Fifth International Forum on Long-Term Energy Scenarios (LTES) for the Clean Energy Transition

September 9 – 11, 2024| Hybrid Event

Day 3 Event Proceedings

Event summary

The 5th LTES Forum hosted approximately 40 attendees at IRENA Innovation and Technology Center offices in Bonn, Germany, while 100 people participated in the Forum online. The participants represented a diverse array of stakeholders, such as government officials, intergovernmental organisations, development partners and non-profit organizations. The Forum focused on alignment between energy and climate planning, the role of scenario planning for de-risking investment for the clean energy transition, scenario communication, lifestyle changes, energy security, and hydrogen integration. Through presentations, panel discussions, and attendees' interventions the Forum facilitated the exchange of knowledge and experiences on different aspects of the planning of LTES.

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- The discussion highlighted that building trust is crucial when navigating the uncertainties in long-term energy scenarios, emphasizing the importance of strong connections among all actors through proper stakeholder engagement.
- It was noted that collaboration and consistency in model calibration are important for comparing results across different models and can help in addressing development uncertainties.
- Governments are encouraged to foster stable regulatory and policy environments, as this can reduce uncertainties for investors and supports adequate private sector participation in the energy and electricity sectors.

Session 9

- The discussion highlighted that countries are becoming more realistic about the role of hydrogen and its derivatives to support the transition as they develop scenarios which inform their long-term energy planning and the incorporation of the new technology in their energy mixes.
- The discussion highlighted the importance of aligning hydrogen strategies with national energy transition plans to address just transition concerns, such as the social and environmental challenges faced by Colombia's hydrogen planning.
- Countries have identified the potential of hydrogen use in various end use sectors, specifically the hard to electrify sectors such as steel production. The speaker from Chile noted that the country is considering using hydrogen in their copper mining operations, with the goal of producing 'green copper' and fostering a more sustainable extractives sector.
- Given the high cost of hydrogen and its derivatives, the discussion highlighted that identifying and securing offtake agreements is a critical challenge that must be overcome to attract sufficient investment. It was noted that while energy models can incorporate different hydrogen price assumptions, a key challenge is bridging the gap between model outputs and real-world market uncertainties regarding investors and off-takers.

Session 8 (Co-hosted with VTT Technical Research Ltd., Finland): Communicating and responding to uncertainties in scenarios

Moderator: *Tiina Koljonen*, Research Team Leader, VTT Technical Research Centre of Finland

Opening remarks: *Gustavo de Naciff Andrade*, Deputy Head of Energy Economics, EPE, Brazil

Panelists:

- *Marissa Cerezo,* Director, Renewable Energy Management Bureau, Department of Energy, The Philippines
- *Joel Flores,* Energy Planning Analyst, General Directorate of Energy, Hydrocarbons, and Mines of El Salvador
- *Malene Hovgaard Vested,* Advisor, Danish Energy Agency
- *Michelle Akute,* Manager – Energy Planning, Energy and Petroleum Regulatory Authority

Session Objective: This session delved into managing uncertainties in LTES and translating them into actionable policy frameworks. Practitioners gained insights into identifying uncertainties, communicating mitigation measures, and taking action towards implementing these measures.

Key Takeaways:

- The discussion highlighted that building trust is crucial when navigating the uncertainties in long-term energy scenarios, emphasizing the importance of strong connections among all actors through proper stakeholder engagement.
- It was noted that collaboration and consistency in model calibration are important for comparing results across different models and can help in addressing development uncertainties.
- Governments are encouraged to foster stable regulatory and policy environments, as this can reduce uncertainties for investors and supports adequate private sector participation in the energy and electricity sectors.

