Energy Chile - California
Executive Summary
Session 4: Green Hydrogen Transition

August 18th, 2021

The Chile California Council and the Ministry of Energy of Chile held the last of four working group sessions that discussed common challenges and opportunities Chile and California face as they transition to more sustainable energy systems. The fourth session took place August 18th, 2021, and focused on comparing their green hydrogen transition goals, key challenges, and opportunities. A consolidated document of the four sessions will be prepared highlighting the tangible results of these sessions and next steps to follow.

This executive summary provides an extract of what was discussed in the fourth session. Participants, sponsors, and organizers all found the session very useful and had positive comments on what was achieved.

This summary highlights the strategy, incentives and challenges that Chile and California face to promote a green hydrogen industry. The main takeaway is that strategies targeting both demand and supply need to be developed to create a hydrogen market. Infrastructure development, incentives, certifications, and research in hydrogen uses are all needed to develop the market.

The rest of the document showcases participants and the agenda of the meeting before providing a summary of key points that came out of the meeting.

I. PARTICIPANTS

Javiera Aldunate – Ministry of Energy of Chile	Karen Douglas – Commissioner of California Energy Commission
Max Correa – Ministry of Energy of Chile	Alana Sanchez - California Energy Commission
Gabriel Prudencio - Ministry of Energy of Chile	Mike Petouhoff – California Energy Commission
Allan Najum - DECYTI, Ministry of Energy of Chile	Eli Harland – California Energy Commission
Rafael Friedmann - CCC Chair	Anna Ferrera – California Energy Commission
Aura Rearte - ACESOL	Brian Goldstein – Energy Independence Now
Nicolás Westenenk - Generadoras de Chile	Juan Pablo Carvallo - UC Berkeley
Sebastián González - ACESOL	Héctor De la Torre - California Air Resources Group
Marcela Angulo – CCC Councilor & University of Concepción	Ignacio Fernández – Southern California Edison
Eduardo Gorsch – Siemens	Merrian Borgeson - Natural Resources Defense Council
Arturo Brandt – TFS Green	Dr. Fereidoon Sioshansi – Menlo Energy Economics
Brian Walsh – Wind Ventures	Matías Alcalde - Chile California Council
Cristóbal Silva – Kayyak Ventures	Manuela Díaz - Chile California Council
Rodrigo Castro – Genesis Ventures	Josefina Edwards - Chile California Council
Javiera Canales – UC Berkeley	

AGENDA RECAP

*Times are expressed in Pacific Standard Time (California)

PART 1: Introductory remarks		
9:00 am – 9:05 am	Welcome & general protocols for the meeting	Representative before the CCC Matias Alcalde
PART 2: Chile & California Context		
9:15 am - 9:25 am	Pillars of the "Green Hydrogen Plan of Chile by the Ministry of Energy of the Government of Chile".	Head of Fuels and New Energy Division Max Correa
9:25 am - 9:35 am	Pillars of the "Green Hydrogen Plan of California by the California Energy Commission".	Commissioner Karen Douglas
PART 3: Discussion groups Participants were assigned in advance in the following discussion groups, to work on a "living" document of simultaneous work. These conversations discussed successful and failed experiences of programs, policies, and incentives useful both for Chile and California.		
9:35 am - 10:05 am	**Group 1:** Priority areas to create demand for green hydrogen - different uses and available technologies of green H2, both as fuel and storage, for transportation and industry.	
	Group 2: Social impact - what implications will the national green hydrogen policy have in terms of territorial planning and how this will affect communities.	
	Group 3: Green hydrogen markets and world scenario -balance between local generation / consumption vs importation / exportation, regarding knowledge, technology, and infrastructure.	
PART 4: Open Discussion, conclusions, and next steps		
10:05 am - 10:15 am	Each group selected a representative to present the main points of view discussed	
10:15 am - 10:40 am	Questions and open discussion	
10:40 am - 11:00 am	Identification of the main actions to work on for the future meetings. Comments to consider for the next sessions	

II. PRINCIPAL FINDINGS AND DISCUSSIONS

A summary of what was presented and discussed in the meeting follows per the meeting agenda presented above.

