.). *Indonesia – Mining by the numbers, 2023*. (n.d.). Retrieved from <https://www.spglobal.com/marketintelligence/en/news-insights/research/indonesia-mining-by-the-numbers-2023>

<sup>241</sup> MEA Journal (2022, December). *Public Perception of Renewable Energy in Indonesia: Implication for Communication Strategy*. Retrieved from <https://journal.stiemb.ac.id/index.php/mea/article/view/2517>.



current state of its green hydrogen sector, coupled with various challenges across regulatory, technological, financial, and educational domains, indicates that Indonesia **may not be an optimal candidate** currently for a green hydrogen export PPP initiative. The country's nascent stage in green hydrogen development, characterized by the early efforts to build infrastructure and formulate strategic policies, suggests a need for substantial additional progress before it can fully capitalize on such international partnerships. Thus, the ITA should closely monitor the country as their status might change significantly from 2030 onwards.

Indonesia possesses significant potential for growth in the green hydrogen sector, underscored by its vast renewable energy resources and governmental initiatives like the National Hydrogen Strategy. Strategic collaborations with countries such as Japan, Singapore, and in the European Union for technological development and long-term green hydrogen supply further highlight its potential. The country's role as a leading nickel exporter, crucial for electrolyzer production, presents a unique opportunity to leverage domestic resources for green hydrogen development. Existing investments and the initiation of pilot projects indicate a positive trajectory towards embracing green hydrogen as part of its energy mix.

Despite these promising aspects, Indonesia faces several key challenges that impede its progress in the green hydrogen sector; regulatory and policy ambiguities, technological and infrastructural inadequacies, financial constraints, and a significant green skills gap within the workforce. The lack of a cohesive regulatory framework specifically tailored for green hydrogen, coupled with the high costs of technology adoption and infrastructure development, particularly in transport and storage, critically affects the sector's growth. Finally, the geographical characteristics of Indonesia complicate the efficient production and distribution of green hydrogen.

Below is a summary of our key recommendations for ensuring the success of an Indonesian-targeted green hydrogen PPP initiative:

- Encourage U.S.-Indonesia partnerships focused on technology transfer and the development of green hydrogen infrastructure, leveraging U.S. technological strengths and Indonesia's renewable energy potential
- Explore avenues for international cooperation and financial assistance to mobilize additional investment for renewable energy projects, focusing on technology deployment and infrastructure development. Advocate for transparent and predictable pricing mechanisms that account for non-price barriers and promote investment in clean energy technologies
- Establish close collaboration with the U.S. Clean Energy Working Group for Indonesia

- Foster partnerships with SOEs and the government and support infrastructure development, including investments in port facilities, storage infrastructure, and transportation networks
- Support financial mechanisms and incentives that lower the entry barriers for green hydrogen production and infrastructure investments in Indonesia
- Monitor the development and implementation of Indonesia's National Hydrogen Strategy
- Support research and pilot projects in Indonesia that demonstrate the viability and benefits of green hydrogen, particularly in sectors like mining that are critical to Indonesia's economy
- Investigate investment / PPP opportunities regarding other renewables in Indonesia as Indonesia's renewable energy capacity is not yet sufficient to support the affordable production of green hydrogen
- Facilitate the development of workforce training programs in collaboration with Indonesian institutions, focusing on green hydrogen technologies to address the skill gap
- Use media partnerships to increase public awareness and support for green hydrogen in Indonesia, highlighting its benefits for sustainable energy and economic development.

## Bibliography

1. Asian Development Bank (n.d.). *Renewable Energy Tariffs and Incentives in Indonesia: Review and Recommendations* [Review of Renewable Energy Tariffs and Incentives in Indonesia: Review and Recommendations]. <http://dx.doi.org/10.22617/TCS200254>.
2. Business-Indonesia (n.d.) *Hydrogen in Indonesia*. The first comprehensive online investor guide to Indonesia's Prime Businesses. <https://business-indonesia.org/hydrogen>.
3. Celios (2023). *Accelerating the Just Energy Transition: Challenges and Opportunities for Regions*, July 2023. Retrieved from <https://celios.co.id/wp-content/uploads/2023/10/CELIOS-Accelerating-the-Just-Energy-Transition-Challenges-and-Opportunities-for-Regions.pdf>.
4. Center on Global Energy Policy at Columbia SIPA (2023, August). *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia*. <https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>.
5. Chevron (2022 November). *Pertamina, keppel infrastructure, and chevron sign agreement to explore development of green hydrogen and ammonia projects*. <https://www.chevron.com/newsroom/2022/q4/pertamina-keppel-and-chevron-sign-agreement>.
6. Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute. <https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>.
7. Eco-Business (2023, September 2). *Lack of "bankable" climate projects hurting Indonesia's energy transition*. Eco-Business. <https://www.eco-business.com/news/lack-of-bankable-climate-projects-hurting-indonesias-energy-transition/>.
8. EKONID AHK Indonesia (2023, October 10). *Green Hydrogen in Indonesia: How to Move Forward* [Webinar}.BUMN, Pertamina. <https://www.youtube.com/watch?v=qISTzrR08S4>.
9. Energy Tracker Asia (2024, February). *Indonesia to Experience a Green Jobs Boom, But Policy Changes Integral*. Retrieved from <https://energytracker.asia/indonesia-to-experience-a-green-jobs-boom-but-policy-changes-integral/>.

10. ESMAP (2020). *Green Hydrogen in Developing Countries*. Washington, DC: World Bank.  
<https://documents1.worldbank.org/curated/en/953571597951239276/pdf/Green-Hydrogen-in-Developing-Countries.pdf>.
11. IEA (n.d.) *Executive summary – An Energy Sector Roadmap to Net Zero Emissions in Indonesia – Analysis*.  
<https://www.iea.org/reports/an-energy-sector-roadmap-to-net-zero-emissions-in-indonesia/executive-summary>.
12. Global Center of Excellence for Green Hydrogen (2024, March 30). *Indonesia*.  
<https://isa-ghic.org/countries/indonesia>
13. Green Hydrogen Organisation (n.d.). *GH2 Country Portal - Indonesia*. (n.d.). Retrieved March 26, 2024, from <https://gh2.org/countries/indonesia>
14. Gunawan, D. (2022). *Unlocking the potential of hydrogen in Indonesia*. In H. Ardiansyah, & P. Ekadewi (Eds.), *Indonesia post-pandemic outlook: Strategy towards net-zero emissions by 2060 from the renewables and carbon-neutral energy perspectives* (209–235). BRIN Publishing.  
<https://penerbit.brin.go.id/press/catalog/download/562/480/11501?inline=1>.
15. Indonesia Business Post (2023, December 28). *Indonesia anticipates significant growth in green hydrogen demand*. Indonesia Business Post.  
<https://indonesiabusinesspost.com/risks-opportunities/indonesia-anticipates-significant-growth-in-green-hydrogen-demand/>.
16. Indonesia Business Post (2024, February). *Indonesia's First! PLN Launches Green Hydrogen Refueling Station*. Retrieved from  
<https://indonesiabusinesspost.com/risks-opportunities/indonesias-first-pln-launches-green-hydrogen-refueling-station/>.
17. International Trade Administration (2024). *Indonesia - Country Commercial Guide*.  
<https://www.trade.gov/country-commercial-guides/indonesia-energy>.
18. Iphe (n.d.). *Working Groups and Task Forces*. (n.d.).  
<https://www.iphe.net/working-groups-task-forces>.
19. Jhanesta, W. (2023, December 28). *Indonesian hydrogen outlook 2024*. petromindo28.  
<https://www.petromindo.com/news/article/indonesian-hydrogen-outlook-2024>.

20. Malaymail (2023, November). *Indonesia, Germany develop green jobs in renewable energy sector*. Retrieved from [https://www.malaymail.com/news/money/2023/11/24/indonesia-germany-develop-green-jobs-in-renewable-energy-sector/104026#google\\_vignette](https://www.malaymail.com/news/money/2023/11/24/indonesia-germany-develop-green-jobs-in-renewable-energy-sector/104026#google_vignette).
21. Mahiddin, F & et.al. (2023, February 24). *Indonesia: Renewable Energy Laws And Regulations 2023*. Mondaq. <https://www.mondaq.com/renewables/1286536/renewable-energy-laws-and-regulations-2023>.
22. MEA Journal (2022, December). *Public Perception of Renewable Energy in Indonesia: Implication for Communication Strategy*. Retrieved from <https://journal.stiemb.ac.id/index.php/mea/article/view/2517>.
23. Ministry of Energy and Mineral Resources (2023). *National Hydrogen Strategy* [Review of National Hydrogen Strategy]. <https://ebtke.esdm.go.id/post/2023/12/15/3680/strategi.hidrogen.nasional>.
24. Nugraha, A. (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects, new investment*. Spglobal.com; S&P Global Commodity Insights. <https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>.
25. Pertamina (2022, March). *Pertamina, PT Pupuk Indonesia, and Mitsubishi Corporation Agree to Develop Blue/Green Hydrogen and Ammonia Business*. <https://www.pertamina.com/en/news-room/news-release/pertamina-pt-pupuk-in-donesia-and-mitsubishi-corporation-agree-to-develop-blue-green-hydrogen-and-ammonia-business>.
26. Power, A. (2023, December 6). *ACWA Power signs deal to develop the largest green hydrogen project in Indonesia*. ACWA Power. <https://www.acwapower.com/news/acwa-power-signs-deal-to-develop-the-largest-green-hydrogen-project-in-indonesia/>.
27. Reccessary (2023, October). *Indonesia launches first green hydrogen plant, aims to become global supplier*. Retrieved from <https://www.reccessary.com/en/news/id-announcement/Indonesia-launches-first-green-hydrogen-plant-aims-become-global-supplier>.
28. Reuters. (2023, August 28). *Germany's Augustus Global Investment plans to build hydrogen plant in Indonesia*. Reuters. <https://www.reuters.com/sustainability/climate-energy/germanys-august-global-investment-plans-build-hydrogen-plant-indonesia-2023-08-28/>.

29. S&P Global (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects, new investment*.  
<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>.
30. S&P Global (n.d.). *Indonesia – Mining by the numbers, 2023*. Retrieved from  
<https://www.spglobal.com/marketintelligence/en/news-insights/research/indonesia-mining-by-the-numbers-2023>.
31. SEADS (n.d.). *Can green hydrogen help Indonesia meet its net-zero goals?*  
<https://seads.adb.org/solutions/can-green-hydrogen-help-indonesia-meet-its-net-zero-goals>.
32. Sembcorp (2023, October). *Sembcorp and PT PLN (Persero) Sign Joint Development Study Agreement on Green Hydrogen Production and Export*.  
<https://www.sembcorp.com/sg/news-and-insights/news/2023/sembcorp-and-pt-pln-persero-sign-joint-development-study-agreement-on-green-hydrogen-production-and-export/>.
33. Singh, A. N. and R. (2024, January 4). *Indonesia's national hydrogen strategy sets stage for pilot projects, New Investment*. S&P Global Commodity Insights.  
<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/010424-indonesias-national-hydrogen-strategy-sets-stage-for-pilot-projects-new-investment>.
34. The Diplomat – Asia-Pacific Current Affairs Magazine (2024, February 16). *Indonesia's fossil fuel subsidies threaten its energy transition*.  
<https://thediplomat.com/2024/02/indonesias-fossil-fuel-subsidies-threaten-its-energy-transition/>.
35. Wood, J. (2023, May 25). *HDF Energy signs MoUs for green hydrogen on two continents*. Windpower Monthly. Retrieved from  
<https://www.windpowermonthly.com/article/1824053/hdf-energy-signs-mous-green-hydrogen-two-continents>.
36. World Trade Organization. (2023). *International trade and green hydrogen: Supporting the global transition to a low-carbon economy*. Retrieved from  
[https://www.wto.org/english/res\\_e/booksp\\_e/green\\_hydrogen\\_e.pdf](https://www.wto.org/english/res_e/booksp_e/green_hydrogen_e.pdf).

## Appendix A - Stakeholder Table U.S.

|                   | Stakeholder                                      | Stakeholder Description                                                                                                                                                                                                                                                       | Level of Support | Reason for Resistance or Support                                                                                                                                                                                                                                                                                                              |
|-------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Government</b> | U.S. Department of Energy (DOE)                  | Oversees national energy policy and energy production                                                                                                                                                                                                                         | Support          | DOE is leading many federal initiatives: Energy Earthshots Initiative: Hydrogen Shot, Regional Clean Hydrogen Hubs: Hydrogen Hub Matchmaker, Clean Hydrogen Electrolysis Program, Clean Hydrogen Manufacturing and Recycling RD&D Activities that will enable / enhance U.S. competitiveness t also has several offices dedicated to hydrogen |
|                   | International Trade Administration (ITA)         | An agency within the U.S. Department of Commerce focused on export development and competitiveness                                                                                                                                                                            | Support          | /                                                                                                                                                                                                                                                                                                                                             |
|                   | DOE National Energy Technology Laboratory (NETL) | Under the DOE Office of Fossil Energy, focuses on applied research for the clean production and use of domestic energy resources. R&D on the supply, efficiency, and environmental constraints of producing and using fossil energy resources while maintaining affordability | Support          | This program complements NETL's mission                                                                                                                                                                                                                                                                                                       |
|                   | DOE Loan Programs Office (LPO)                   | ~ \$300 billion in loan authority to finance projects that support clean energy deployment and energy infrastructure reinvestment to reduce emissions.                                                                                                                        | Support          | This program could benefit from LPO's support which could advance its remit                                                                                                                                                                                                                                                                   |

|                 |                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                   |                                                                           |
|-----------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------|
|                 | DOE Hydrogen and Fuel Cell Technologies Office (HFTO)      | Conducts comprehensive efforts to overcome the technological, economic, and institutional barriers to the development of hydrogen and fuel cells.                                                                                                                                                                                                                                                                                                                                                                                              | Support           | This program complements HTFO's mandate                                   |
|                 | Hydrogen Interagency Task Force (HIT)                      | A collaboration among U.S. federal agencies to advance a whole-of-government approach to executing the national clean hydrogen strategy, including development of a robust market supported by domestic supply chains and sustainable jobs. The Departments of Agriculture, Commerce, Defense, Interior, Labor, Transportation, Treasury, State as well as the Environmental Protection Agency, National Aeronautics and Space Administration, Small Business Administration, and U.S. Special Presidential Envoy for Climate are represented. | Support           | With a whole government approach HIT would likely support ITA's program   |
| <b>Academia</b> | Hydrogen Initiative, Stanford University                   | A collaboration of researchers , industry leaders & governments to enable the use of hydrogen to achieve deep decarbonization. It focuses on the hydrogen value chain of hydrogen generation, transportation, storage, applications and the policies that govern hydrogen markets.                                                                                                                                                                                                                                                             | Support           | Hydrogen Initiative would support this program which advances its mission |
|                 | Center on Global Energy Policy (CGEP), Columbia University | Fosters dialogue on energy and climate problems and solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Support / Neutral | CGEP would likely support efforts to decarbonise with green hydrogen.     |



|                       |                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                    |
|-----------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------|
| <b>Private Sector</b> | Linde PLC                        | A global multinational chemical company. It's the world's largest industrial gas company by market share and revenue. Globally, Linde has more than 500 hydrogen production plants. Through its ITM Linde Electrolys is joint venture, Linde has become one of the world's leading suppliers of green hydrogen produced using proton exchange membrane electrolyzer technologies. Market cap 2023: \$226.42 billion.                          | Support | This program would support its business expansion within Chile and Japan           |
|                       | Air Products and Chemicals (APC) | APC sells industrial gases and chemicals and provides related equipment and expertise. APC operates more than 100 hydrogen plants and maintains the world's largest hydrogen distribution network. Air Products has an extensive hydrogen-dispensing technology patent portfolio and has been involved in more than 250 hydrogen-fueling projects worldwide. Market cap: US\$55.1 billion.                                                    | Support | This program would support its business expansion within the green hydrogen sector |
|                       | Cummins                          | Cummins designs, manufactures and distributes engines, filtration and power-generation products with a specialization in diesel and alternative fuel engines and generators. Their brand Accelera, features "a diverse portfolio of zero-emissions solutions, includ(ing) battery systems, fuel cells, ePowertrain systems and electrolyzers." Accelera started electrolyzer production in Minnesota, US.. The company is set to showcase its | Support | This program would support its business expansion within the green hydrogen sector |