Session Summary

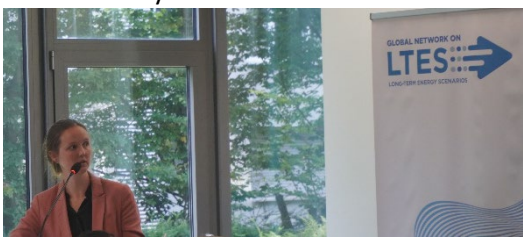
Tiina Koljonen (VTT Technical Research Centre of Finland) emphasized the significant uncertainties in the clean energy transition and the importance of adapting to different uncertainties through effective communication and response strategies. Tiina illustrated the energy transition's complexity with a model showing uncertainty levels and scopes, she noted that most of the LTES require broad, integrative approaches that consider not only energy systems but also sustainability, technology, and market factors. She noted the importance of addressing energy demand alongside emissions reduction, stressing the importance of technical solutions implemented alongside societal and behavioral changes. Finally, it was noted that, to improve scenario planning amidst uncertainty, Finland has developed three reference scenarios for their climate and energy strategies, an approach aimed at incorporating a broader perspective.

Marissa Cerezo (Philippines' Renewable Energy Management Bureau) shared insights on handling uncertainties in the energy transition, highlighting the complexity of scenario planning in the face of investor expectations and governmental shifts. In the Philippines, the power sector is privatized, and the government's role is to create a stable environment to attract investment. Given this context, policies are formed through a transparent and inclusive consultation process involving public and private stakeholders, ensuring that all concerns and insights are incorporated thereby fostering long-term buy-in for energy policies.

The Philippine plans to expand renewable energy sources to become the primary power source by 2040, which necessitates reskilling and upskilling the workforce to avoid job displacement during this transition. Regarding attracting financing, roadmaps for specific energy technologies, such as solar, are crucial to signal government intentions to investors, but these are subject to updates due to political cycles and shifting priorities. Energy security remains a high priority given the country's reliance on imported fossil fuels, and there is a strong drive to develop indigenous renewable resources. Lastly, Marissa emphasized that energy security, climate commitments, and social development must align in a balanced approach. While the Philippines values its climate commitments, it must also address unique challenges related to its geographic isolation and dependence on imports.

Joel Flores (General Directorate of Energy, Hydrocarbons, and Mines of El Salvador) presented on managing uncertainties in long-term energy scenarios and the critical importance of adaptability in policy development. He highlighted that uncertainties in the energy transition are intensified by factors such as fossil fuel price volatility, technological advances, and climate change. It was emphasized that managing these uncertainties is essential to ensure resilient energy policies, optimize investment timing, and maximize the benefits of the energy transition.

In El Salvador energy scenarios play a vital role in gaining political support and guiding decision-making by providing an evidence-based framework to anticipate energy needs and opportunities. To integrate uncertainties into decision-making, El Salvador identifies and prioritizing relevant scenario inputs which encompass economic, social, environmental, and regulatory factors. In conclusion it was noted that stakeholder engagement, especially in managing uncertainties, helps build consensus across public, private, and civil society sectors.



Malene Hovgaard Vested (Danish Energy Agency) discussed how uncertainties impact energy scenario planning and policy-making, emphasizing the challenges of accurately predicting future outcomes. Malene outlined three primary categories of uncertainty as identified by the IPCC, each with unique characteristics and mitigation strategies: (i)Development Uncertainty which involves unpredictable factors, such as changes in human behavior, lifestyle preferences, and technological advancement; (ii) Model Uncertainty which arise from potential inaccuracies within the modeling itself, such as misrepresenting critical variables; and (iii) Data Uncertainty occasioned by missing, inaccurate, or outdated data. To address these uncertainties, the Danish Energy Agency employs several strategies. For development uncertainty, they conduct sensitivity analyses by adjusting one parameter at a time and observing the impact on the model. For model uncertainties, they conduct ad-hoc calibrations of variables like electric vehicle adoption rates. Finally, for data uncertainties, they engage stakeholders through public hearings, which sometimes reveal errors,

such as an instance where incorrect CO_2 emissions data was submitted due to a typo, the error was highlighted during stakeholder consultations.