Chile Context

- The hydrogen strategy of Chile is a part of the energy transition for climate action. The government is committed to fighting climate change. Chile has significant challenges in distribution, transmission, storage, and efficiency of the energy system.
- Hydrogen is part of the larger carbon neutrality plan, where coal-fired power plants will be replaced with renewables and the electricity produced will cover other sectors' energy needs.
- Currently, Chile is phasing out coal. In 2020, it was about 40% of the electricity grid. Phase out likely will be faster than 2040.
- In 2021, Chile increased its solar and wind capacity by 6GW, which is double the capacity developed in the last 10 years.
- Chile with about 800 GW of renewable electric potential, has 70 times more renewable energy capacity than current electric demand.
- The high quality of renewables - solar in the north and strong winds in southern Patagonia - could be harnessed to produce hydrogen for export, fueling Chile's economy and helping the rest of the world transition to clean energy.
- The Climate Plan calls for green hydrogen to account for 20-28% of the reduction of Carbon emissions.
- Chile is very competitive in renewables, having a 37% solar capacity factor and 70-75% capacity factor for onshore wind, much higher than elsewhere.
- Chile can produce the most competitive hydrogen in the world, and other products derived from it, with a $0.95-1.05 USD/Kg H2 expected by the end of 2030. If the cost is less than $2/Kg, it is already competitive with fossil fuels.
- Chile is far from large hydrogen markets, but it can compensate for it with cheaper generation costs.
- Clean hydrogen can offer as many economic benefits and value creation as the current mining industry. If done right, it will have fewer externalities and will build human capital and local value.
- In November 2020, Chile launched a participatory strategy which included an advisory council with people from broad political backgrounds to discuss the role for Green Hydrogen.
- Due to the large renewable potential, Chile has set very ambitious goals. Electrolysis capacity operating and under development will be 5GW, which requires 7.5 GW of renewables to fuel these by 2025.
- The Ministry of Energy has a new team working specifically on:
    - Regulations and permits.
    - Coordinating alliances to increase both domestic and international demand.
    - Incentives and financing to help drive forward the market as hydrogen is not competitive yet, to make the market evolve faster.
    - Plans to develop adequate infrastructure; coordinating ports, electrical and distribution infrastructure to foster the growth of hubs.
    - Research and development to accelerate project deployment and generate green jobs.
- Chile will accelerate the deployment of green hydrogen in 6 prioritized applications to build local supply chains: oil refineries, ammonia, mining haul trucks, heavy-duty trucking, long-range buses and blending hydrogen into the gas grid (up to 20%).
- Chile has achieved 5 key milestone for hydrogen:
    - $50M USD in the first call for financing green hydrogen projects. Which includes funding for around 10 MW of electrolysis facilities.
    - $265M USD for a Clean Technologies Institute, which is an open innovation platform for clean energy and mining technologies.
    - International outreach; memorandum of understanding with Singapore and the Port of Rotterdam.

- Fast track piloting, three guides for hydrogen tech in production, mining, and transportation with streamlined approval processes for pilot initiatives.
- An energy efficiency law, which includes energy efficiency standards for vehicles.