|  |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                            |
|--|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                 | next generation hydrogen engine in mid 2024.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |         |                                                                                                                                                                                                            |
|  | AES Corporation | <p>An independent power producer that stands to supply the renewable power needed to run electrolysis for green-hydrogen production.</p> <p>AES previously stated it would build a \$4 billion renewables-powered hydrogen facility with Air Products by 2027, turning 1.4 GW of renewable generation into 200 metric tons per day of green hydrogen, far bigger than anything like it in the U.S. today, and a step toward the DOE's goal of producing 10 million metric tons of clean hydrogen annually by 2030.</p> | Support | AES Corporation is a beneficiary of the DOE's Regional Clean Hydrogen Hubs                                                                                                                                 |
|  | Air Liquide     | A French multinational company and the second-largest supplier of industrial gases by revenues globally.                                                                                                                                                                                                                                                                                                                                                                                                               | Support | Air Liquide is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Amazon          | <p>Amazon invested early in hydrogen to power forklifts at its warehouses. As of 2022, Amazon was running 15,000 forklifts at 70 fulfillment centers on green hydrogen with help from partner Plug Power, while scoping out the fuel for decarbonizing its delivery fleet. California and the Pacific Northwest hubs aim to remake the West Coast heavy-duty trucking network in a cleaner,</p>                                                                                                                        | Support | Amazon is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector      |

|  |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |                                                                                                                                                                                                |
|--|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |              | hydrogen-powered image. Amazon has explicitly said it is testing hydrogen trucks for shipping and fuel cells for powering its buildings, and it wants to use its bulk purchasing power to expand the market for cleanly produced hydrogen.                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                |
|  | Bloom Energy | This long-running and perennially unprofitable cleantech player has sold solid-oxide fuel cells to give customers 24/7 onsite power production without any combustion. Those fuel cells historically have run on fossil gas, but more recently Bloom has played up its hydrogen competency so its purported climate solutions don't depend on a steady supply of fossil fuels. It recently tested its high-temperature solid-oxide electrolyzer at government research centers, and it claims it produces hydrogen more efficiently than other leading electrolyzer technologies. | Support | As a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Chevron      | Chevron makes 1 million metric tons of hydrogen the gas per year from fossil fuels, much of which is used to refine oil. Clean hydrogen wise Chevron owns a majority stake in the electrolysis and storage venture in Delta, Utah known as ACES; it also is working on Gulf Coast hydrogen production with Air Liquide and other partners.                                                                                                                                                                                                                                        | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector    |
|  | ExxonMobil   | Exxon's base of infrastructure in the Gulf and know-how for making and selling liquid fuels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested                                                                                                         |

|  |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |         |                                                                                                                                                                                                                                |
|--|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                           | <p>may give it an edge in the emerging clean-hydrogen economy. Piping gases around and flushing them underground is one of Exxon's strong suits. If the existing carbon pipelines around Houston can't support competitive blue-hydrogen production, it's hard to imagine anywhere else that could.</p>                                                                                            |         | <p>and aware of this program that would support its business expansion within the green hydrogen sector</p>                                                                                                                    |
|  | Holtec                    | <p>Holtec is participating in two of the hubs that will tap existing nuclear fleets to supply carbon-free power for electrolysis. The 24/7 industrial demand for hydrogen production would make for welcome commercial demand at legacy nuclear plants that have struggled to keep their doors open.</p>                                                                                           | Support | <p>Holtec is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>                   |
|  | Mitsubishi Power Americas | <p>Mitsubishi got in early on green hydrogen and is working on the fully integrated hydrogen project in Delta, Utah, which will combine production, underground storage and use for power and other needs. That experience, plus a big balance sheet and a trusted brand in heavy power equipment, made Mitsubishi Power a sought-after partner for the Gulf Coast and Pacific Northwest hubs.</p> | Support | <p>Mitsubishi Power America Is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p> |
|  | Plug Power                | <p>Plug Power started off making fuel cells but hit its commercial stride by selling thousands of fuel-cell forklifts to Amazon. Now it is building its own green-hydrogen production with electrolyzer technology.</p>                                                                                                                                                                            | Support | <p>Plug Power is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>               |

|                      |                                                   |                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                                                                                                                                          |
|----------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | TC Energy                                         | TC Energy is developing 10 blue and green hydrogen hubs across North America.                                                                                                                                                                                                                                                                                                                 | Support | TC Energy is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|                      | CF Industries                                     | A U.S. Manufacturer and distributor of agricultural fertilizers, including ammonia, urea, and ammonium nitrate products, based in Deerfield, Illinois. CF Industries is constructing North America's first commercial-scale green ammonia production capability at its Donaldsonville Complex in Louisiana.<br><br>Green ammonia is ammonia produced using hydrogen from carbon-free sources. | Support | This program would support its business expansion within the green hydrogen sector                                                                                                                       |
|                      | Hydrogen Forward                                  | Hydrogen Forward is a coalition of companies and organizations across the hydrogen value chain that are working to ensure hydrogen is a key contributing solution in the energy transition.                                                                                                                                                                                                   | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |
|                      | Fuel Cell and Hydrogen Energy Association (FCHEA) | The FCHEA is the leading industry association in the U.S. representing more than 100 leading organizations advancing production, distribution, and use of innovative, clean, safe, and reliable hydrogen energy.                                                                                                                                                                              | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |
| <b>Civil Society</b> | Green Hydrogen Coalition (GHC)                    | The GHC is an educational non-profit. It focuses on building top-down momentum for scalable green hydrogen projects that leverage multi-sector opportunities to simultaneously scale supply and                                                                                                                                                                                               | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |

|  |                                          |                                                                                                                                                                                                                                                                            |                     |                                                                                                                                                |
|--|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                          | demand.                                                                                                                                                                                                                                                                    |                     |                                                                                                                                                |
|  | Clean Air Task Force (CATF)              | CATF is a non-profit that aims to build momentum for solutions based on scientific evidence, intellectual integrity, and pragmatism. Its mission is to push the technology and policy changes needed to achieve a zero-emissions, high-energy planet at an affordable cost | Support             | This program aligns with CATF's mission                                                                                                        |
|  | Natural Resources Defense Council (NRDC) | The NRDC is a U.S. non-profit international environmental advocacy group.                                                                                                                                                                                                  | Support conditional | While this program aligns with CATF's mission, NRDC may be aware and supportive of grass root resistance in Chile, Indonesia and other markets |
|  | Rocky Mountain Institute (RMI)           | RMI is an independent, non-partisan, nonprofit that aims to transform global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all.                                                       | Support             | This program aligns with RMI's mission                                                                                                         |
|  | Bipartisan Policy Center (BPC)           | The BPC is a not-for-profit organization that ensures policymakers work across party lines to craft bipartisan solutions                                                                                                                                                   | Support             | This program aligns with PBC's mission                                                                                                         |
|  | GTI Energy                               | GTI is a non-profit “focused on developing, scaling, and deploying energy transition solutions that improve lives, economies, and the environment.                                                                                                                         | Support             | As an administer for Multiple regional clean Hydrogen Hubs GTI would be well placed to benefit and support this program                        |

## Appendix B - Stakeholder Table Indonesia

|                                  | Stakeholder                                     | Stakeholder Description                                                                                                                                                                                                                                                                                                                          | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i>                                                                                                                                                                                                                        |
|----------------------------------|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Inter-national / Regional Entity | Asia Development Bank (ADB)                     | The ADB facilitates sustainable energy initiatives across Asia and the Pacific by partnering with development enterprises on projects, such as green hydrogen ventures in Indonesia.                                                                                                                                                             | Support                                                                                     | With significant funding from Japan, a supporter of regional green hydrogen growth, the ADB seeks to extend its green hydrogen investment approach from Malaysia to Indonesia, motivated by financial incentives.                                                                                                  |
|                                  | Just Energy Transition Partnership (JETP)       | The JETP supports countries in shifting from fossil fuels to renewable energy, offering funding and technical assistance to phase out coal and develop clean energy, while promoting jobs and inclusivity in a low-carbon economy.                                                                                                               | Neutral                                                                                     | The Just Energy Transition Partnership primarily focuses its funding on retiring coal operations, showing less interest in green hydrogen initiatives.                                                                                                                                                             |
| Government                       | Ministry of Energy and Mineral Resources (ESDM) | This ministry oversees regulatory measures, and incentives, and promotes investments in the green hydrogen sector, including key directorates for Oil and Gas, New Renewable Energy and Energy Conservation, and Electricity. Notably, the Directorate General of Oil and Gas is considered the most influential due to its extensive expertise, | Support                                                                                     | They are highly motivated to offer strong support due to the direct benefits they receive from owning the plants. Their strategic placement of highly skilled individuals within the directorate strengthens its influential position in the ministry, further solidifying their path toward becoming the sector's |

|  |                                                               |                                                                                                                                                                                                                                                                                                                                |         |                                                                                                                                                                                                                                                                                                                               |
|--|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                                               | financial capacity and internal dynamics.                                                                                                                                                                                                                                                                                      |         | leading force.                                                                                                                                                                                                                                                                                                                |
|  | Perusahaan Listrik Negara (PLN)/ PLN Nusantara Power (PLN NP) | The sole utility company government-owned corporation that has a monopoly on electric power distribution in Indonesia and generates the majority of the country's electrical power. PLN NP was created as a subsidiary of the state-owned enterprise to bypass bureaucratic obstacles and enhance the speed of its operations. | Neutral | Their support for green hydrogen is currently low due to a primary focus on profit, seeking cost-effective options and being open to all possibilities. Facing financial challenges and aiming for quick returns, their enthusiasm for green hydrogen is expected to grow as the sector evolves and becomes more viable.      |
|  | Ministry of Environment and Forestry (KLHK)                   | The KLHK ministry is responsible for managing and conserving the nation's forests.                                                                                                                                                                                                                                             | Neutral | Currently, Green Hydrogen isn't a major priority as policies are still in the early stages. However, greater participation is anticipated as development progresses.                                                                                                                                                          |
|  | Investment Coordinating Board (BKPM)                          | BKPM reports directly to the president, its main aim is to attract both domestic and foreign investments across various sectors, including the green hydrogen industry. This involves offering a range of incentives and support to interested investors.                                                                      | Support | Acknowledging the capital-intensive nature of the hydrogen industry, they maintain a strong interest in its development. Nevertheless, given their broader investment strategy, they won't actively seek out green hydrogen projects. However, they remain open to facilitating such investments should opportunities emerge. |
|  | National Development Planning Agency (Bappenas)               | It serves as the primary think tank and architect for the ESDM's national hydrogen strategy, offering vast expertise with an economic focus.                                                                                                                                                                                   | Support | Highly supportive yet lacking the power to enact policies, this planning agency focuses on backing the Directorate General of New Renewable Energy and Energy Conservation without direct policy implementation authority.                                                                                                    |



|                       |                                                           |                                                                                                                                                                                                                                             |         |                                                                                                                                                                                                                        |
|-----------------------|-----------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Academia</b>       | The National Research and Innovation Agency (BRIN)        | A government agency established to consolidate and oversee all national research and innovation activities. BRIN operates under direct presidential oversight, aiming to enhance Indonesia's research capabilities and innovation outcomes. | Support | Although it primarily focuses on long-term innovative technologies such as electrolysis, rather than the immediate implementation of green hydrogen, it remains a strong supporter.                                    |
|                       | Singapore University of Technology and Design (SUTD)      | SUTD stands as a premier educational institution within the region, driving technological innovation and design thinking of hydrogen through collaborative academic and research efforts.                                                   | Support | It engages in extensive research on hydrogen, focusing on technological advancements aimed at the long-term development of hydrogen energy.                                                                            |
|                       | The Asia Research Institute (ARI)                         | ARI stands out as a leading research hub on Asian studies, based at the National University of Singapore.                                                                                                                                   | Support | Supported by significant funding from Japanese and South Korean entities, which are primarily focused on hydrogen development, recently released a report detailing the supply and demand for green hydrogen in Japan. |
|                       | Indonesia's Institute for Essential Service Reform (IESR) | IESR is a key organization in Indonesia focusing on sustainable energy transition and climate policy, covering a broad range of renewable energy and environmental sustainability issues, namely, green hydrogen.                           | Support | It is the most influential due to its strong government connections, focusing on immediate, straightforward policy execution and short-term goals.                                                                     |
| <b>Private Sector</b> | Pertamina                                                 | Pertamina is Indonesia's state-owned energy company, involved in oil, gas, and renewable energy, including exploration, production, and distribution. It's key to Indonesia's energy sustainability and independence efforts.               | Support | It's part of the Oil and Gas Directorate, which leads hydrogen development efforts, making it a key ally in advancing green hydrogen projects.                                                                         |
|                       | HDF Energy                                                | HDF Energy is a global leader in the hydrogen industry, focusing on developing                                                                                                                                                              | Support | As a leader in Indonesia's green hydrogen sector, the company aims to expand its                                                                                                                                       |

|                      |                                                    |                                                                                                                                                                                                                                                                                                                     |         |                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      |                                                    | large-scale hydrogen infrastructure and advanced fuel cell technology. The company is leading the creation of Asia's first multi-MW hydrogen power plant in Sumba.                                                                                                                                                  |         | pilot project across 20 additional sites within Indonesia.                                                                                                                                                                                                                                                                                                                                            |
|                      | TotalEnergies                                      | A leader in Indonesia's energy sector, engaging in upstream and downstream activities, including innovative projects like the Subma pilot. The company is exploring various investment opportunities in Indonesia, focusing on renewable energy sources such as solar power and hydrogen.                           | Support | With their substantial financial resources, TotalEnergies has a diverse operation portfolio that includes, among other initiatives, hydrogen energy. Their established presence in the oil and gas sector bolsters their support for such initiatives. Given this background, it's reasonable to anticipate their interest in expanding into green hydrogen to meet the extensive global energy needs |
|                      | Air Liquide                                        | A French multinational company and the second-largest supplier of industrial gasses by revenues globally.                                                                                                                                                                                                           | Neutral | Primarily focused on small-scale projects like fertilizer production, its engagement with green hydrogen projects is relatively limited.                                                                                                                                                                                                                                                              |
| <b>Civil Society</b> | The Institute for Essential Services Reform (IESR) | Indonesian think tank focusing on energy and environmental issues. It is a prominent figure in green hydrogen development and advocates for a low-carbon energy system through public policy based on scientific studies, capacity development assistance, and strategic partnerships with non-governmental actors. | Support | IESR works in close partnership with the ESDM. Known for producing numerous reports, it plays a crucial role in the sector.                                                                                                                                                                                                                                                                           |
|                      | Indonesian Renewable Energy Society (METI)         | An association focused on renewable energy in Indonesia, acting as a platform for networking and collaboration through annual industry events.                                                                                                                                                                      | Support | Its primary role is to foster networking and educational platforms that bolster the transition to renewable energy, particularly in areas like green hydrogen.                                                                                                                                                                                                                                        |

|  |                                                     |                                                                                                                                                                                                                          |         |                                                                                                                                                                                                                                                                    |
|--|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Indonesian Chamber of Commerce and Industry (KADIN) | A prominent association representing entrepreneurs and businesses in Indonesia, advocating for the interests of its members, engaging in policy dialogues, and fostering economic growth and development in the country. | Support | <p>They have a track record of influencing government policies through lobbying efforts.</p> <p>Recently, their leaders have indicated plans to advocate for hydrogen-related policies over the next 1-3 years, aligning with the agenda of the new president.</p> |
|--|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

# MEMO II

# Green Hydrogen

## *Japan*

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## Executive Summary

This memo details the opportunities and challenges related to a potential United States (U.S.) public-private partnership (PPP) aimed at promoting green hydrogen technology exports to Japan. Our analysis explores stakeholders, market dynamics, relevant policies, export challenges, sectoral growth challenges, key competitors, and public education requirements, along with recommendations for the ITA.