Michelle Akute (Kenya's Energy and Petroleum Regulatory Authority) discussed the challenges of managing demand-side uncertainties in Kenya's energy planning. She noted that while supply-side uncertainties have reduced over the years due to well-established stakeholder planning, demand-side forecasting remains complex. This is largely due to evolving energy needs, especially with the rise of new technologies such as electric mobility (e-mobility) and electric cooking, which will likely change consumption patterns.

Kenya previously expanded electricity supply and adopted a 5000 MW capacity target which overlooked actual demand growth. This misalignment revealed gaps in demand forecasting, prompting Kenya to adopt data refinement practices and seek demand models better suited to the local context. However, many models remain data-intensive and challenging to implement due to resource limitations, creating ongoing uncertainty. It was noted that Kenya is committed to stakeholder engagement in planning as the country is focused on developing collaborative energy transition strategies. Finally, to address uncertainties Kenya is undergoing significant capacity building to adapt its models and assumptions to the latest tools and methodologies, supported by partnerships with external experts.

Plenary Session Summary

Marissa Cerezo (Philippines' Renewable Energy Management Bureau) addressed the evolving nature of uncertainties in energy transition, noting how increase as new goals and technologies, such as offshore wind, emerge. She noted that governments should ensure two main aspects for investors: demand presence, as this ensures a market for renewable investments and policy predictability and the ensuring of streamlined and time-bound permit processing procedures. Finally, it was noted that digitization can contribute to efficient permitting despite the need for reliable internet and electricity supply. She concluded by emphasizing the importance of open communication, collaborative engagement, and fostering investor confidence to effectively manage these uncertainties.

Joel Flores (General Directorate of Energy, Hydrocarbons, and Mines of El Salvador) noted that certain uncertainties, such as fuel price volatility, are constants in energy planning and must always be factored into renewable energy scenarios in El Salvador. He highlighted that while past uncertainties focused on fuel volatility and public energy tenders, new challenges include assessing the feasibility of green hydrogen for domestic use or export, as well as navigating the implications of electric mobility.

Malene Hovgaard Vested (Danish Energy Agency) discussed the evolution of uncertainties across three categories: (i) Data uncertainty: It was noted that Denmark has significantly reduced data uncertainty with high-quality, detailed historical data, making data input one of the easier aspects; (ii) Model uncertainty: as the added complexity of models results in excessive details which can complicate achieving actionable insights, inadvertently increasing uncertainty in their results. Finally (iii) Development uncertainty which has intensified due to the rapid change in the energy system and an increasingly volatile global context, including factors like the war in Ukraine, which has affected fuel prices and the outlook for energy

scenarios. It was concluded that uncertainties overall are increasing, partly because energy transitions now require swift, large-scale changes under unpredictable conditions.

Michelle Akute (Kenya's Energy and Petroleum Regulatory Authority) highlighted two main challenges contributing to uncertainty in Kenya's energy planning. First is the evolving demand and technology readiness given the complexity of accurately assessing capacity needs, especially as demand fluctuates between high and low periods. Secondly, private sector engagment is hampered by delays and procedural obstacles given the frequent revisions in planning, complicating the integration of private sector contributions into long-term strategies.

Audience Interventions

Ilija Batas Bjelic (Institute of Technical Sciences, Serbia) commented on the complexities of managing uncertainties in energy planning, emphasizing that traditional approaches often involve scenario analysis to account for different uncontrollable exogenous variables. It was noted that by creating multiple scenarios, planners can develop solutions for a range of possible conditions thereby accounting for additional uncertainties.

Hans Josef (Germany) emphasized the need for clear, effective communication with politicians about the energy transition, pointing out that the complexity and abundance of uncertain data can often overwhelm and confuse decision-makers.

Charlie Heaps (Stockholm Environment Institute) provided an in-depth reflection on various types of uncertainty in energy scenario planning. Regarding behavioral uncertainty it was highlighted that it is necessary to differentiate between consumer and producer responses when designing policy signals, as each group may react in unique ways to changes in the energy landscape. Further, it was noted that inconsistent or ambiguous framing of energy transition concepts can lead to varied interpretations, complicating stakeholder understanding and decision-making. Charlie highlighted a challenge in modeling, interconnected uncertainties, where variables may not be entirely independent, potentially leading to biases in scenario projections. He recommended using Monte Carlo simulations to assess variable distributions but acknowledged the limitations of such methods.