California context

- Decarbonization policy for the electricity sector has been set up by California law calling for 100% clean energy and retail sales by 2045, in addition to the governor's executive order calling for 100% ZEV by 2035.
- The potential role for hydrogen and the strategies needed to stimulate and scale the market have been actively revisited. Most of California's early successes with the integration of hydrogen have been in the transportation sector.
- Green hydrogen is an alternative that could replace or complement the uses of fossil gas in the electric system.
- The CEC is actively looking at how to increase efficiency and build up economies of scale in the generation, storage, and conversion of green hydrogen to take full advantage of the renewable power that California has been producing very effectively.
- The CEC hosted a workshop to explore the status of green hydrogen and its potential role in California:
  - Germany and Denmark's presenters gave a better perspective about plans and programs around hydrogen that worked well in those countries.
  - Department of Energy and California presenters are looking for a project based in California; one of those is in Los Angeles.
  - Los Angeles Department of Water and Power is looking to repurpose the coal-fired Intermountain power plant by utilizing a blend of natural gas and hydrogen.
  - Technologies supported include: electrolyzers, fuel cells, combustion technologies, storage, and hydrogen-powered transportation.
- Additional budget is expected for funding research and development of hydrogen technologies.
- There is a large potential for partnerships to research, develop, and deploy new technologies for the electricity sector, industrial decarbonization, and storage.
- Even though there are many ways that the economy could use green hydrogen, this is not considered a 100% replacement for fossil gas generation.
- Green hydrogen can provide firm, dispatchable and decarbonized generation to supply additional support to the grid when renewables are not producing enough electricity.
- Creating an ecosystem is critical for the production and scale of green hydrogen. Due to California being a large renewable producer, the deployment of green hydrogen must be where there are land-based renewables, such as photovoltaic solar, and potentially onshore and offshore wind.
- Supply scalability is one of the constraints of green hydrogen; resolving how fast the supply can be scaled will be critical to explore different niches

Summary of Group Discussions

Group 1 - Priority areas to create demand for green hydrogen - different uses and available technologies of green H2, both as fuel and storage, for transportation and industry.

Challenges and opportunities

- The main challenge is how to incentivize more supply that would foster more demand for end uses of hydrogen.
- Solid regulatory and political will would be needed to set long-term rules that can foster stability for investments in projects.
- Trying to scale up low hanging fruit for demand might encourage investments in supply that will allow costs to go down and achieve economies of scale.
- Domestic uses of hydrogen can get the ball rolling internationally, potentially paving the way for hydrogen exports.
- The carbon market is playing a significant role for those industries that are very CO2 intensive. The carbon tax represents an opportunity for Chile to adopt green hydrogen.
- The main challenge with green hydrogen is lowering costs as much as possible so that it can replace fossil fuels in more energy-intensive uses.
- Demand is uncertain due to the lack of knowledge about the production costs of green hydrogen versus other electric alternatives or other technologies that can be used.
- The variability between technologies for electrolyzers creates a level of uncertainty to predict the cost of green hydrogen production.
- Certified green hydrogen from renewables can promote the willingness of the off-takers to pay for the green premium, which will accelerate purchases and incent investments in supply. This will require the government to set up the certification rules.

Group 2 - Social impact -- what implications will the national green H2 policy have in terms of territorial planning, and how this will affect communities.

Challenges and opportunities

- The proper role of the government is to focus on supporting decarbonization strategies and making core investments to develop green hydrogen.
- Focusing on exporting hydrogen should not come before scaling up renewables and interconnecting them so they are available for multiple uses.
- There is a big difference between green electrolytic hydrogen, which uses renewable electricity, and bio sources of hydrogen in California. California runs the risk of just having the existing steam methane reformation process using natural gas continuing but putting some biomass credits on top. This could become a real problem because it would not develop the technologies needed for electrolysis and does not solve local air pollution issues for communities suffering from refining processes.
- Investing in large-scale physical infrastructure early on without knowing how much hydrogen could scale up and how quickly, and without knowing which sector it will be most useful for, could represent a problem for investors.
- There is significant concern about the gas industry or gas companies encouraging early investment in new hydrogen pipelines and other infrastructure when there is no certainty where and when the infrastructure will be needed.
- Hydrogen and biomethane can be a distraction for the electrification of different sectors. It is necessary to ensure that the conversation about new fuels does not distract from the larger picture about decarbonizing our economies.
- It is better to use electricity first rather than produce hydrogen to turn it into an end-use fuel. It takes around five times more energy to heat a building with hydrogen than directly with electricity using heat pumps.

Group 3: Green hydrogen markets and world scenario -- balance between local generation /consumption vs. importation/exportation, regarding knowledge, technology, and infrastructure.