**Key Stakeholders:** Key stakeholders in Japan's hydrogen ecosystem include international bodies like the Hydrogen Council and ASEAN. Domestically, government entities such as METI, the Ministry of the Environment, NEDO, GIF, and JBIC are pivotal. The private sector, represented by companies such as Toshiba Energy Systems & Solutions Corporation, Siemens Energy, and Hitachi, leads various initiatives. Academic institutions, such as the University of Tokyo and the Tokyo Institute of Technology, provide research insights. Civil society organizations like the Japan Hydrogen Association (JH2A), Renewable Energy Institute (REI), Japan Climate Initiative (JCI), Japan H2 Mobility (JHyM), Clean Fuel Ammonia Association, and The Hydrogen Energy Network (HyNet) contribute to sustainable energy discourse and advocacy.

**Market Analysis:** Japan is actively pursuing a hydrogen-based energy future, with ambitious goals outlined in its Basic Hydrogen Strategy aimed at positioning the country as a global leader in this field. By 2030, Japan aims to supply 3 million tons of hydrogen, increasing to 20 million tons by 2050, alongside efforts to reduce supply costs and expand its global

presence in hydrogen-related technologies. This strategy involves significant financial investment, international collaborations, and advancements in technology, particularly in fuel cell vehicles and power generation. Japan's clear policy direction and strategic approach position it as a key player in the global transition to a hydrogen economy.

**Key Codes, Standards, and Regulatory Frameworks:** Japan's updated hydrogen strategy, introduced in June 2023, marks a significant legislative shift towards green hydrogen technology, motivated by global efforts to reduce dependence on Russian energy and address climate concerns. Supported by legislative amendments such as the Act on Rationalizing Energy Use and the Act on Sophisticated Methods of Energy Supply Structures, hydrogen and ammonia are now officially recognized as non-fossil fuels, signaling a departure from conventional energy approaches. Additionally, Japan's Green Growth Strategy aims to achieve carbon neutrality by 2050, with substantial funding from the Green Innovation Fund allocated to drive innovation and adoption of green technologies across various sectors. These legislative measures highlight Japan's proactive approach towards establishing a sustainable hydrogen economy and advancing towards carbon neutrality. However, challenges such as the high cost and intermittency of renewables and disparities in governmental support pose hurdles to achieving these ambitious goals.

**Export Challenges:** Japan's hydrogen focus presents opportunities and challenges for U.S. exporters. Compliance with strict standards, including Japanese Industrial Standards (JIS), is crucial. Despite Japan's participation in the WTO's Government Procurement Agreement, access to contracts, particularly in energy, may be limited due to exemptions. Additionally, Japan's stringent safety and environmental regulations pose compliance hurdles. Understanding and navigating these regulations are essential for success, emphasizing the need for ongoing monitoring and collaboration. Recommendations include providing financing options, participating in trade shows, advocating for policy dialogue, and facilitating research to support U.S. exporters and enhance bilateral trade in the hydrogen sector.

**Challenges to Sectoral Growth:** Japan's pursuit of hydrogen as a linchpin for decarbonization and industrial competitiveness, epitomized by its pioneering Basic Hydrogen Strategy of 2017, encounters multifaceted challenges. Among these obstacles is Japan's significant reliance on imported fossil fuels for electricity, impeding the transition to green hydrogen production reliant on renewable energy sources. Despite Japan's prominence in fuel cell technology, achieving cost competitiveness for green hydrogen remains a formidable task due to high production costs and technological limitations, exacerbated by disparities in electrolyzer market scale compared to European and Chinese counterparts. Criticism emerges concerning the strategy's prioritization of fossil-fuel-based hydrogen over green alternatives. Furthermore, infrastructural constraints in hydrogen distribution pose logistical challenges. Recommendations include

closely monitoring Japan for future export opportunities and attentiveness to its technological pathway decisions amidst efforts to maintain a diversified portfolio of carriers.

**Main Competitors for US Export:** Malaysia, Indonesia, and Australia serve as key competitors for the United States in the green hydrogen technology export market. Countries in Southeast Asia, especially Malaysia and Indonesia, produce around 3 million metric tons of hydrogen. Additionally, Australia and Japan are taking steps to strengthen their collaboration on clean energy, strengthening opportunities for trade, including Australia's Hydrogen Energy Supply Chain pilot project.

For the United States to effectively compete, the ITA should foster partnerships with Japanese government and energy companies, and alignment with local standards and development processes is crucial. Additionally, the U.S. should consider investing in the APAC region's green hydrogen development through technology transfer and knowledge exchange.

**Public Education:** Japan, leading the global shift towards green hydrogen, confronts challenges in public education and perception regarding this energy transition. Despite efforts to educate both the workforce and the public through partnerships, materials, and government training, a strong preference for cheaper gray hydrogen persists among the Japanese populace. To overcome this hurdle, fostering a collaborative partnership between the U.S. and Japan, similar to Japan's EU collaboration, can enhance educational initiatives. Encouraging Japan to initiate a comprehensive public

education campaign, expanding beyond website resources, and integrating renewable energy education into academic curricula from preschool to higher education are crucial steps. Additionally, facilitating private-public partnerships in vocational training can equip the workforce with skills essential for a green hydrogen economy, ultimately solidifying Japan's leadership in this transformative energy sector.

Japan's hydrogen-based effort underscores its commitment to leadership in the global clean energy transition. Despite challenges such as compliance with stringent standards, Japan's clear policy direction and strategic investments position it as a key player in driving innovation and adoption of green hydrogen technologies. U.S. exporters should prioritize fostering partnerships, aligning with local standards, and investing in the region's green hydrogen development. Collaboration between the U.S. and Japan, coupled with comprehensive public education initiatives, will be **ideal** for a green hydrogen export PPP initiative.

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## Introduction

This memo discusses the potential for a United States public-private partnership (PPP) focused on promoting green hydrogen technology exports to Japan. It introduces key domestic and international stakeholders, the current state of the geothermal market, key codes and regulatory frameworks, export challenges, sectoral growth challenges, competitor analysis, and public education requirements. We provide recommendations related to managing stakeholders, sectoral and export growth, and public education that can facilitate the success of a PPP targeted toward Japan. The conclusion includes a summary of these recommendations. Finally, the appendices at the end of the report provide further in-depth stakeholder analysis.

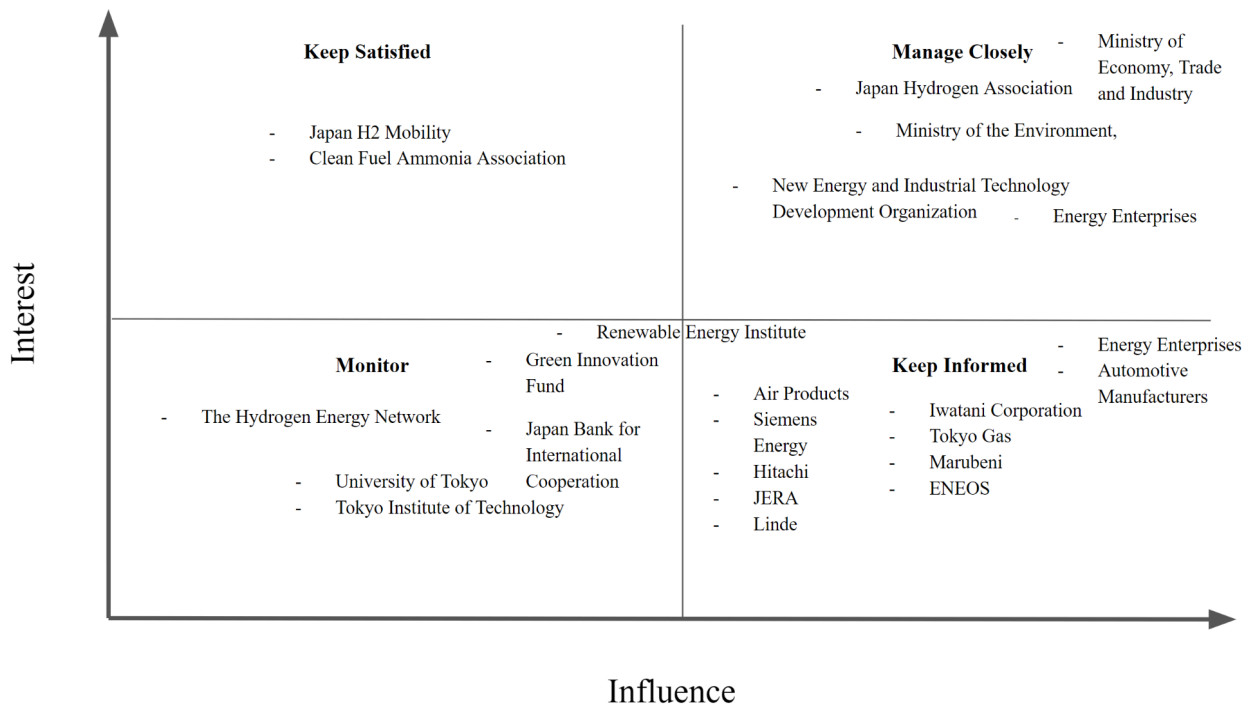
## Key Stakeholders

Identifying and understanding the various stakeholders involved in the implementation of a green hydrogen Public-Private Partnership (PPP) is vital for strategic alignment, risk management, and resource allocation. Stakeholder analysis, in the context of Japan's hydrogen landscape, can be effective in building relationships, enhancing legitimacy, and ensuring accountability within a complex system. Likewise, we have identified the following stakeholders working at international, regional levels across government, the private sector, academic, and civil society in Japan.

- *International /Regional Entity:* Hydrogen Council, ASEAN.
- *Government:* Ministry of Economy, Trade and Industry (METI), Ministry of the Environment, New Energy and Industrial Technology Development Organization (NEDO), Green Innovation Fund (GIF) and the Japan Bank for International Cooperation (JBIC)
- *Private Sector:* Energy Enterprises (Toshiba Energy Systems & Solutions Corporation, Kawasaki Heavy Industries, Mitsubishi Heavy Industries), Automotive Manufacturers (Toyota Motor Corporation, Honda), Iwatani Corporation, Tokyo Gas, Marubeni, ENEOS, Air Products, Siemens Energy, Hitachi, JERA, Linde.
- *Academia:* University of Tokyo, Tokyo Institute of Technology.
- *Civil Society:* Japan Hydrogen Association (JH2A), Renewable Energy Institute (REI), Japan Climate Initiative (JCI), Japan H2 Mobility (JHyM), Clean Fuel Ammonia Association, The Hydrogen Energy Network (HyNet).

## Recommendation

The following interest-influence matrix displays the recommended action for ITA for each stakeholder (i.e., monitor, keep satisfied, keep informed, or manage closely).



**Figure 1:** Japan Green Hydrogen Stakeholder Analysis Matrix

## Market Analysis

Japan is aggressively pursuing a hydrogen-based energy future, setting ambitious targets to become a global leader in the field. The nation's initial Basic Hydrogen Strategy in 2017 laid the groundwork for an expansive approach towards developing hydrogen as a major energy resource, aiming to bolster energy security, reduce carbon emissions, and maintain industrial competitiveness.

By 2030, Japan aims to supply 3 million tons of hydrogen, escalating to 20 million tons by 2050, a significant jump from its current levels. The strategy envisions a reduction in hydrogen supply costs to 30 JPY per normal cubic meter by 2030, with a further drop to 20 JPY per Nm3 by 2050.

Japan is also looking to increase the global presence of its water electrolysis equipment to approximately 15GW by 2030.<sup>242</sup>

Investment is a key pillar of Japan's strategy, with the government planning to channel more than 15 trillion JPY into the hydrogen and ammonia supply chain sector within 15 years. Recognizing the importance of international cooperation, Japan has been actively developing partnerships, particularly with Australia, as demonstrated by the world's first liquefied hydrogen transportation vessel, the Suiso Frontier.<sup>243</sup>

The country is also at the forefront of fuel cell technology, especially fuel cell vehicles (FCVs). It has set mobility targets of 200,000 FCVs by 2025, expanding to 800,000 by 2030, alongside an increase in hydrogen fueling stations to 320 by 2025 and 900 by 2030. This push towards FCVs is part of a larger plan to decarbonize the transportation sector.<sup>244</sup>

In addition to the automotive industry, Japan is focusing on the use of hydrogen in power generation, with strategies to support high-hydrogen-mixed combustion systems and the development of 100%-hydrogen combustion systems. The country is also investing in hydrogen use in heavy industries, like green steel production, and is looking at hydrogen and ammonia for power generation.<sup>245</sup>

To bolster the hydrogen economy, Japan is actively investing in research and development, maintaining a diverse technological portfolio, and is pushing for innovation in hydrogen production, transportation, and storage technologies. The government's support structure includes the Zero Emissions Creators 500 program, aimed at assisting young energy and environmental researchers.

Japan's hydrogen strategy is not without its challenges, including criticism for its initial prioritization of fossil-fuel-based hydrogen sources. However, the current strategy addresses these concerns by shifting focus to renewable sources of hydrogen, aiming for a cleaner hydrogen supply chain in the long run.

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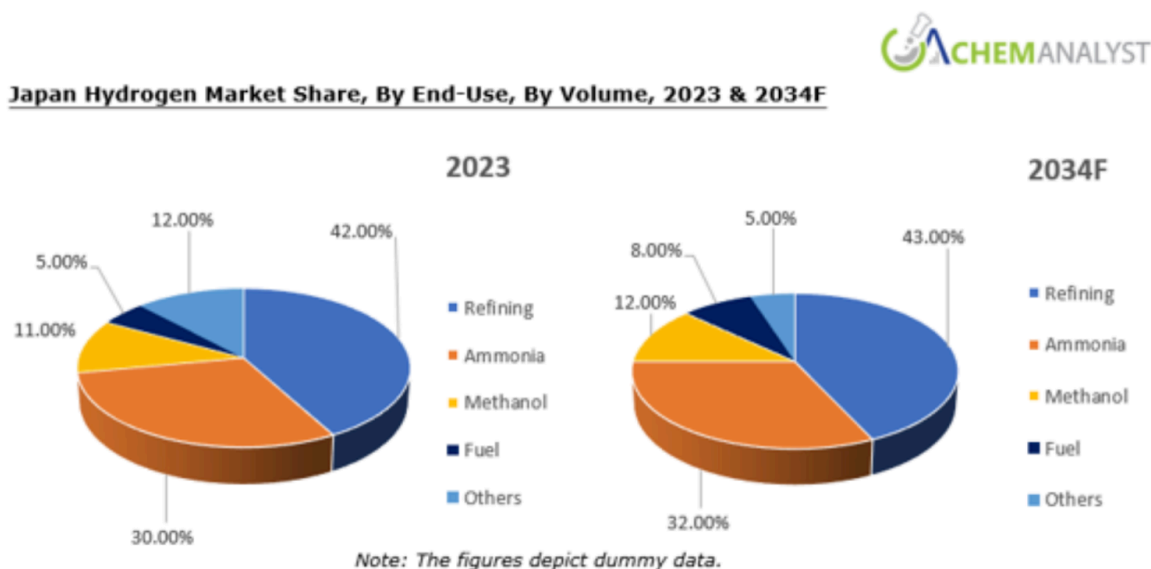
<sup>242</sup> Bocobza, J., & Tanabe, M. (2023, June 26). Japan Hydrogen Basic Strategy. White & Case LLP. <https://www.whitecase.com/insight-alert/japan-hydrogen-basic-strategy>

<sup>243</sup> Akimoto, D. (2023, July 10). *A look at Japan's latest hydrogen strategy*. The Diplomat. <https://thediplomat.com/2023/07/a-look-at-japans-latest-hydrogen-strategy/>

<sup>244</sup> Nakano, J. (2021, October 21). *Japan's Hydrogen Industrial Strategy*. CSIS. <https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>

<sup>245</sup> Bocobza, J., & Tanabe, M. (2023, June 26). Japan Hydrogen Basic Strategy. White & Case LLP. <https://www.whitecase.com/insight-alert/japan-hydrogen-basic-strategy>

As Japan's hydrogen market evolves, its strategic initiatives, ambitious targets, and international collaborations position it to potentially become a dominant force in the global transition towards a hydrogen economy.



**Figure 2: Japan Hydrogen Market Share**

The growth of the green hydrogen market in Japan is underpinned by the nation's ambitious policy framework and significant financial commitments, positioning Japan as a leading player in the global transition to a low-carbon economy.