Morjana Moreira dos Anjos (Renewables Grid Initiative) noted that stakeholders frequently question uncertainties to challenge the credibility and ambition of scenario goals. It was noted that it is vital to ensure proper communication thereby maintain stakeholder confidence in scenario outcome.

Camila de Araujo Ferraz (Brazil Energy Research Office (EPE)) acknowledged the importance of communicating uncertainties to policymakers, she highlighted the initial challenge of recognizing and prioritizing uncertainties as a foundational step in the scenario development process in Brazil. It emphasized that much of the effort in scenario planning involves determining which uncertainties to address and how to rank them, often through extensive stakeholder engagement to define scope, challenges, and priorities.

Session 9: Integrating Hydrogen Development into LTES: Addressing Key Policy Questions

Moderator: *James Walker*, Team Lead, Renewable Gases, IRENA

Panelists:

- *Francisco Domenech Guzmán*, Energy Foresight Analyst, Ministry of Energy, Chile
- *Jessica Arias Gaviria*, Deputy Director of Energy Demand, Mining and Energy Planning Unit (UPME), Colombia
- *Florian Knobloch*, Senior Policy Advisor, Scenarios and Economic Aspects of Climate Protection and the Energy Transition, German Federal Ministry for Economic Affairs and Climate Action

Session Objective: This session provided a comprehensive overview of the role of hydrogen in Long-Term Energy Scenarios (LTES) and its implications for national energy planning. During the session, participants discussed how hydrogen development can be aligned with broader national and international energy and climate goals. Additionally, they explored key policy questions related to hydrogen development within energy planning.

Key Takeaways:

- The discussion highlighted that countries are becoming more realistic about the role of hydrogen and its derivatives to support the transition as they develop scenarios which inform their long-term energy planning and the incorporation of the new technology in their energy mixes.
- The discussion highlighted the importance of aligning hydrogen strategies with national energy transition plans to address just transition concerns, such as the social and environmental challenges faced by Colombia's hydrogen planning.
- Countries have identified the potential of hydrogen use in various end use sectors, specifically the hard to electrify sectors such as steel production. The speaker from Chile noted that the country is considering using hydrogen in their copper mining operations, with the goal of producing 'green copper' and fostering a more sustainable extractives sector.
- Given the high cost of hydrogen and its derivatives, the discussion highlighted that identifying and securing offtake agreements is a critical challenge that must be overcome to attract sufficient investment. It was noted that while energy models can incorporate different hydrogen price assumptions, a key challenge is bridging the gap between model outputs and real-world market uncertainties regarding investors and off-takers.

Session Summary

James Walker (IRENA) welcomed participants and clarified that in this session the term *Renewable Gasses* refers to hydrogen and its derivatives. He noted that the session would focus on the role of hydrogen and derivatives in the decarbonization of hard-to-abate sectors and the context of the emerging markets. He noted that IRENA's World Energy Transitions Outlook (WETO) 2023 highlighted the role of electrification in decarbonization and the need to increase global Total Electricity Supply (TES) by 2030. WETO 2023 notes that about 14% of total final energy demand could be met by hydrogen and its derivatives, ammonia, methane and kerosene. Therefore to meet the 1.5° Celsius goal by mid-century it is necessary to increase electrolyser capacity from 1 GW to 5700 GW by 2050.

Francisco Domenech Guzmán (Ministry of Energy, Chile) noted that Chile has significant renewable energy reserves, with abundant quantities of sun in the north and centre and wind in the south. However, demand is concentrated in the north while the south lacks access to the national grid. It was highlighted that Chile has a liberalized electricity market and since 2022 has developed an extensive regulatory framework. Chile developed the Green Hydrogen Action Plan 2023-2030 to ensure the proper deployment of hydrogen necessary for decarbonization. Chile intends to leverage wind energy in the south to produce hydrogen which will be exported to the US and Europe. Additionally, the country has small-scale solar projects in the north which will also be used for hydrogen production.