Challenges and opportunities

- California is ahead of every other state in terms of hydrogen. However, the lack of manufacturer diversity, the number of fueling pumps and the amount of fuel available show that hydrogen as a technology is still immature.
- The role of hydrogen in the energy system is much more significant than transportation. It has different uses in the overall energy system for energy storage, industrial decarbonization, and disaster resilience. This makes H2 attractive and very challenging in defining the boundaries of what the market should and could do.
- A big challenge for governments is that both hydrogen demand and supply need to be created.
- Locomotive manufacturers in rail transportation and heavy-duty trucking are bullish on hydrogen as a transition fuel.
- Large pickup trucks and large SUVs are a sweet spot for hydrogen. It may not be practical for small commuter vehicles.
- About 80-85% of the stock of combustion gas turbines across the US could be replaced with hydrogen because of the presence of salt caverns that can store hydrogen for weeks or even months. H2 can compensate for long stretches of variability in solar and wind in many parts of the country, supplying peak capacity and resource adequacy for the power system.
- In California, about 50% of people living in multi-family housing may not have access to a vehicle charger. In these cases, hydrogen can help to provide equal access to zero-emission transportation technologies.
- The regulatory community in California is recognizing and trying to provide some balance on the market and acknowledging that no singular technology is going to be the silver bullet.
- Opening a car market for both technologies (battery and fuel cell) is needed to create competition. However, there are not enough hydrogen stations for the market to take over the development of stations in California.
- The CEC funded a program with Hyundai for heavy-duty H2-fueled trucks. The goal is to be able to transport products from the Port of Oakland to other parts of California using hydrogen power. It is intended to be achieved through the installation of three high-capacity H2 pumping stations.
- The United States Department of Energy announced a program to bring prices down to $1 USD per kilogram of hydrogen by 2030.
- Strengthening the supply side for hydrogen is a real need. California gave rebates for zero-emission vehicles, which created a market for electric vehicles. However, it was not enough to support the fuel cell vehicle market.
- Assigning a fossil fuel penalty will force the transition into new technologies. Hyundai was the first company to announce large-scale production in 2000. They made 1500 H2-fueled trucks, and all of them went to Switzerland because of a combination of incentives and disincentives.
- There is a significant need to do more research around the multiple uses of hydrogen, find ways to help policymakers prioritize uses, and show the economic case for hydrogen exports.
- Strengthening the hydrogen supply network is needed to achieve the California goals for medium and heavy-duty transportation trucks by 2045. Multiple problems surfaced in the past as hydrogen fueling stations stored an average of 180 kg per day and run out of fuel multiple times per day. Eventually, these service stations were shut down.
- Secure the supply chain by expanding production and merchant capabilities at existing production plants, with redundant critical equipment in case a disruption or failures.

FINAL DISCUSSION

- To develop a hydrogen market, it is important to understand the different uses of hydrogen and the different technologies available. For example, different types of hydrolysis can lead to different uses, and hydrogen markets.
- The hydrogen industry in Chile should be well studied and planned, according to the current reality of the country. The fact that in Chile hydrogen can produce 70% of the current energy demand reflects how attractive hydrogen can be. The role of H2 should seek its use in the most cost-effective and beneficial options to avoid the risk of investing in large infrastructure for hydrogen and ending up with grey hydrogen.
- Chile should first focus on internal policies for decarbonizing the economy, displacement of coal power plants, and strengthening the interconnection of the central and north electric systems instead of thinking of producing hydrogen for export.
- Governments need to develop standards that define what green or renewable hydrogen is, and a tracking system that traces and certifies the origin of the hydrogen to ensure it is green.
- Labeling the hydrogen should include different shades of green depending on how it is `produced. For example, distinguishing whether it is through an electrolyzer fueled by a wind farm or one connected to an electric grid with a high level of green energy.
- In the current stage of the hydrogen industry, more effort is needed to figure out targeted use cases where hydrogen does something specific, that can't be accomplished very well through other means.
- Because hydrogen production will never be less expensive than the electricity used to make it, hydrogen should be used to store renewable electricity.
- Industries that are interested in being decarbonized represent funding sources for H2 (e.g., the fossil fuels industry). This could help to develop a hydrogen industry and let the government redirect the incentives into other areas where it is more needed.
- The H2 industry represents an opportunity to connect science and industry, opening possibilities of multiple use cases and much innovation.