#### **Policy and Financial Commitment:**

Japan's commitment of 15 trillion yen (approximately \$107.5 billion) over 15 years to develop its hydrogen industry is a cornerstone of this strategy. This investment aims to boost domestic energy advancements and establish a comprehensive hydrogen supply chain .<sup>246</sup>

#### **Hydrogen Production and Supply Goals:**

The plan is to increase Japan's domestic hydrogen supply by 50% from current levels to approximately 3 million tons by 2030, scaling up to 20 million tons by 2050. This aligns with global hydrogen demand projections from the International Energy Agency (IEA), anticipating a surge to 88.3 million tons by 2030 and 287 million tons by 2050 .

<sup>246</sup> Kahla, C. (2024a, March 5). Fueling the future: Japan's \$20 billion clean hydrogen strategy . Locate2u. <https://www.locate2u.com/technology/japan-investment-clean-hydrogen-strategy/#:~:text=Hydrogen%3A%20Subsidizing%20the%20future&text=The%20funds%20will%20increase%20the,as%20reported%20by%20Kr%2DAsia.>

**Technological and Industrial Advancement:**

To bolster its competitive edge in hydrogen production, Japan has set clear targets for its industry, including capturing a 10% share of the global electrolyzer market and establishing a “pathway” to low-carbon hydrogen, aiming for a carbon intensity of 3.4kg of CO<sub>2</sub> or less per kilogram of hydrogen produced .

**Infrastructure and Market Development:**

Japan's strategy encompasses substantial infrastructure development. A focus area is the scaling up of electrolyser capacity to 15 gigawatts by the end of the decade, from less than 1 GW presently. The promotion of fuel cell vehicles (FCVs), hydrogen-powered buses, and other hydrogen-fueled transport forms part of the broader infrastructure goals, aiming for widespread deployment by 2030 .

**International Collaborations and Supply Chains:**

Japan has forged international partnerships, notably with Australia, for the Suiso Frontier project – the world’s first liquefied hydrogen transportation vessel. These partnerships are vital for Japan's strategy to build a robust international hydrogen supply chain and increase production scale .

**Market Incentives and Subsidies:**

The Japanese government has planned support schemes to encourage industry and research, including cluster development support for industrial clusters and supply chains, as well as producer support schemes aiming at expanding supply volume and reducing costs .

**Regional and Global Leadership:**

Through events like the Hydrogen Energy Ministerial Meeting and by leveraging opportunities such as Expo 2025 in Osaka, Japan aims to showcase its hydrogen technology leadership and vision for a hydrogen-based economy. The country's policies also reflect a willingness to support the hydrogen sector based on carbon intensity rather than the “color” of hydrogen, indicating a strategic approach that favors environmentally sustainable hydrogen production .

In summary, Japan's clear policy direction, combined with substantial financial investment and a strategic approach to industry development and international collaboration, sets the stage for robust growth in its green hydrogen market. This growth is expected to be a key contributor to Japan's broader goals of decarbonization and economic transformation.

### *Recommendations*

1. Given the ambitious hydrogen strategy of Japan and the existing challenges for U.S. exporters, the U.S. government might consider a multi-faceted approach to support U.S. hydrogen energy exports to Japan.
2. Facilitate Bilateral Technical Standards Dialogues: Establish a U.S.-Japan bilateral committee to align and harmonize standards for hydrogen technologies. This committee could work towards mutual recognition of certifications and testing, easing the process for U.S. hydrogen technologies to meet Japanese Industrial Standards (JIS). This dialogue can also involve stakeholders from both countries to continually adapt to emerging technologies in the hydrogen sector.
3. Expand Government-to-Government Collaboration: Strengthen government-to-government partnerships through memoranda of understanding (MOUs) that focus on hydrogen technology collaboration. These agreements could cover joint research and development projects, pilot projects for hydrogen use in various sectors, and the development of international hydrogen supply chains where U.S. technologies and services can be highlighted.
4. Promote U.S. Participation in Japan's Hydrogen Projects: Advocate for U.S. companies' participation in Japan-funded hydrogen projects. With Japan planning significant investments in the hydrogen sector, the ITA can play a crucial role in ensuring U.S. companies are well-represented in bids and projects, particularly those focusing on innovative hydrogen production, storage, and transportation technologies.
5. Encourage U.S.-Japan Private Sector Partnerships: Facilitate partnerships between U.S. and Japanese companies in the hydrogen sector. This could involve creating platforms for networking, partnership development, and exchange of best practices in hydrogen technology. Such collaborations could accelerate the entry of U.S. hydrogen technologies into Japan by leveraging local partners' market knowledge and networks.

By adopting these recommendations, the ITA can significantly enhance support for U.S. hydrogen energy exporters, aligning with Japan's clean energy ambitions and fostering bilateral trade in this emerging sector.

## **Key Codes, Standards, and Regulatory Frameworks**

In June 2023, Japan unveiled a revised Hydrogen Basic Strategy, signaling a significant shift towards green hydrogen technology. Motivated by various factors, including G7 commitments to reduce reliance on Russian energy, escalating calls for climate action, and enticing hydrogen

subsidies from key global initiatives such as the EU's Green Deal Industrial Plan and the US' Inflation Reduction Act, Japan embarked on this transformative journey.<sup>247</sup>

This updated strategy marks a pivotal moment since Japan's initial hydrogen strategy was released in December 2017, which was the world's first national hydrogen strategy.<sup>248</sup> However, the energy landscape has evolved substantially since then, necessitating a comprehensive reevaluation. With an ambitious vision to foster both public and private sector investment amounting to 15 trillion yen (approximately NZD 173.4 billion) over the next 15 years, Japan aims to augment hydrogen utilization sixfold by 2040.<sup>249</sup>

Central to this refreshed strategy are three key features outlined by Japanese government officials. Firstly, the establishment of a new mid-term volume target, aiming for 12 million tonnes per annum of hydrogen production by 2040, representing a sixfold increase from current levels. Secondly, a dedicated "pathway" towards low-carbon hydrogen, with a target of achieving 3.4kg or less of CO<sub>2</sub> emissions for every 1kg of hydrogen produced. Lastly, a strategic objective is to secure a 10% share of the global electrolyzer market for Japanese companies, further underscoring Japan's commitment to becoming a frontrunner in hydrogen technology.<sup>250</sup>

Moreover, the Japanese government has unveiled supportive schemes integral to the successful implementation of this strategy. These include cluster development support aimed at establishing internationally competitive industrial clusters and robust supply chains, with an expected investment of 1 trillion yen (approximately NZD 11.5 billion). Additionally, a producer support scheme is envisioned to expand supply volume and drive down production costs, with investments exceeding 7 trillion yen (approximately NZD 80.9 billion).<sup>251</sup> Japan's Ministry of Economy, Trade, and Industry (METI) is poised to release detailed information on these schemes

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<sup>247</sup> (2023, November 22). *Japan: hydrogen strategy - November 2023*. New Zealand Ministry of Foreign Affairs and Trade.

<https://www.mfat.govt.nz/en/trade/mfat-market-reports/japan-hydrogen-strategy-november-2023/#:~:text=The%20Hydrogen%20Strategy&text=Japan>

<sup>248</sup> Ohno, T. & et. al., (2022). *Re-examining Japan's Hydrogen Strategy: Moving Beyond the "Hydrogen Society" Fantasy* [Review of *Re-examining Japan's Hydrogen Strategy: Moving Beyond the "Hydrogen Society" Fantasy*]. Renewable Energy Institute.

[https://www.renewable-ei.org/pdffdownload/activities/REI\\_JapanHydrogenStrategy\\_EN\\_202209.pdf](https://www.renewable-ei.org/pdffdownload/activities/REI_JapanHydrogenStrategy_EN_202209.pdf)

<sup>249</sup> *Japan to invest \$107 billion in hydrogen supply over 15 years*. (2023, June 6). Reuters.

<https://www.reuters.com/business/energy/japan-invest-107-bln-hydrogen-supply-over-15-years-2023-06-06/>

<sup>250</sup> James, W. (2024, January 23). *Japan's hydrogen ambitions may do more harm than good*. East Asia Forum. <https://eastasiaforum.org/2024/01/23/japans-hydrogen-ambitions-may-do-more-harm-than-good/>

<sup>251</sup> Corbeau, A. S., & Kaswiyanto, R. P. (n.d.). *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia*. Center on Global Energy Policy. <https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>

by March 2024, underscoring Japan's proactive stance towards realizing a sustainable hydrogen economy.<sup>252</sup>

However, these measures and strategies are not without challenges. Notably, in the realm of hydrogen, while renewable sources are acknowledged, caution is urged, emphasizing adherence to the "3E+S Principles" (Energy security, economic efficiency, environmental considerations, and safety). This underscores industry concerns regarding the high cost and intermittency of renewables. Moreover, while international support for expanding hydrogen and ammonia supply chains in Asia is robust, Japanese companies seeking to engage in regional renewable businesses encounter limited support, reflecting disparities in governmental backing and industry dynamics.<sup>253</sup>

Japan's hydrogen policies diverge significantly from global trends in hydrogen strategy observed in Europe, the US, China, Australia, and other regions, necessitating a reevaluation both as a decarbonization and energy security strategy. Japan's emphasis on gray and blue hydrogen, which have little to no impact on emissions reduction, coupled with its heavy reliance on imported hydrogen, has resulted in Japan lagging behind other nations in domestic green hydrogen production. Despite leading efforts to expand the market for hydrogen-consuming products, Japan's strategy appears outdated, failing to adapt to recent global shifts. Without corrective action, Japan risks not only missing its 1.5°C targets but also facing criticism for greenwashing. Additionally, there's a looming threat to the international competitiveness of Japanese manufacturing if products are perceived as high in greenhouse gas intensity. Thus, a recalibration of Japan's hydrogen strategy is imperative to align with global advancements and climate objectives.<sup>254</sup>

The amended Act on Rationalizing Energy Use, enacted in 2022, reflects a pivotal shift towards reducing reliance on fossil fuels by embracing non-fossil alternatives. This transformative approach is further underscored by an amendment to the Act on Sophisticated Methods of Energy Supply Structures, where hydrogen and ammonia are officially recognized as non-fossil fuels. This legislative maneuver not only signals a departure from traditional energy paradigms

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<sup>252</sup> METI Ministry of Economy, Trade and Industry. (2020). Meti.go.jp. <https://www.meti.go.jp/english/>

<sup>253</sup> InfluenceMap. (n.d.). GX (Green transformation) basic policy and roadmap. Retrieved from <https://japan.influencemap.org/policy/GX-Green-Transformation-5477>

<sup>254</sup> Renewable Energy Institute. (2023, June 29). Revised basic hydrogen strategy offers no clear path to carbon Neutrality | Position paper | Renewable energy institute. Retrieved from <https://www.renewable-ei.org/en/activities/reports/20230720.php>



but also signifies a strategic commitment to fostering a more sustainable and diversified energy landscape.<sup>255</sup>

Launched in 2020, the Green Growth Strategy Through Achieving Carbon Neutrality in 2050 sets forth an ambitious roadmap aimed at attaining net zero carbon emissions by 2050. A significant elevation of its prior targets, the strategy now aims to slash emissions by an impressive 46% from 2013 levels by 2030, demonstrating a heightened commitment to expedite progress towards carbon neutrality. To catalyze innovation across various sectors, the strategy leverages a comprehensive array of policy tools, spanning from budget allocations and taxation adjustments to regulatory reforms.<sup>256</sup>

A cornerstone of Japan's initiative towards carbon neutrality is the establishment of the Green Innovation Fund, endowed with a substantial \$18.2 billion allocation. Over the course of the next decade, this fund is poised to deliver sustained backing for a spectrum of initiatives, spanning from ambitious research and development endeavors to the practical implementation of green technologies within society. By introducing these supportive mechanisms and leveraging 2 trillion yen (U \$13.2 billion) of governmental funds to stimulate initial investments, the aim is to incentivize private enterprises to amplify their efforts in R&D and capital expenditure. Crucially, the monitoring of projects funded by this initiative will be conducted with a keen eye on their cross-sectoral impact, evaluating criteria such as international competitiveness, commercialization potential, and the capacity to attract private investment.<sup>257 258</sup>

The hydrogen focus of Japan's strategy prioritizes the widespread integration of hydrogen into society, identifying urgent tasks such as commercializing hydrogen power generation turbines and fuel cell trucks. The main strategy revolves around reducing prices and increasing domestic incorporation, aiming to introduce up to 3 million tons of hydrogen by 2030 and 20 million tons by 2050. This entails distributing technologies, enhancing competitiveness, and fostering bilateral and multilateral cooperation, as exemplified by agreements with the US and EU.<sup>259</sup> Japan seeks to leverage its technological strengths to strengthen international competitiveness,

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<sup>255</sup> Renewable Energy Institute. (2023, June 29). Revised basic hydrogen strategy offers no clear path to carbon Neutrality | Position paper | Renewable energy institute. Retrieved from <https://www.renewable-ei.org/en/activities/reports/20230720.php>

<sup>256</sup> METI. (2022, October 17). Green growth strategy through achieving carbon neutrality in 2050 / METI ministry of economy, trade and industry. Retrieved from [https://www.meti.go.jp/english/policy/energy\\_environment/global\\_warming/ggs2050/index.html](https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/index.html)

<sup>257</sup> NEDO. (n.d.). Overview of the green innovation fund projects. Retrieved from <https://green-innovation.nedo.go.jp/en/about/>

<sup>258</sup> The Government of Japan. (2021, September 16). Japan's green growth strategy will accelerate innovation. Retrieved from [https://www.japan.go.jp/kizuna/2021/09/green\\_growth\\_strategy.html](https://www.japan.go.jp/kizuna/2021/09/green_growth_strategy.html)

<sup>259</sup> Ibid.

accelerating the commercialization of hydrogen power generation turbines and fuel cell trucks. Research and development efforts target improving efficiency and durability, with an emphasis on market expansion. Early commercialization goals extend to transportation and storage technologies, including large-scale equipment, electrolyzers, and water electrolyzers. International standardization and cost reduction initiatives aim to facilitate global adoption, ensuring Japan's sustained competitiveness in the burgeoning hydrogen economy. Additionally, efforts are underway to ease entry barriers to overseas markets, fostering a conducive environment for international collaboration and innovation in hydrogen technologies.<sup>260</sup>

In June 2023, Japan unveiled a revised Hydrogen Basic Strategy, underlining four key objectives. Firstly, it aims to bolster the supply of hydrogen and ammonia within Japan, escalating from 2 million tons to 3 million tons by 2030, reaching 12 million tons by 2040, and ultimately targeting 20 million tons by 2050. Secondly, the strategy is geared towards slashing hydrogen supply costs domestically, targeting a reduction from 100 Japanese yen per normal cubic meter (Nm<sup>3</sup>) to 30 yen per Nm<sup>3</sup> by 2030, further lowering to 20 yen per Nm<sup>3</sup> by 2050. Thirdly, there's a concerted effort to expand the global presence of Japanese companies in the production of water electrolysis equipment, aiming to reach approximately 15 GW by 2030. Finally, the strategy endeavors to catalyze both public and private investments into the hydrogen and ammonia supply chain sectors, with a set goal of attracting more than 15 trillion yen (\$107.5 billion) over the next 15 years.<sup>261</sup>

The revised Hydrogen Basic Strategy unveiled by Japan in June 2023 delineates specific targets and initiatives aimed at advancing the nation's hydrogen economy. Key among these is a mid-term volume target of 12 million tonnes per annum by 2040, representing a significant six-fold increase from current levels. Additionally, the strategy charts a "pathway" to low-carbon hydrogen, striving for emissions of 3.4kg of CO<sub>2</sub> or less per 1kg of hydrogen produced. Another focal point is a 10% target for Japanese companies' share of the global electrolyzer market, aiming to bolster Japan's position in this critical sector.<sup>262</sup>

Seeking international collaboration, Japan is keen on establishing partnerships to develop a robust hydrogen supply chain, scale up hydrogen and ammonia production, and drive down costs. Motivated by G7 commitments to reduce reliance on Russian energy, as well as incentives

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<sup>260</sup> IEA. (2023). *Hydrogen*. IEA. <https://www.iea.org/energy-system/low-emission-fuels/hydrogen>

<sup>261</sup> Akimoto, D. (2023, July 7). A look at Japan's latest hydrogen strategy. Retrieved from <https://thediplomat.com/2023/07/a-look-at-japans-latest-hydrogen-strategy/>

<sup>262</sup> New Zealand Ministry of Foreign Affairs and Trade. (2023, November). Japan: Hydrogen strategy - November 2023. Retrieved from <https://www.mfat.govt.nz/en/trade/mfat-market-reports/japan-hydrogen-strategy-november-2023/>

like subsidies under the EU's Green Deal Industrial Plan and the US' Inflation Reduction Act, Japan is poised to leverage these opportunities to bolster its hydrogen endeavors.<sup>263</sup>

The strategy emphasizes core strategic areas vital for Japan's global industrial competitiveness in hydrogen, particularly through the commercialization of domestically developed hydrogen-related technologies like electrolyzers. Moreover, the Japanese government plans to implement support schemes under the new strategy, including cluster development support to establish competitive industrial clusters and supply chains, backed by significant public and private investment. Additionally, a producer support scheme aims to expand supply volume and reduce supply costs, with substantial investment anticipated. Japan's Ministry of Economy, Trade, and Industry (METI) is expected to unveil detailed schemes by March 2024.<sup>264</sup>

The future implementation of hydrogen-fired power generation, supported by a stable supply chain, is projected to have a significant price-stabilizing effect. Assuming successful cost reductions, this would mitigate the impact of sudden price hikes, with potential savings equivalent to approximately 8,600 yen per year in household electricity rates.<sup>265</sup> Compared to fossil fuels, hydrogen demonstrates a lower dependency on specific regions. With the establishment of a stable supply chain and the attainment of competitive pricing, hydrogen-fired power generation is poised to offer stability in pricing.