It was noted that the Green Hydrogen Action Plan 2023-2030 was developed in a consultative manner and includes 111 action points to be implemented between Phase I 2023-2026 (investment signals, standard, ammonia and off-takers) and Phase II 2026-2030 (productive linkages & decarbonization). The Action Plan considers the geopolitical situation and identifies potential international hydrogen buyers.

The green hydrogen industry in Chile is fast growing and in 2024 a Danish consortium HNH Energy applied for a permit for a project amounting to 11 Billion USD for green hydrogen and ammonia (about the project).

Jessica Arias Gaviria (Mining and Energy Planning Unit (UPME) Colombia) noted that Colombia's Hydrogen Roadmap was inspired by Chile's Green Hydrogen Action Plan. Colombia's Hydrogen Roadmap considers how potential costs and transportation options may affect the global demand for hydrogen. Further, the country has a pilot hydrogen project in their transport sector and other hard-to-abate sectors to gauge the uptake of hydrogen domestically. Colombia notes that for a just energy transition and to meet national decarbonisation targets, the country needs 90GW by 2050 to meet electrification needs.

The country intends to use hydrogen to decarbonize hard-to-abate sectors, the speaker noted that meeting domestic and potential export demand for hydrogen could require up to 120GW by 2050 of new renewable energy capacity. As the country develops its hydrogen sector, it contends with social and environmental conflicts that arise from communities being excluded from energy planning given the historical impact of the coal industry on them. Therefore, the Ministry plans to work with communities to ensure proper engagement during the development of the hydrogen sector. To ensure transparency Colombia is mapping ongoing hydrogen projects and plans to share the information publicly for the benefit of government agencies and communities.

Florian Knobloch (German Federal Ministry for Economic Affairs and Climate Action) noted that Germany is working to achieve carbon neutrality by 2045 while ensuring economic development, leveraging various technologies including hydrogen. Germany works with many international partners and through its energy partnership with the Government of Chile and private companies supporting the HaruOni project in the South of Chile. Germany has a network of 30 dedicated hydrogen partnerships and plans to engage Colombia and other countries in the sector.

Through their modelling framework, Germany takes an evidence-based approach to policymaking. Germany has 2 main long-term scenarios; one scenario is based on electrification and the use of hydrogen in sectors that cannot be easily electrified. The second main scenario allows hydrogen use in multiple sectors- including those that can be easily electrified including heating and transport. The price of hydrogen in the second scenario is lower than the first. Modelling for hydrogen scenarios is done by a consortium led by the Fraunhofer Institute for System and Innovation Research in Karlsruhe.

In Germany, hydrogen is produced in the north using offshore wind, however, the country's scenarios include imported hydrogen from other European Union countries. Additionally, the country intends to import hydrogen and its derivatives from Chile, Colombia, Namibia and Australia. Given the projected large demand for hydrogen, Germany in 2024 adopted the Import Strategy for Hydrogen and Hydrogen Derivatives which features projections up to 2045.

The strategy includes scenarios which are used for infrastructure planning, including planning for pipelines for hydrogen connecting import points to off-takers. Additionally, the scenarios are used to inform investment by both the public and private sectors. The country is further planning for inter-country pipelines to connect Germany and Denmark for hydrogen import.

Germany is currently mapping potential domestic hydrogen buyers and considering whether industry players, of hard-to-abate sectors such as steel production, will pay a premium price for green hydrogen or whether they will shift production to other parts of the world that do not have stringent regulations and have high subsidies thereby lowering energy costs. High costs can dissuade industry players from making the transition to green hydrogen, and the national government ought to devise strategies to ensure a net positive response from the market.

Panel Discussion

Florian Knobloch (German Federal Ministry for Economic Affairs and Climate Action) noted that Germany has models that show high demand for hydrogen, however, the Ministry is working to map demand and ensure that potential buyers sign binding offtake Memoranda of Understanding. To incentivize industry players the government needs to subsidise hydrogen to ensure sustained demand, which is expensive and often lasts for many years.