## Export Challenges

Japan's approach to the hydrogen economy is characterized by stringent adherence to national standards and a commitment to fostering a robust domestic industry, which creates both opportunities and challenges for U.S. exporters.

The Japanese Industrial Standards (JIS) play a central role in establishing requirements for a wide range of products and technologies. For hydrogen technologies, including components and systems, adherence to the specific JIS safety and performance criteria is mandatory. These standards, which may differ from those set by the ISO or ANSI, necessitate that all hydrogen-related technologies entering the Japanese market comply strictly with JIS standards.

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<sup>263</sup> New Zealand Ministry of Foreign Affairs and Trade. (2023, November). Japan: Hydrogen strategy - November 2023. Retrieved from <https://www.mfat.govt.nz/en/trade/mfat-market-reports/japan-hydrogen-strategy-november-2023/>

<sup>264</sup> New Zealand Ministry of Foreign Affairs and Trade. (2023, November). Japan: Hydrogen strategy - November 2023. Retrieved from <https://www.mfat.govt.nz/en/trade/mfat-market-reports/japan-hydrogen-strategy-november-2023/>

<sup>265</sup> METI. (2022, October 17). Green growth strategy through achieving carbon neutrality in 2050 / METI ministry of economy, trade and industry. Retrieved from [https://www.meti.go.jp/english/policy/energy\\_environment/global\\_warming/ggs2050/index.html](https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/index.html)

It's important to note that, due to the emerging nature of hydrogen technology, the JIS is continuously evolving, and U.S. exporters must stay informed of any updates to ensure compliance.<sup>266</sup>

In the realm of government procurement, Japan is a participant in the WTO's Government Procurement Agreement but maintains certain exemptions that can affect foreign companies' access to procurement contracts, especially in strategic sectors such as energy.<sup>267</sup>

Moreover, the safety and environmental regulations in Japan are among the most rigorous in the world. Any hydrogen storage and fuel cell technologies must conform to Japan's stringent safety regulations for high-pressure gasses, which may exceed the standards typically found in U.S. regulations. This could mean additional compliance efforts for U.S. exporters to meet the specific requirements of the Japanese market.

Understanding these policies and regulations is crucial for U.S. exporters looking to enter the Japanese hydrogen market. The success of such endeavors would likely hinge on ongoing monitoring of Japan's regulatory landscape, close cooperation with local partners, and engagement with Japanese standards organizations to stay abreast of the latest developments in hydrogen standards and requirements.

### *Recommendations*

1. **Support Export Financing and Insurance:** Through the Export-Import Bank of the United States and other agencies, provide competitive financing options and insurance for U.S. hydrogen technology exports to Japan. Given the high initial costs associated with hydrogen projects, financial support can be a decisive factor for Japanese buyers considering U.S. technology.
2. **Leverage Trade Shows and Expos:** Actively promote U.S. hydrogen technologies in Japan through participation in key trade shows, expos, and bilateral trade missions. With Japan hosting Expo 2025 in Osaka, there's a strategic opportunity to showcase U.S. innovation in hydrogen energy, fostering partnerships and opening new avenues for exports.
3. **Policy Advocacy and Dialogue on Regulatory Barriers:** Engage in continuous policy dialogue with Japanese counterparts to address regulatory barriers identified by U.S. exporters. This includes advocating for transparent and predictable regulatory processes, especially concerning safety and environmental regulations for hydrogen technologies.

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<sup>266</sup> Japanese Industrial Standards Committee. <https://www.jisc.go.jp/eng/>

<sup>267</sup> Niunoya, M., Shima, M., & Masaki, K. (2021, November 24). Hydrogen law and regulation in Japan: CMS expert guides. Hydrogen law and regulation in Japan | CMS Expert Guides. <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/japan>

4. Research and Information Sharing: Provide U.S. exporters with up-to-date market intelligence on Japan's hydrogen industry, including regulatory changes, market trends, and opportunities. This can be achieved through reports, webinars, and advisory services, ensuring U.S. businesses are well-equipped to navigate the Japanese market.

By adopting these recommendations, the ITA can significantly enhance support for U.S. hydrogen energy exporters, aligning with Japan's clean energy ambitions and fostering bilateral trade in this emerging sector.

## Challenges to Sectoral Growth

Japan envisions hydrogen as a pivotal element for decarbonizing its economy while sustaining industrial competitiveness and energy security. With the issuance of the Basic Hydrogen Strategy in 2017, Japan became the first nation to adopt a comprehensive national framework for hydrogen development, showcasing its commitment to achieving carbon neutrality and fostering a hydrogen-based society by 2050.<sup>268</sup> However, Japan is also facing some severe challenges, such as dependency on fossil fuel imports, cost competitiveness, regulatory framework, and infrastructure development.

Japan's heavy reliance on imported fossil fuels for electricity, which constitutes around 77% of its electricity supply, underscores a significant challenge to the shift towards green hydrogen, which relies on renewable energy sources for a carbon-neutral production process. The slow pace of renewable energy integration, particularly solar and wind, due to various regulatory and infrastructural challenges, hinders the availability of clean electricity needed for green hydrogen production.<sup>269</sup> Japan is considered an archetype of a demand-heavy import country as it has the technical, financial, and social commitment to decarbonize its heavy industry sectors, however, it faces resource constraints on the production site.<sup>270</sup>

Despite being a leader in fuel cell technology, Japan faces hurdles in making green hydrogen cost-competitive compared to conventional energy sources and other renewables. The current cost of hydrogen production remains a barrier, with efforts underway to reduce it significantly by 2050. This cost competitiveness challenge is compounded by technological hurdles in scaling up

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<sup>268</sup> *A look at Japan's latest hydrogen strategy*. (2023, July 7). The Diplomat – Asia-Pacific Current Affairs Magazine. <https://thediplomat.com/2023/07/a-look-at-japans-latest-hydrogen-strategy/>

<sup>269</sup> *Japan's transition toward a renewable energy future*. (2022, September 30). The National Bureau of Asian Research (NBR). <https://www.nbr.org/publication/japans-transition-toward-a-renewable-energy-future/>

<sup>270</sup> Expert Interview, March 20, 2024, Natalie Janzow, RMI.

hydrogen production and utilization technologies to meet national goals.<sup>271</sup> The LCOH of green hydrogen in Japan is reported to be 2-3x higher than that of China for example. Costs are expected to converge over the upcoming decades, but under limited renewables uptake in Japan, it is very likely that renewable electricity will come at a premium, making it difficult to reconcile with the need for low-cost clean electricity.<sup>272</sup>

The comparison between Japanese companies and their European and Chinese counterparts in the electrolyzer market reveals significant differences in efficiency, production capacity, and costs, which are crucial for deploying hydrogen at scale. Japanese companies exhibit a production efficiency of about 70%, somewhat lower than the 75-80% efficiency rates reported by most European and Chinese companies. However, this comparison might not be entirely accurate due to differing metrics for efficiency, with the latter focusing on stack efficiency rather than overall system efficiency.

The core differences between Japanese companies and their European and Chinese counterparts in the electrolyzer market hinge on production achievements, operational systems, and the cost structure of electrolyzers. European and Chinese firms are already operationalizing electrolyzer manufacturing as a mainstream business activity, evidenced by their delivery of 1,000 to 3,500 units and plans to escalate production capacity to gigawatt levels shortly. On the contrary, among the leading Japanese electrolyzer manufacturers, one remains in the demonstration phase, and the other, albeit having commenced deliveries, operates on a scale notably smaller than its European and Chinese competitors. These international companies are progressing towards establishing production systems capable of generating several hundred megawatts to a few gigawatts annually. Meanwhile, Japanese firms are only beginning to venture into mass production systems, indicating a significant gap in the scale and maturity of electrolyzer production between Japan and these nations which ultimately manifests differences in cost.<sup>273</sup>

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<sup>271</sup> *Japan's hydrogen industrial strategy*. (n.d.). CSIS | Center for Strategic and International Studies. <https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>

<sup>272</sup> Japan's bet on hydrogen is still unwavering despite decades of lackluster progress. (n.d.). IEEFA | Institute for Energy Economics and Financial Analysis. <https://ieefa.org/resources/japans-bet-hydrogen-still-unwavering-despite-decades-lackluster-progress>

<sup>273</sup> Renewable Energy Institute. (2022). *Re-examining Japan's Hydrogen Strategy*. [https://www.renewable-ei.org/pdfdownload/activities/REI\\_JapanHydrogenStrategy\\_EN\\_202209.pdf](https://www.renewable-ei.org/pdfdownload/activities/REI_JapanHydrogenStrategy_EN_202209.pdf)

|        | Main companies                  | Type          | Product | Max capacity MW | Efficiency %   | Results                                                  | Production capacity | Equipment cost \$/kW              | Target                         |
|--------|---------------------------------|---------------|---------|-----------------|----------------|----------------------------------------------------------|---------------------|-----------------------------------|--------------------------------|
| Europe | Thyssenkrupp nucera (Germany)   | Alkaline      | ○       | 20 MW           | 78.2*          | Delivered over 600 units (10 GW)                         | 1 GW/year           |                                   | 5 GW/year (2025)               |
|        | Siemens Energy (Germany)        | PEM           | ○       | 17.5 MW         | 75             | Delivered several dozen MW, received order for 50 MW     |                     |                                   | 3 GW/year (2025)               |
|        | Nel (Norway)                    | Alkaline, PEM | ○       | 85 MW           | 79.9* Alkaline | Delivered 3,500 units (since 1927)                       | 500 MW/year         | Approx. \$200/kW (2025: \$1.5/kg) | 10 GW (2025)                   |
|        | McPhy (France)                  | Alkaline      | ○       | 20 MW           | 78.2*          | Received order for 100 MW unit                           |                     |                                   | 1 GW/year (2024)               |
|        | ITM Power (UK)                  | PEM           | ○       | 5 MW            | 70.9           | Delivered 100 MW unit                                    | 1 GW/year           |                                   | 5 GW/year (2024)               |
| China  | PERIC                           | Alkaline, PEM | ○       | 7.5 MW          | 81.8* Alkaline | Delivered 1,000 units (since 1984)                       | 300 units/year      | \$200/kW Proposed to Sinopec      | 5 GW/year (2025 end)           |
|        | Longi Hydrogen                  | Alkaline      | ○       | 7.5 MW          | 79.9*          |                                                          | 1.5 GW (2022 end)   | \$205/kW Proposed to Sinopec      |                                |
|        | Cokerill Jingli (John Cokerill) | Alkaline      | ○       | 6.5 MW          | 70.3           | Delivered 1,000 units (500 MW)                           | 200 MW/year (2021)  | \$205/kW Proposed to Sinopec      | Planning Gigafactory in France |
| Japan  | Asahi Kasei                     | Alkaline      | —       | 10 MW           | 70.3           | Participated in demonstration project in Germany         |                     | \$1,200/kW (2022)                 | \$433/kW 2030 Target           |
|        | Hitachi Zosen                   | PEM           | ○       | 1 MW            | 70.3           | Delivered several dozen units, received orders for 15 MW |                     | \$3,158/kW (2022)                 | \$542/kW 2030 Target           |

**Figure 3: Main electrolyzer companies and development status<sup>274</sup>**

However, it is also worth mentioning that Japan is leading when it comes to hydrogen innovation in general. The IEA published a study in 2023 using International Patent Families (IPFs) as a metric to measure patenting activities in different categories of hydrogen-related technologies with the following results below:<sup>275</sup>

<sup>274</sup> Renewable Energy Institute. (2022). *Re-examining Japan's Hydrogen Strategy*.

[https://www.renewable-ei.org/pdffdownload/activities/REI\\_JapanHydrogenStrategy\\_EN\\_202209.pdf](https://www.renewable-ei.org/pdffdownload/activities/REI_JapanHydrogenStrategy_EN_202209.pdf)

<sup>275</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>



|               | Share of All<br>Hydrogen-<br>Related IPFs | Production | Storage,<br>Distribution,<br>and<br>Transformation | Industrial<br>Applications |
|---------------|-------------------------------------------|------------|----------------------------------------------------|----------------------------|
| Japan         | 24%                                       | 20%        | 22%                                                | 28%                        |
| US            | 20%                                       | 19%        | 23%                                                | 19%                        |
| Germany       | 11%                                       | 10%        | 14%                                                | 12%                        |
| Rep. of Korea | 7%                                        | 6%         | 5%                                                 | 9%                         |
| France        | 6%                                        | 7%         | 9%                                                 | 4%                         |
| PRC           | 4%                                        | 5%         | 3%                                                 | 3%                         |
| Netherlands   | 3%                                        | 4%         | 2%                                                 | 3%                         |
| UK            | 3%                                        | 3%         | 2%                                                 | 2%                         |
| Switzerland   | 2%                                        | 2%         | 1%                                                 | 2%                         |
| Canada        | 2%                                        | 2%         | 2%                                                 | 1%                         |

**Figure 4:** Revealed Technology Advantages in Hydrogen Technologies by Value Chain Segments (2011-2020)<sup>276</sup>

While Japan has established a comprehensive national hydrogen framework, criticisms have been levied against its effectiveness and focus. For example, the Renewable Energy Institute highlighted the prioritization of fossil-fuel-based gray or blue hydrogen over green hydrogen in the initial strategy. Until at least 2030, the government's strategy sees gray hydrogen as the main supply source. This points to a need for clearer policy direction and support specifically for green hydrogen. The Renewable Energy Institute also points out that a majority of Japan's budget is spent on low-priority applications for hydrogen.<sup>277</sup>

One last challenge to sectoral growth that needs to be mentioned is infrastructure development. The development of hydrogen infrastructure, including pipelines, storage, and refueling stations, is in its nascent stages in Japan. The lack of a robust hydrogen infrastructure network presents

<sup>276</sup> Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute.

<https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>

<sup>277</sup> Renewable Energy Institute. (2022). *Re-examining Japan's Hydrogen Strategy*.

[https://www.renewable-ei.org/pdfdownload/activities/REI\\_JapanHydrogenStrategy\\_EN\\_202209.pdf](https://www.renewable-ei.org/pdfdownload/activities/REI_JapanHydrogenStrategy_EN_202209.pdf)



logistical challenges in distributing hydrogen across the country, especially considering Japan's geographical layout and the concentration of industrial activities in certain regions.<sup>278</sup>

### *Recommendations*

To conclude, we would advise the ITA to closely monitor and consider Japan for future exports. Besides the barriers discussed in this chapter a lot of advantages remain. However, we would advise to closely monitor which technological pathway Japan will choose as they currently try to keep their technology options open and invest in a portfolio of different carriers.<sup>279</sup>

## Main Competitors for U.S. Exports

Under its national decarbonization strategy, Japan has the ambition to scale hydrogen production across the industries by 2030 and 2050. “In addition to the current target of expanding consumption of hydrogen to around 3 million tons per year by 2030 and about 20 million tons per year by 2050, the strategy sets forth a new target of about 12 million tons per year (including ammonia) for 2040.”<sup>280</sup> Given the resource constraint Japan faces in securing cost competitive renewable energy, Japan is planning to secure green hydrogen import supply from overseas countries. These countries, especially Malaysia, Indonesia, and Australia, may appear as a competitor for the United States in exporting green hydrogen.

**Southeast Asia.** In Southeast Asia, approximately 3 million metric tons of hydrogen are produced, accounting for about 3 percent of the global hydrogen production. The primary source of this hydrogen is natural gas, as the largest hydrogen producers in the region, including Indonesia and Malaysia, are also significant gas producers. Since 2020, roughly half of the publicly announced projects or agreements in the region have been initiated by Japan.<sup>281</sup> The majority of initiatives in Southeast Asia are currently in the preliminary stages, involving the signing of memoranda of understanding and conducting feasibility studies. As Japan intends to

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<sup>278</sup> Coca, N. (2023, April 6). *Hydrogen in Japan: 5 years after its first plan, goals remain distant*. Energy Monitor. <https://www.energymonitor.ai/tech/hydrogen/a-half-decade-after-its-first-plan-japans-hydrogen-goals-remain-distant/?cf-view>

<sup>279</sup> Japan's hydrogen industrial strategy. (n.d.). CSIS | Center for Strategic and International Studies. <https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>

<sup>280</sup> *Overview of Basic Hydrogen Strategy*. (2023, June). Agency for Natural Resources and Energy. [https://www.meti.go.jp/shingikai/enecho/shoene\\_shinene/suiso\\_seisaku/pdf/20230606\\_4.pdf](https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_4.pdf)

<sup>281</sup> *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia*. Center on Global Energy Policy at Columbia SIPA. (2023, August). <https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>

import hydrogen, Japanese companies are exploring different methods to transport hydrogen or its derivatives across long distances. These methods include using ammonia, liquid organic hydrogen carriers, liquid hydrogen, or e-methane. Key foreign countries who are active in production of green hydrogen in Southeast Asia include below. They collaborate with Japanese companies to conduct feasibility studies and explore possibilities of green hydrogen in the region and export to Japan.

- **Petronas (Malaysia).** The Japanese petroleum company ENEOS, in collaboration with Malaysia's Petronas, aims to make a final investment decision in 2023 regarding the initial commercial-scale renewable hydrogen-to-MCH (methylcyclohexane) project. This project intends to supply hydrogen to ENEOS' refineries.<sup>282</sup>
- **Panca Amara Utama (Indonesia).** Japanese companies have entered into agreements with Panca Amara Utama, an Indonesian petrochemical company, and Petronas, a Malaysian company, to jointly develop low-carbon ammonia and hydrogen production facilities in Indonesia and Malaysia. These agreements aim to explore the feasibility of ammonia and hydrogen production in each country, with the possibility of exporting these products to Japan in the future.<sup>283</sup>

**Australia.** Australia and Japan are strengthening their longstanding energy partnership in clean energy. They have initiated a project involving the shipment of liquid hydrogen, which aims to boost Australia's hydrogen export industry and create opportunities for Australian businesses engaged in hydrogen supply chain projects. During the Leaders' Meeting, Prime Minister Kishida expressed appreciation for Prime Minister Morrison's proposal to establish the Australian Clean Hydrogen Trade Program, which will receive a funding of \$150 million. The program's initial phase will prioritize supporting Australian hydrogen supply chain projects that attract foreign investments, with a specific focus on exporting clean hydrogen to Japan as part of the Japan-Australia Partnership on Decarbonisation through Technology.<sup>284</sup> Key project development cases between Australia and Japan include:

- **AGL Energy (Australia).** In January 2022, the Hydrogen Energy Supply Chain (HESC) pilot project, valued at \$500 million, produced hydrogen from brown coal in Victoria's LaTrobe Valley. The hydrogen was then transported to Japan via a specially designed

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<sup>282</sup> *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia*. Center on Global Energy Policy at Columbia SIPA. (2023, August).

<https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>.

<sup>283</sup> *Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia*. Center on Global Energy Policy at Columbia SIPA. (2023, August).

<https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>.

<sup>284</sup> *Clean hydrogen collaboration with Japan*. Australian Government. Department of Foreign Affairs and Trade. (2022 February).

<https://www.dfat.gov.au/about-us/publications/trade-investment/business-envoy/business-envoy-february-2022/clean-hydrogen-collaboration-japan>.

vessel and utilized in coal-fired power plants. The project is a collaborative effort led by a consortium comprising Japanese companies J-Power and Kawasaki Heavy Industries, as well as Shell and AGL from Australia.<sup>285</sup>

- **Stanwell (Australia).** The Aldoga industrial development zone in Central Queensland, Australia, has been selected as the location for a 3-gigawatt electrolyser plant dedicated to renewable hydrogen production, as announced by the state government. The project is a joint venture between government-owned generator Stanwell and Japanese industrial company Iwatani Corporation. They have secured 236 hectares (583 acres) of land for the facility, which aims to export significant volumes of green hydrogen worldwide by the early 2030s.<sup>286</sup>

**EU.** The EU and Japan have strengthened their hydrogen collaboration through a Memorandum of Cooperation, which aims to drive innovation and combine the two global hydrogen markets. Signed by EU Commissioner for Energy Kadri Simson and Japan's Minister of Economy, Trade, and Industry, Yasutoshi Nishimura, the agreement focuses on promoting the development, trade, and use of sustainable hydrogen technologies. This initiative is a key component of the EU-Japan Green Alliance, focusing on the commitment to climate neutrality by 2050 and the clean energy transition. The partnership will include policy alignment, knowledge exchange on hydrogen research and applications, support for project development, and educational initiatives to facilitate a transition to renewable and low-carbon hydrogen solutions.<sup>287</sup>

In terms of recommendations for the United States to tap into the green hydrogen space targeted at the Japanese market, the United States may consider exploring partnership opportunities with Japanese conglomerates, energy companies, and governments to collaborate on green hydrogen projects, including investing in US green hydrogen development. In addition, the United States can explore the possibility of participating in green hydrogen development in the APAC region through technology transfer and knowledge exchange via workshops and initiatives to share best practices and advancements in green hydrogen production targeted at the Japanese market. Furthermore, the United States may consider supporting infrastructure development in Southeast Asia and Australia, including investments in port facilities, storage infrastructure, and transportation networks for hydrogen.

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<sup>285</sup> 'Just a new fossil fuel industry': Australia to send first shipment of liquefied hydrogen to Japan. The Guardian. (2022. January).

<https://www.theguardian.com/australia-news/2022/jan/21/just-a-new-fossil-fuel-industry-australia-to-send-first-shipment-of-liquefied-hydrogen-to-japan>.

<sup>286</sup> Stanwell, Iwatani pick site for 3-GW green hydrogen facility in Queensland. Renewables Now. (2021. June).

<sup>287</sup> European Commission. (2022). EU and Japan step up cooperation on hydrogen. Retrieved from [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_22\\_7322](https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7322)

## Public Education

### *Introduction*

In 2017, Japan was the first country in the world that created a national hydrogen strategy, adopting a Basic Hydrogen Strategy, with the goal of becoming the trailblazer of hydrogen use in the world.<sup>288</sup> In 2020, Japan created a Green Growth Strategy, with hydrogen being one of the core priorities of this strategy.<sup>289</sup> Japan, driven by international competition, has invested funds in research and development of a societal adaptation of a green hydrogen transition.<sup>290</sup> Yet, in order to meet Japan's high ambitions to be a leader in green hydrogen energy, a shift in public education and perception of green hydrogen energy needs to occur. This section highlights setbacks in Japan's current education and public perception of green hydrogen, along with recommendations on how the U.S. Department of Commerce can improve this.

### *Findings*

Shifting public perceptions of green hydrogen will be essential in the transition towards a green hydrogen economy in Japan. According to a Japanese national survey from 2023, when Japanese respondents were asked whether or not they preferred grey hydrogen (which was cheaper, but yielded higher emissions) or green hydrogen (which was more costly, yet yielded lower emissions), 55% indicated that they preferred grey hydrogen, while 45% indicated a preference for green hydrogen.<sup>291</sup> This illustrates how to the general Japanese public, environmental concerns are not enough to incentivize a public preference towards green hydrogen energy.

Japan is taking steps to educate its workforce about green hydrogen. In 2022, Japan and the European Union signed a Memorandum of Cooperation to signify a partnership to work together to further production of green hydrogen, including key elements in vocational training and education that institutions from both countries could strengthen through this agreement.<sup>292</sup> The

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<sup>288</sup> Japan's Hydrogen Industrial Strategy. (2021, October). Center for Strategic & International Studies. Retrieved from <https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>.

<sup>289</sup> Japan's vision and actions toward hydrogen-based economy. (n.d.). Ministry of Economy, Trade and Industry. Retrieved from

[https://iea.blob.core.windows.net/assets/dc5e783e-c4b4-4878-9534-48e8a6472c98/20211124-IEA-EGRD\\_HYoshida.pdf](https://iea.blob.core.windows.net/assets/dc5e783e-c4b4-4878-9534-48e8a6472c98/20211124-IEA-EGRD_HYoshida.pdf).

<sup>290</sup> *ibid*

<sup>291</sup> Evaluating the attitudes of Japanese society towards the hydrogen economy: A comparative study of recent and past community surveys. (2024, February). International Journal of Hydrogen Energy. Retrieved from <https://www.sciencedirect.com/science/article/pii/S036031992302493X>.

<sup>292</sup> EU and Japan step up cooperation on hydrogen. (2022, December). European Commission. Retrieved from [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_22\\_7322](https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7322).

Ministry of the Environment of the Government of Japan has produced public education materials on green hydrogen, creating videos, articles, brochures, and other curriculum available to the public on their website.<sup>293</sup> They also have content on their website training the public on governmental projects around green hydrogen.<sup>294</sup> The Government of Japan also created a training for government officials on how supply chains of hydrogen energy can be sourced from renewable energy.<sup>295</sup>

It is evident that Japan is taking steps to strengthen public understanding of green hydrogen through its various educational materials, partnerships, and trainings. Yet, there is a need for it to strengthen public perception of green hydrogen, and an opportunity for Japan to further train its workforce for a green hydrogen economy. Education of public perception, workforce knowledge, and academia settings will help Japan further its interests in pioneering a green hydrogen economy.

### *Recommendations*

1. Build a cooperative partnership between the U.S. and Japan, similar to the Memorandum of Cooperation between Japan and the EU, where institutions of both countries collaborate to build education programs (academic and vocational) on green hydrogen.
2. Encourage Japan to create a public education campaign on the benefits of green hydrogen energy production compared to gray hydrogen energy production to shift public perceptions of it. Encourage Japan to educate the public beyond just posting educational material on their website, such media partnerships with news outlets
3. Encourage and assist Japan in amending its academic curriculums to educate the public about the importance of renewable energy throughout all levels of education, from preschool up to advanced college degrees.
4. Encourage Japan to build private-public partnerships in vocational training, where Japan's Ministry of Environment works with companies involved in the supply chain of green hydrogen energy production to educate the workforce on various skills in renewable energy and low-carbon production processes

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<sup>293</sup> Low-carbon: What is a Hydrogen Supply Chain? (n.d.). Ministry of the Environment Government of Japan. Retrieved from [https://www.env.go.jp/seisaku/list/ondanka\\_saisei/lowcarbon-h2-sc/en/index.html](https://www.env.go.jp/seisaku/list/ondanka_saisei/lowcarbon-h2-sc/en/index.html).

<sup>294</sup> Low-carbon: What is a Hydrogen Supply Chain? (n.d.). Ministry of the Environment Government of Japan. Retrieved from [https://www.env.go.jp/seisaku/list/ondanka\\_saisei/lowcarbon-h2-sc/en/index.html](https://www.env.go.jp/seisaku/list/ondanka_saisei/lowcarbon-h2-sc/en/index.html).

<sup>295</sup> Knowledge Co-Creation Program. (2022). JICA. Retrieved from [https://www.jica.go.jp/Resource/brazil/portuguese/office/courses/dbil86000000rs8a-att/GI\\_202107927J001\\_.pdf](https://www.jica.go.jp/Resource/brazil/portuguese/office/courses/dbil86000000rs8a-att/GI_202107927J001_.pdf).

## Conclusion

The detailed analysis provided in this memo emphasizes Japan's dynamic progression within the green hydrogen sector, showcasing its aspirations to become a leading force in hydrogen technology globally. Japan's strategic investments, policy frameworks, and international partnerships serve as the groundwork for transitioning towards a hydrogen-based economy and achieving carbon neutrality by 2050. Nevertheless, this journey is fraught with challenges such as technological advancements, cost reductions, infrastructure development, and public awareness, necessitating collaborative efforts across public and private sectors both domestically and internationally, including with allies like the United States.

For the United States, the potential for collaboration with Japan in green hydrogen is vast. By focusing on aligning standards, fostering government and private sector partnerships, and addressing technical and financial barriers, the U.S. can play a pivotal role in Japan's hydrogen economy. Additionally, jointly enhancing public education and perception of green hydrogen can expedite its adoption in Japan, benefiting both nations in their decarbonization efforts.

Ultimately, this memo outlines a roadmap for intensified collaboration between the U.S. and Japan in advancing the global hydrogen economy, acknowledging the significance of innovation, policy coherence, and stakeholder engagement in overcoming forthcoming challenges. As Japan progresses towards a sustainable, hydrogen-driven future, and multiple indications that Japan **may is an optimal candidate** currently for a green hydrogen export PPP initiative, the potential for U.S. involvement presents a strategic opportunity to contribute to and benefit from Japan's green hydrogen evolution, reinforcing shared objectives of energy security, environmental sustainability, and economic growth.