Francisco Domenech Guzmán (Ministry of Energy, Chile) stated that there ought to be a balance between domestic decarbonization priorities and catering to the emergence of a potential global market. In the long run, there are different potential pathways for Chile, and the country is planning for off-grid projects to ensure system stability of the national grid. for domestic use and contribute to national decarbonization plans.

Jessica Arias Gaviria (Mining and Energy Planning Unit (UPME) Colombia) noted that Colombia is keen on incorporating hydrogen in its national energy mix and is keen on leveraging the technology to ensure energy efficiency. The country is further planning for the decarbonization of hard-to-abate sectors including steel production through the use of hydrogen. Colombia is first planning for the domestic use of hydrogen and is careful when communicating scenarios on the export of hydrogen to reduce misunderstandings with the local communities. Colombia is developing 30 green hydrogen projects and is currently conducting a study on the technical constraints of the grid. The study is aimed at understanding what additional investments on the grid are needed and the cost of transmission as it is currently not clear who will pay for grid expansion.

Florian Knobloch (German Federal Ministry for Economic Affairs and Climate Action) noted that in Germany the industry will be the largest offtaker of hydrogen especially in sectors which cannot be easily electrified. The country further intends to ensure grid integration of hydrogen as higher renewable energy capacity results in additional electrolyser capacity. In Germany, renewable energy penetration is currently at 60% and by 2030 is expected to grow to 80%.

Gustavo de Naciff Andrade (EPE, Brazil) noted that the incorporation of hydrogen in scenarios, causes major uncertainty in energy scenarios given the novel nature of the industry. In the short term there is already uncertainty around the domestic market as it is not clear who the potential industry off-takers are. He asked about the challenges to the electricity systems of hydrogen exporting countries as this is a new type of demand which requires a lot of investment in transmission in countries including in Chile and Brazil. He noted that there is a need for clarity on whether the projects will go forward as this impacts the final decision on investing in expanding the transmission infrastructure.

Francisco Domenech Guzmán (Ministry of Energy, Chile)- noted that projects in the south will be off-grid projects, given the national grid limitations, however there is still a need to expand the transmission infrastructure. For projects in the north of Chile it is possible to connect them to the power grid there is the question of how much investment is needed to respond to variations in demand.

Question and Answer Session

Farhan Memon (Pakistan) asked about the aggregate demand of hydrogen and which industries will be the main off-takers. He asked whether there were scenarios on the projected price of hydrogen in the coming years considering varied supply and demand. Further, he asked which countries are the potential exporters of hydrogen.

Rohit Sen (ICLE) asked which countries would be net importers and which would be net exporters. He inquired how Germany plans to ensure the security of supply given that the country intends to import two-thirds of their hydrogen in the future. Further, he asked what the role of sub-national governments would be in the industry. From a geopolitical standpoint, he enquired on what happens when there are sanctions on hydrogen exporting countries, giving the example of the oil sector where Iran and Venezuela are the largest producers of oil but due to sanctions countries cannot trade with them.

Wisdom Ahiataku-Togobo (Alternate Technology Consult Ghana) asked what the levelised cost of energy for generating power from hydrogen is projected to be. Further he asked whether there was any country generating electricity from green hydrogen and using it domestically.

Reshma Francy (World Energy Council) asked about energy equity, specifically access to clean energy. In Germany, she asked how the constraints are modelled into the sectors and how they decide which sector gets access to clean energy first. For Colombia, she asked what metrics were used to decide which stakeholder should be consulted.

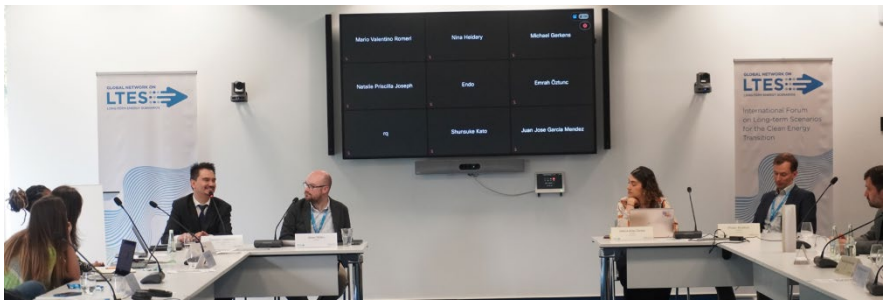
Asami Miketa (IRENA) Given Chile's approach to integrating hydrogen strategies and planning with overall national energy planning she asked what advice could be given to countries to adopt a similar approach.

Online participant- Noted that Germany has 2 scenarios and asked how the economics of hydrogen were considered. They asked whether the use of hydrogen in end use sectors more competitive than electrification in Germany.

Malik Muhammad (Pakistan) asked what kind of scenarios the German ministry ran on energy security, specifically what kind of sensitivity assessments were conducted by the Ministry of Energy.

Panel Responses

Francisco Domenech Guzmán (Ministry of Energy, Chile)- noted that Chile uses international projections to model demand of hydrogen. The country uses 3 main scenarios pessimistic, optimistic and Business and Usual (BAU). On energy security, Chile is working with the navy to pilot the use of hydrogen in ships and boats through retrofitting to ensure security of supply and national security.



In Chile all hydrogen markets are private, so the government makes proposals for the markets and works with them. The country is working towards using hydrogen in its copper mining sector to increase the production of green copper.

It was noted that Chile has proper coordination between ministries as required by law. Ministries are allowed to have their own plans but are required to coordinate with all other ministries to ensure consistency. Additionally, Chile recognizes that stakeholder participation is vital to ensure long term success of plans

Jessica Arias Gaviria (Mining and Energy Planning Unit (UPME) Colombia) noted that Colombia plans to be a net exporter of hydrogen, but contended that it would be difficult to plan for the sector without identified offtakers. She noted that Colombia engages the private sector in their planning given the high cost of hydrogen production and subsequent high cost of using hydrogen as an energy source in different industries.

It was further noted that Colombia is working to integrate metrics on water use for hydrogen projects from a regional perspective as stress on water resources may cause conflicts with local communities.

She noted that communities living near renewable energy porjects and hydrogen projects will expect lower cost of electricity, however it is vital that the government identifies avenues for financing the necessary transmission infrastructure without burdening the communities. Colombia is further analysing the impact of the hydrogen industry on electricity pricing.

To ensure proper interministerial coordination, Colombia is evaluating their Hydrogen roadmap and exploring how to integrate it with the national energy transition roadmap.

Florian Knobloch (German Federal Ministry for Economic Affairs and Climate Action) noted that Germany is working to diversify hydrogen supply and is collaborating with multiple countries to avoid over reliance on a single producer. It was noted that there will be very few major importers of hydrogen including Germany, Japan, South Korea, Belgium and the Netherlands and there will be multiple exporters as hydrogen can be produced anywhere thereby ensuring security of supply.

Germany has a website on with information on their models, methodology and results (Langfristszenarien). Germany uses least cost optimized modelling to find the lowest cost for hydrogen.

While hydrogen demand in the heating and building sector is expected to be close to zero in the electrification scenario there is expected to be some demand in the building sector in the scenario with low hydrogen cost. It was noted that in Germany's models, hydrogen is expected to be imported from Europe to ensure security of supply.

It was noted that the levelized cost of hydrogen in Germany is quite high given the double auctions of hydrogen derivatives from global markets and selling to domestic off takers. The first hydrogen contract went to a producer in Egypt who sells green ammonia at the price of 1000 USD per barrel which translated to 4 USD per kilogram of hydrogen (*News Article* The "Egypt Green Hydrogen" project in SCZONE wins a contract worth € 397 million to export green fuel to Europe). Given the high cost of hydrogen Germany does not intend to use hydrogen to produce electricity but will rely on other sources including renewable energy and battery storage technology.