Below is a summary of our key recommendations for ensuring the success of an Japan-targeted green hydrogen PPP initiative:

- Facilitate partnerships between U.S. and Japanese companies in the hydrogen sector to expedite market entry
- Provide competitive financing options and insurance for U.S. hydrogen technology exports to Japan
- Initiate bilateral discussions on technical standards for hydrogen technologies between the U.S. and Japan
- Strengthen governmental collaborations through MOUs focusing on joint research and development endeavors

- Actively showcase U.S. hydrogen technologies in Japan through participation in trade shows and expos
- Engage in ongoing policy dialogue with Japanese counterparts to address regulatory barriers for U.S. exporters
- Advocate for U.S. company involvement in Japan-funded hydrogen projects and promote U.S. technologies
- Equip U.S. exporters with updated market intelligence on Japan's hydrogen industry
- Explore collaborative opportunities with Japanese entities and invest in U.S. green hydrogen initiatives
- Foster cooperative educational and public awareness efforts on green hydrogen between the U.S. and Japan

## Bibliography

1. Akimoto, D. (2023, July 7). *A look at Japan's latest hydrogen strategy*. (2023, July 7). The Diplomat – Asia-Pacific Current Affairs Magazine. <https://thediplomat.com/2023/07/a-look-at-japans-latest-hydrogen-strategy/>
2. Bocobza, J., & Tanabe, M. (2023, June 26). *Japan Hydrogen Basic Strategy*. White & Case LLP. <https://www.whitecase.com/insight-alert/japan-hydrogen-basic-strategy>
3. Clean hydrogen collaboration with Japan. Australian Government. Department of Foreign Affairs and Trade. (2022 February). <https://www.dfat.gov.au/about-us/publications/trade-investment/business-envoy/business-envoy-february-2022/clean-hydrogen-collaboration-japan>.
4. Coca, N. (2023, April 6). *Hydrogen in Japan: 5 years after its first plan, goals remain distant*. Energy Monitor. <https://www.energymonitor.ai/tech/hydrogen/a-half-decade-after-its-first-plan-japans-hydrogen-goals-remain-distant/?cf-view>
5. Dina Azhgaliyeva, KE Seetha Ram, and Haoran Zhang. (2023). *Hydrogen in Decarbonization Strategies in Asia and the Pacific*. Asian Development Bank Institute. <https://www.adb.org/sites/default/files/publication/914281/hydrogen-decarbonization-strategies-asia-and-pacific.pdf>
6. Evaluating the attitudes of Japanese society towards the hydrogen economy: A comparative study of recent and past community surveys. (2024, February). International Journal of Hydrogen Energy. Retrieved from <https://www.sciencedirect.com/science/article/pii/S036031992302493X>.
7. EU and Japan step up cooperation on hydrogen. (2022, December). European Commission. Retrieved from [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_22\\_7322](https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7322).
8. European Commission. (2022). EU and Japan step up cooperation on hydrogen. Retrieved from [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_22\\_7322](https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7322)
9. Expert Interview, March 20, 2024, Natalie Janzow, RMI.
10. InfluenceMap. (n.d.). GX (Green transformation) basic policy and roadmap. Retrieved from <https://japan.influencemap.org/policy/GX-Green-Transformation-5477>



11. *Japan's bet on hydrogen is still unwavering despite decades of lackluster progress.* (n.d.). IEEFA | Institute for Energy Economics and Financial Analysis.  
<https://ieefa.org/resources/japans-bet-hydrogen-still-unwavering-despite-decades-lackluster-progress>
12. Japan's Hydrogen Industrial Strategy. (2021, October). Center for Strategic & International Studies. Retrieved from  
<https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>.
13. Japan's Investments in Hydrogen and Its Derivatives in Southeast Asia. Center on Global Energy Policy at Columbia SIPA. (2023, August).  
<https://www.energypolicy.columbia.edu/japans-investments-in-hydrogen-and-its-derivatives-in-southeast-asia/>.
14. *Japan's transition toward a renewable energy future.* (2022, September 30). The National Bureau of Asian Research (NBR).  
<https://www.nbr.org/publication/japans-transition-toward-a-renewable-energy-future/>
15. Japan's vision and actions toward hydrogen-based economy. (n.d.). Ministry of Economy, Trade and Industry. Retrieved from  
[https://iea.blob.core.windows.net/assets/dc5e783e-c4b4-4878-9534-48e8a6472c98/20211124-IEA-EGRD\\_HYoshida.pdf](https://iea.blob.core.windows.net/assets/dc5e783e-c4b4-4878-9534-48e8a6472c98/20211124-IEA-EGRD_HYoshida.pdf).
16. 'Just a new fossil fuel industry': Australia to send first shipment of liquefied hydrogen to Japan. The Guardian. (2022, January).  
<https://www.theguardian.com/australia-news/2022/jan/21/just-a-new-fossil-fuel-industry-australia-to-send-first-shipment-of-liquefied-hydrogen-to-japan>.
17. Kahla, C. (2024a, March 5). *Fueling the future: Japan's \$20 billion clean hydrogen strategy*. Locate2u.  
<https://www.locate2u.com/technology/japan-investment-clean-hydrogen-strategy/#:~:text=Hydrogen%3A%20Subsidizing%20the%20future&text=The%20funds%20will%20increase%20the,as%20reported%20by%20Kr%2DAsia>.
18. Knowledge Co-Creation Program. (2022). JICA. Retrieved from  
[https://www.jica.go.jp/Resource/brazil/portuguese/office/courses/dbil86000000rs8a-att/GI\\_202107927J001\\_.pdf](https://www.jica.go.jp/Resource/brazil/portuguese/office/courses/dbil86000000rs8a-att/GI_202107927J001_.pdf).
19. Low-carbon: What is a Hydrogen Supply Chain? (n.d.). Ministry of the Environment Government of Japan. Retrieved from  
[https://www.env.go.jp/seisaku/list/ondanka\\_saisei/lowcarbon-h2-sc/en/index.html](https://www.env.go.jp/seisaku/list/ondanka_saisei/lowcarbon-h2-sc/en/index.html).

20. METI. (2022, October 17). Green growth strategy through achieving carbon neutrality in 2050 /
21. METI ministry of economy, trade and industry. Retrieved from [https://www.meti.go.jp/english/policy/energy\\_environment/global\\_warming/ggs2050/index.html](https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/index.html)
22. Nakano, J. (2021, October 21). *Japan's Hydrogen Industrial Strategy*. CSIS. <https://www.csis.org/analysis/japans-hydrogen-industrial-strategy>
23. NEDO. (n.d.). Overview of the green innovation fund projects. Retrieved from <https://green-innovation.nedo.go.jp/en/about/>
24. New Zealand Ministry of Foreign Affairs and Trade. (2023, November). Japan: Hydrogen strategy - November 2023. Retrieved from <https://www.mfat.govt.nz/en/trade/mfat-market-reports/japan-hydrogen-strategy-november-2023/>
25. Niunoya, M., Shima, M., & Masaki, K. (2021, November 24). *Hydrogen law and regulation in Japan: CMS expert guides*. Hydrogen law and regulation in Japan | CMS Expert Guides. <https://cms.law/en/int/expert-guides/cms-expert-guide-to-hydrogen/japan>
26. Overview of Basic Hydrogen Strategy. (2023, June). Agency for Natural Resources and Energy. [https://www.meti.go.jp/shingikai/enecho/shoene\\_shinene/suiso\\_seisaku/pdf/20230606\\_4.pdf](https://www.meti.go.jp/shingikai/enecho/shoene_shinene/suiso_seisaku/pdf/20230606_4.pdf).
27. Renewable Energy Institute. (2022). *Re-examining Japan's Hydrogen Strategy*. [https://www.renewable-ei.org/pdfdownload/activities/REI\\_JapanHydrogenStrategy\\_EN\\_202209.pdf](https://www.renewable-ei.org/pdfdownload/activities/REI_JapanHydrogenStrategy_EN_202209.pdf)
28. Renewable Energy Institute. (2023, June 29). Revised basic hydrogen strategy offers no clear path to carbon Neutrality | Position paper | Renewable energy institute. Retrieved from <https://www.renewable-ei.org/en/activities/reports/20230720.php>
29. Stanwell, Iwatani pick site for 3-GW green hydrogen facility in Queensland. Renewables Now. (2021. June).

30. The Government of Japan. (2021, September 16). Japan's green growth strategy will accelerate innovation. Retrieved from [https://www.japan.go.jp/kizuna/2021/09/green\\_growth\\_strategy.html](https://www.japan.go.jp/kizuna/2021/09/green_growth_strategy.html)

## Appendix A - Stakeholder Table U.S.

|                   | Stakeholder                                      | Stakeholder Description                                                                                                                                                                                                                                                       | Level of Support | Reason for Resistance or Support                                                                                                                                                                                                                                                                                                              |
|-------------------|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Government</b> | U.S. Department of Energy (DOE)                  | Oversees national energy policy and energy production                                                                                                                                                                                                                         | Support          | DOE is leading many federal initiatives: Energy Earthshots Initiative: Hydrogen Shot, Regional Clean Hydrogen Hubs: Hydrogen Hub Matchmaker, Clean Hydrogen Electrolysis Program, Clean Hydrogen Manufacturing and Recycling RD&D Activities that will enable / enhance U.S. competitiveness t also has several offices dedicated to hydrogen |
|                   | International Trade Administration (ITA)         | An agency within the U.S. Department of Commerce focused on export development and competitiveness                                                                                                                                                                            | Support          | /                                                                                                                                                                                                                                                                                                                                             |
|                   | DOE National Energy Technology Laboratory (NETL) | Under the DOE Office of Fossil Energy, focuses on applied research for the clean production and use of domestic energy resources. R&D on the supply, efficiency, and environmental constraints of producing and using fossil energy resources while maintaining affordability | Support          | This program complements NETL's mission                                                                                                                                                                                                                                                                                                       |
|                   | DOE Loan Programs Office (LPO)                   | ~ \$300 billion in loan authority to finance projects that support clean energy deployment and energy infrastructure reinvestment to reduce emissions.                                                                                                                        | Support          | This program could benefit from LPO's support which could advance its remit                                                                                                                                                                                                                                                                   |

|                 |                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                   |                                                                           |
|-----------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------|
|                 | DOE Hydrogen and Fuel Cell Technologies Office (HFTO)      | Conducts comprehensive efforts to overcome the technological, economic, and institutional barriers to the development of hydrogen and fuel cells.                                                                                                                                                                                                                                                                                                                                                                                              | Support           | This program complements HTFO's mandate                                   |
|                 | Hydrogen Interagency Task Force (HIT)                      | A collaboration among U.S. federal agencies to advance a whole-of-government approach to executing the national clean hydrogen strategy, including development of a robust market supported by domestic supply chains and sustainable jobs. The Departments of Agriculture, Commerce, Defense, Interior, Labor, Transportation, Treasury, State as well as the Environmental Protection Agency, National Aeronautics and Space Administration, Small Business Administration, and U.S. Special Presidential Envoy for Climate are represented. | Support           | With a whole government approach HIT would likely support ITA's program   |
| <b>Academia</b> | Hydrogen Initiative, Stanford University                   | A collaboration of researchers , industry leaders & governments to enable the use of hydrogen to achieve deep decarbonization. It focuses on the hydrogen value chain of hydrogen generation, transportation, storage, applications and the policies that govern hydrogen markets.                                                                                                                                                                                                                                                             | Support           | Hydrogen Initiative would support this program which advances its mission |
|                 | Center on Global Energy Policy (CGEP), Columbia University | Fosters dialogue on energy and climate problems and solutions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Support / Neutral | CGEP would likely support efforts to decarbonise with green hydrogen.     |

|                       |                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                    |
|-----------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------|
| <b>Private Sector</b> | Linde PLC                        | A global multinational chemical company. It's the world's largest industrial gas company by market share and revenue. Globally, Linde has more than 500 hydrogen production plants. Through its ITM Linde Electrolys is joint venture, Linde has become one of the world's leading suppliers of green hydrogen produced using proton exchange membrane electrolyzer technologies. Market cap 2023: \$226.42 billion.                          | Support | This program would support its business expansion within Chile and Japan           |
|                       | Air Products and Chemicals (APC) | APC sells industrial gases and chemicals and provides related equipment and expertise. APC operates more than 100 hydrogen plants and maintains the world's largest hydrogen distribution network. Air Products has an extensive hydrogen-dispensing technology patent portfolio and has been involved in more than 250 hydrogen-fueling projects worldwide. Market cap: US\$55.1 billion.                                                    | Support | This program would support its business expansion within the green hydrogen sector |
|                       | Cummins                          | Cummins designs, manufactures and distributes engines, filtration and power-generation products with a specialization in diesel and alternative fuel engines and generators. Their brand Accelera, features "a diverse portfolio of zero-emissions solutions, includ(ing) battery systems, fuel cells, ePowertrain systems and electrolyzers." Accelera started electrolyzer production in Minnesota, US.. The company is set to showcase its | Support | This program would support its business expansion within the green hydrogen sector |

|  |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                            |
|--|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                 | next generation hydrogen engine in mid 2024.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |         |                                                                                                                                                                                                            |
|  | AES Corporation | <p>An independent power producer that stands to supply the renewable power needed to run electrolysis for green-hydrogen production.</p> <p>AES previously stated it would build a \$4 billion renewables-powered hydrogen facility with Air Products by 2027, turning 1.4 GW of renewable generation into 200 metric tons per day of green hydrogen, far bigger than anything like it in the U.S. today, and a step toward the DOE's goal of producing 10 million metric tons of clean hydrogen annually by 2030.</p> | Support | AES Corporation is a beneficiary of the DOE's Regional Clean Hydrogen Hubs                                                                                                                                 |
|  | Air Liquide     | A French multinational company and the second-largest supplier of industrial gases by revenues globally.                                                                                                                                                                                                                                                                                                                                                                                                               | Support | Air Liquide is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Amazon          | <p>Amazon invested early in hydrogen to power forklifts at its warehouses. As of 2022, Amazon was running 15,000 forklifts at 70 fulfillment centers on green hydrogen with help from partner Plug Power, while scoping out the fuel for decarbonizing its delivery fleet. California and the Pacific Northwest hubs aim to remake the West Coast heavy-duty trucking network in a cleaner,</p>                                                                                                                        | Support | Amazon is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector      |

|  |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |                                                                                                                                                                                                |
|--|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |              | hydrogen-powered image. Amazon has explicitly said it is testing hydrogen trucks for shipping and fuel cells for powering its buildings, and it wants to use its bulk purchasing power to expand the market for cleanly produced hydrogen.                                                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                |
|  | Bloom Energy | This long-running and perennially unprofitable cleantech player has sold solid-oxide fuel cells to give customers 24/7 onsite power production without any combustion. Those fuel cells historically have run on fossil gas, but more recently Bloom has played up its hydrogen competency so its purported climate solutions don't depend on a steady supply of fossil fuels. It recently tested its high-temperature solid-oxide electrolyzer at government research centers, and it claims it produces hydrogen more efficiently than other leading electrolyzer technologies. | Support | As a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|  | Chevron      | Chevron makes 1 million metric tons of hydrogen the gas per year from fossil fuels, much of which is used to refine oil. Clean hydrogen wise Chevron owns a majority stake in the electrolysis and storage venture in Delta, Utah known as ACES; it also is working on Gulf Coast hydrogen production with Air Liquide and other partners.                                                                                                                                                                                                                                        | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector    |
|  | ExxonMobil   | Exxon's base of infrastructure in the Gulf and know-how for making and selling liquid fuels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Support | A beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested                                                                                                         |



|  |                           |                                                                                                                                                                                                                                                                                                                                                                                                    |         |                                                                                                                                                                                                                                |
|--|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                           | <p>may give it an edge in the emerging clean-hydrogen economy. Piping gases around and flushing them underground is one of Exxon's strong suits. If the existing carbon pipelines around Houston can't support competitive blue-hydrogen production, it's hard to imagine anywhere else that could.</p>                                                                                            |         | <p>and aware of this program that would support its business expansion within the green hydrogen sector</p>                                                                                                                    |
|  | Holtec                    | <p>Holtec is participating in two of the hubs that will tap existing nuclear fleets to supply carbon-free power for electrolysis. The 24/7 industrial demand for hydrogen production would make for welcome commercial demand at legacy nuclear plants that have struggled to keep their doors open.</p>                                                                                           | Support | <p>Holtec is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>                   |
|  | Mitsubishi Power Americas | <p>Mitsubishi got in early on green hydrogen and is working on the fully integrated hydrogen project in Delta, Utah, which will combine production, underground storage and use for power and other needs. That experience, plus a big balance sheet and a trusted brand in heavy power equipment, made Mitsubishi Power a sought-after partner for the Gulf Coast and Pacific Northwest hubs.</p> | Support | <p>Mitsubishi Power America Is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p> |
|  | Plug Power                | <p>Plug Power started off making fuel cells but hit its commercial stride by selling thousands of fuel-cell forklifts to Amazon. Now it is building its own green-hydrogen production with electrolyzer technology.</p>                                                                                                                                                                            | Support | <p>Plug Power is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector</p>               |

|                      |                                                   |                                                                                                                                                                                                                                                                                                                                                                                               |         |                                                                                                                                                                                                          |
|----------------------|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                      | TC Energy                                         | TC Energy is developing 10 blue and green hydrogen hubs across North America.                                                                                                                                                                                                                                                                                                                 | Support | TC Energy is a beneficiary of the DOE's Regional Clean Hydrogen Hubs and would likely be interested and aware of this program that would support its business expansion within the green hydrogen sector |
|                      | CF Industries                                     | A U.S. Manufacturer and distributor of agricultural fertilizers, including ammonia, urea, and ammonium nitrate products, based in Deerfield, Illinois. CF Industries is constructing North America's first commercial-scale green ammonia production capability at its Donaldsonville Complex in Louisiana.<br><br>Green ammonia is ammonia produced using hydrogen from carbon-free sources. | Support | This program would support its business expansion within the green hydrogen sector                                                                                                                       |
|                      | Hydrogen Forward                                  | Hydrogen Forward is a coalition of companies and organizations across the hydrogen value chain that are working to ensure hydrogen is a key contributing solution in the energy transition.                                                                                                                                                                                                   | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |
|                      | Fuel Cell and Hydrogen Energy Association (FCHEA) | The FCHEA is the leading industry association in the U.S. representing more than 100 leading organizations advancing production, distribution, and use of innovative, clean, safe, and reliable hydrogen energy.                                                                                                                                                                              | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |
| <b>Civil Society</b> | Green Hydrogen Coalition (GHC)                    | The GHC is an educational non-profit. It focuses on building top-down momentum for scalable green hydrogen projects that leverage multi-sector opportunities to simultaneously scale supply and                                                                                                                                                                                               | Support | This program would support its business expansion of its members within the green hydrogen sector                                                                                                        |

|  |                                          |                                                                                                                                                                                                                                                                                |                     |                                                                                                                                                |
|--|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|  |                                          | demand.                                                                                                                                                                                                                                                                        |                     |                                                                                                                                                |
|  | Clean Air Task Force (CATF)              | CATF is a non-profit that aims to build momentum for solutions based on scientific evidence, and intellectual integrity, and pragmatism. Its mission is to push the technology and policy changes needed to achieve a zero-emissions, high-energy planet at an affordable cost | Support             | This program aligns with CATF's mission                                                                                                        |
|  | Natural Resources Defense Council (NRDC) | The NRDC is a U.S. non-profit international environmental advocacy group.                                                                                                                                                                                                      | Support conditional | While this program aligns with CATF's mission, NRDC may be aware and supportive of grass root resistance in Chile, Indonesia and other markets |
|  | Rocky Mountain Institute (RMI)           | RMI is an independent, non-partisan, nonprofit that aims to transform global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all.                                                           | Support             | This program aligns with RMI's mission                                                                                                         |
|  | Bipartisan Policy Center (BPC)           | The BPC is a not-for-profit organization that ensures policymakers work across party lines to craft bipartisan solutions                                                                                                                                                       | Support             | This program aligns with PBC's mission                                                                                                         |
|  | GTI Energy                               | GTI is a non-profit “focused on developing, scaling, and deploying energy transition solutions that improve lives, economies, and the environment.                                                                                                                             | Support             | As an administer for Multiple regional clean Hydrogen Hubs GTI would be well placed to benefit and support this program                        |

## Appendix B - Stakeholder Table Japan

|                                         | Stakeholder                                    | Stakeholder Description                                                                                                                                                                                                                                                                                          | Level of Support<br><br><i>Would the stakeholder likely support or resist this program?</i> | Reason for Resistance or Support<br><br><i>Why would the stakeholder resist or support?</i>                                                                                                                                                                                                                                                                               |
|-----------------------------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>International / Regional Entity:</b> | Hydrogen Council                               | This is an international initiative led by CEOs that brings together companies to connect the hydrogen supply chain and accelerate the clean energy transition. The council conducts global research to further partnerships between civil society groups, government entities, private entities, and investors. | Support                                                                                     | The stakeholder is likely to support this initiative, because a core goal of the council is to support global efforts that foster collaborations between the public and private sectors for accelerating the clean energy transition.                                                                                                                                     |
|                                         | ASEAN                                          | Known as the Association of Southeast Asian nations, ASEAN comprises ten Southeast Asian nations, namely Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam, functioning as an intergovernmental organization.                                              | Support                                                                                     | For over 30 years, Japan and ASEAN have worked together to promote peace, stability, and development in the region. Their close economic ties underscore the importance of ASEAN's role as a hub for regional cooperation. Japan fully supports ASEAN's efforts to enhance connectivity, recognizing its vital contribution to the stability and prosperity of East Asia. |
| <b>Government</b>                       | Ministry of Economy, Trade and Industry (METI) | METI drives Japan's economic policy, including energy and industry sectors, shaping policies for hydrogen adoption                                                                                                                                                                                               | Support                                                                                     | The PPP initiative aligns with METI's strategy of promoting GH supply chain and economic development. have shown greater                                                                                                                                                                                                                                                  |

|  |                                                                                                   |                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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|  |                                                                                                   | and facilitating public-private partnerships for green innovation and industrial development.                                                                                                                                          |         | interest in regional partnerships but also keen of intl ones. emphasizes and invests in these types of partnerships as means to accelerate RE transition. might resist given the substantial investment in infrastructure, uncertainties that give greater risks to the supply chains, dependency on external resources of GH                                                                                                        |
|  | Ministry of the Environment, New Energy and Industrial Technology Development Organization (NEDO) | NEDO spearheads R&D and technology deployment for renewable energy and hydrogen, fostering innovation and supporting Japan's transition to a sustainable, low-carbon society.                                                          | Support | This initiative is aligned with METI's strategy and their environmental goals. If the partnership is curated to advance these goals, METI will support. It is also aligned with their mission to be global leaders and drive innovation. might resist as they're focused on domestic projects, and have some environmental concerns (doesn't adhere to the highest standards, but also don't necessarily go against METI and resist) |
|  | Green Innovation Fund (GIF)                                                                       | The GIF d invests in innovative projects, including hydrogen technologies, accelerating Japan's green transition and fostering sustainable economic growth through impactful clean energy initiatives.                                 | Support | literally designed to advance the development and deployment of GH, interested in opening new markets- benefits them financially and environmentally. if projects/partnerships don't meet their criteria for investment return they won't play ball. must show scalability potential and a secure supply chain                                                                                                                       |
|  | Japan Bank for International Cooperation (JBIC)                                                   | JBIC's role is to contribute to the sound development of Japan and the international economy and society, by taking responsibility for the financial function in promoting overseas development and securing of important resources to | Support | JBIC aims to increase the competitiveness of Japan in the sector and make Japan a global leader. If economic growth is shown through the PPP initiative, JBIC will be supportive.                                                                                                                                                                                                                                                    |

|                       |                                                                      |                                                                                                                                                                                                                                                                                          |         |                                                                                                                                                                                                                                                                                                    |
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|                       |                                                                      | Japan, maintaining and improving the competitiveness of Japanese industries, protecting global environment preventing disruptions to global financial order while having the objective of supplementing the financial transactions implemented by private sector financial institutions. |         |                                                                                                                                                                                                                                                                                                    |
| <b>Academia</b>       | University of Tokyo                                                  | The University of Tokyo, Japan's premier academic institution, conducts pioneering research in hydrogen technologies, contributing to Japan's leadership in the global hydrogen economy through innovation and education.                                                                | Support | The university would be interested, as it facilitates various regional projects. There is an opportunity for it to work on pilot projects as well with leading research institutions targeted at fostering educational and training programs. This would have to be heavily funded by the US.      |
|                       | Tokyo Institute of Technology                                        | Tokyo Tech is a leading research university in Japan, actively involved in hydrogen research and innovation, driving advancements in hydrogen technologies and fostering collaboration for the hydrogen economy.                                                                         | Support | The Institute would be interested in the research of H2 production, storage and utilization. It already holds international partnerships. Programs that can attract funding would be favored. It is important to note that this institute is protective of intellectual property and data sharing. |
| <b>Private Sector</b> | Energy Enterprises (Toshiba Energy Systems & Solutions Corporation ) |                                                                                                                                                                                                                                                                                          | Support |                                                                                                                                                                                                                                                                                                    |
|                       | Kawasaki Heavy Industries                                            | Kawasaki Heavy Industries is a leading engineering conglomerate in Japan, specializing in hydrogen transport and storage solutions, crucial for establishing global hydrogen supply chains.                                                                                              | Support | Because a core focus of Kawasaki Heavy Industries is to strengthen global hydrogen supply chains, they would be interested in this PPP Initiative.                                                                                                                                                 |

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|  | Mitsubishi Heavy Industries (MHI)                          | MHI is a diversified industrial conglomerate, pivotal in energy infrastructure, including hydrogen production and carbon capture technologies, driving Japan's green hydrogen transition.                  | Support | This initiative would support its business expansion within the green hydrogen sector.                                                                                                                                                                                                                                            |
|  | Automotive Manufacturers (Toyota Motor Corporation, Honda) |                                                                                                                                                                                                            | Support | Both of these corporations have supported initiatives to use hydrogen as a way to reduce emissions.                                                                                                                                                                                                                               |
|  | Iwatani Corporation                                        | Iwatani Corporation is a major hydrogen supplier and operator of refueling stations, central to Japan's hydrogen distribution network and the development of hydrogen infrastructure.                      | Support | Iwatani controls 100% of Japan's liquified hydrogen market and 70% of its compressed and liquid hydrogen market. It also has partnered with Chevron to build and operate hydrogen fueling stations in the U.S. This PPP initiative could support its business expansion within the green hydrogen sector.                         |
|  | Tokyo Gas                                                  | Tokyo Gas is a prominent energy company in Japan, actively involved in hydrogen projects, contributing to domestic hydrogen supply chains and consumption, shaping Japan's energy transition.              | Support | With an aim of 50% carbon neutrality by 20240 using hydrogen and e-methane, Tokyo Gas could benefit from this PPP initiative.                                                                                                                                                                                                     |
|  | Hitachi                                                    | Hitachi is a global technology leader, contributing to energy and infrastructure projects, including hydrogen, advancing technology development and systems integration for the hydrogen economy's growth. | Support | Hitachi is not only investing and expanding its business into green hydrogen technology, working with Toyota to develop hybrid fuel cell railway vehicles, but also following and reporting on relevant U.S. legislation and developments. This initiative could support its business expansion within the green hydrogen sector. |

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|  | Marubeni       | <p>Marubeni Corporation and its consolidated subsidiaries use their broad business networks, both within Japan and overseas, to conduct importing and exporting, as well as domestic business, encompassing a diverse range of business activities across wide-ranging fields including lifestyle, IT solutions, food, agri business, forest products, chemicals, metals &amp; mineral resources, energy, power, infrastructure project, aerospace &amp; ship, finance, leasing &amp; real estate business, construction, industrial machinery &amp; mobility, next generation business development and next generation corporate development.</p> | Support | <p>Marubeni is investing in several hydrogen production and storage developments and green ammonia projects around the world (Oman, Australia, Portugal, and Saudi Arabia). This initiative could support its business expansion within the green hydrogen sector.</p>                                         |
|  | Siemens Energy | <p>Located in 90 countries, Siemens Energy operates across the whole energy landscape. From conventional to renewable power, from grid technology to storage to electrifying complex industrial processes.</p> <p>Its mission is to support companies and countries with what they need to reduce greenhouse gas emissions and make energy reliable, affordable, and more sustainable</p>                                                                                                                                                                                                                                                          | Support | <p>Siemens Energy is working within the METI and NEDO's Green Hydrogen Project and is receiving funding to develop and demonstrate Japan's largest multi megawatt class Polymer Electrolyte Membrane electrolysis. This initiative could support its research in developing Japan's green hydrogen sector.</p> |
|  | Eneos          | <p>Eneos Corporation is Japan's largest petroleum company with a growing presence in other countries.</p> <p>Its businesses include</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Support | <p>Eneos, Idemitsu Kosan and Hokkaido Electric Power Company are partnering to develop a green hydrogen project with at</p>                                                                                                                                                                                    |



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|  |              | exploration, importation, and refining of crude oil; the manufacture and sale of petroleum products, including fuels and lubricants; and other energy-related activities.                                                                                                                                                                                                                                                                                                                                                                                                                                       |         | least 100 MW of electrolysis capacity by 2030. This initiative would support its business expansion within the green hydrogen sector.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|  | Air Products | <p>Air Products provides industrial gasses, related equipment and applications expertise to customers in dozens of industries, including refining, chemical, metals, electronics, manufacturing, and food and beverage. It is a global leader in the supply of liquefied natural gas process technology and equipment.</p> <p>Air Products develops, engineers, builds, owns and operates some of the world's largest industrial gas projects, including gasification projects that sustainably convert abundant natural resources into syngas for the production of high-value power, fuels and chemicals.</p> | Support | <p>Air Products is building the Louisiana Clean Energy Complex that will produce over 750 million standard cubic feet per day of blue hydrogen for the U.S. This plant will use carbon capture to achieve low carbon. The IRA's tax incentives for blue and green hydrogen play a role in confirming Air Products decision to build this facility. This facility follows on from Air Products and AES Corporation's agreement to build and operate a \$4 billion mega-scale green hydrogen facility, located in Wilbarger County, Texas. That will produce over 200 metric tons per day of green hydrogen and powered by approximately 1.4 gigawatts of wind and solar.</p> |
|  | JERA         | JERA is Japan's largest power generation company which operates entire supply chain, from fuel upstream and procurement to power generation                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Support | JERA is partnering with Exxon to explore development of low carbon hydrogen and ammonia project in the U.S. that is expected to be the world's largest low-carbon hydrogen production plant. This initiative would support its current efforts and aid its business expansion.                                                                                                                                                                                                                                                                                                                                                                                              |
|  | Linde        | <p>Linde plc is a global multinational chemical company founded in Germany and domiciled in Ireland and headquartered in the UK.</p> <p>Linde</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Support | Linde's proprietary technology, such as its Cryo Pump technology is being used in fueling stations in Japan. With a focus on transportation and storage Linde which is also present in the U.S. would very                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

|                      |                                   |                                                                                                                                                                                                                                                                                                           |         |                                                                                                                                                                                                                                                                                                                                                                      |
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|                      |                                   | It is the world's largest industrial gas company by market share and revenue. Market cap 2023: \$226.42 billion.                                                                                                                                                                                          |         | likely benefit from this PPP initiative                                                                                                                                                                                                                                                                                                                              |
| <b>Civil Society</b> | Japan Hydrogen Association (JH2A) | JH2A is a consortium of major Japanese industrial, energy, and automotive companies driving the advancement of hydrogen technologies and infrastructure. It fosters collaboration between public and private sectors to promote innovation, investment, and policy advocacy for Japan's hydrogen economy. | Support | They will most likely view international partnerships, namely with the US, as a means to scale the hydrogen market, reduce costs and promote technological innovation, while opting to position Japan as a global leader in hydrogen. Such partnership should be designed to be more attractive than existing regional ones and not harming H2 domestic development. |
|                      | Renewable Energy Institute (REI)  | REI is a leading research and policy organization focused on advancing renewable energy technologies in Japan. It conducts research, provides policy recommendations, and fosters international cooperation to accelerate the transition to sustainable energy, including green hydrogen.                 | Support | REI is likely to support green hydrogen exportation partnerships with the US as they align with its mission and could increase their influence to shape policy towards global H2 development. Should be aligned with their major environmental concerns and climate change agendas.                                                                                  |
|                      | Japan Climate Initiative (JCI)    | JCI is a coalition advocating for ambitious climate policies and sustainability in Japan. It brings together businesses, local governments, and civil society to drive climate action and promote initiatives like green hydrogen for decarbonization.                                                    | Support | Targeted on climate action and sustainability, this initiative would likely support green hydrogen partnerships that contribute to its network expansion, knowledge exchange and advance carbon neutrality and global climate goals.                                                                                                                                 |
|                      | Japan H2 Mobility (JHyM)          | JHyM is a collaborative initiative expanding hydrogen refueling infrastructure to support fuel cell vehicle adoption in Japan.                                                                                                                                                                            | Support | if the partnerships result in increased investment in infrastructure domestically and internationally, coupled with a market expansion strategy of                                                                                                                                                                                                                   |

|  |                                                     |                                                                                                                                                                                                                                                                                                        |         |                                                                                                                                                                                                                                                                                                                                         |
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|  |                                                     | Comprising automakers, energy companies, and government agencies, JHyM accelerates FCV commercialization and contributes to Japan's hydrogen transportation system.                                                                                                                                    |         | FCVs, they will likely support. should adhere to domestic standards and regulations to avoid operational challenges across borders.                                                                                                                                                                                                     |
|  | The Hydrogen Energy, Clean Fuel Ammonia Association | The association promotes ammonia as a clean fuel and hydrogen carrier for power generation, transportation, and industrial applications. It conducts research, fosters collaboration, and advocates for policies supporting the adoption of clean ammonia technologies to decarbonize various sectors. | Support | They would support partnerships that advance H2 and ammonia if they support establishing ammonia's global supply chain, including technology transfer, successful production practices and transportation. Barriers could include technological readiness and scalability capacity of ammonia production and use in the current market. |
|  | The Hydrogen Energy Network (HyNet)                 | A collaborative platform uniting stakeholders to advance hydrogen energy solutions. It facilitates knowledge exchange, fosters partnerships, and advocates for supportive policies, driving innovation and investment in hydrogen technologies, infrastructure, and applications.                      | Support | They would support if investment and innovation strategies are applied, coupled with integration into the Japanese H2 networks and systems.                                                                                                                                                                                             |