Peer Review on Low-Carbon Energy Policies in Peru

APEC Energy Working Group

September 2024

Asia-Pacific
Economic Cooperation

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Preface

The APEC Peer Review on Low-Carbon Energy Policies (PRLCE) was endorsed by the APEC Energy Ministers at the 2010 Energy Ministers Meeting. The review is an extension of APEC Peer Review on Energy Efficiency and follows the same guidelines. The PRLCE seeks to achieve the following objectives:

- Share information on low-carbon energy performance as well as on policies and measures for improving and promoting low-carbon energy in respective economies.
- Provide opportunities for learning from the experiences of other economies and for broadening the network among low-carbon policy experts.
- Explore how low-carbon goals on an overall and /or sectoral basis and action plans could be effectively formulated in each economy under review, taking into account the range of possible strategies that could be used, according to the circumstances of each economy.
- Monitor progress on attaining low-carbon energy goals on an overall and/or sectoral basis and implement action plans if such goals and action plans have already been formulated at the time of the review.
- Provide recommendations for voluntary implementation on how the implementation of action plans could be improved with a view to achieving low-carbon energy goals.

Peru volunteered to undertake the seventh PRLCE since 2012 and one of the first in-person activities of APERC following the COVID-19 pandemic in 2020. The last PRLCE was conducted in Papua New Guinea in 2017.

This report presents the results of a peer review of low-carbon energy policies conducted in Lima, the capital city of Peru.

The primary accountability for each peer review is shared by the economy being reviewed and the Review Team. The peer review in Lima was conducted by a team of five experts (*see Appendix A*) who visited Peru from 4-8 December 2023. During the visit, the Review Team had a comprehensive discussion on low-carbon energy policies with representatives and experts from government ministries and agencies and private and government-owned companies *(see Appendix B*). The Review Team wishes to thank all the presenters and others involved who spent time with the team for discussions, especially the representatives of the General Directorate of Energy Efficiency-Ministry of Energy and Mines of Peru who organised the event.

Executive Summary

Peru's economy experienced notable growth during the past decade with mining and agroindustry playing crucial roles in its economic growth. Peru is committed to the promotion of Low-Carbon Energy, which is reflected in its Nationally Determined Contributions (NDCs). These contributions aim to comply with the agreements and decisions of COP 19, which were ratified during COP 20.

Energy policies are in place that establishes the government legal framework, with emphasis on the promotion and protection of private investment, minimising social and environmental impacts and encouraging energy markets, as well as promoting energy efficiency and development of renewable energies at local, regional, and government level. The Peruvian energy sector operates within a specific institutional framework that includes various government bodies, regulatory entities, and organisations responsible for overseeing and managing different aspects of the energy industry.

Peru has initiated a movement towards a liberalised energy sector, introducing market-oriented reforms to promote competition, attract private investment, and enhance efficiency in its energy industry. Peru has liquified natural gas (LNG) and renewable energy potentials to be exploited. The economy used the renewable energy auction as the mechanism for developing renewable energy projects to diversify the energy fuel mix of the power sector. These auctions involved competitive bidding processes where renewable energy developers submit proposals to supply a certain amount of electricity generated from renewable sources to the grid. Almost all renewable energy projects that are operating in the domestic electricity grid by mid-2023 were developed using this mechanism. In recent years, new projects solar and wind power plants have been developed independently from these auctions, mostly related to some energy demand projects such as mining.

The economy has made quite a few achievements to improve its low-carbon energy policies. During the peer review, the experts came up with several recommendations that will further help the economy achieve its low-carbon energy goals. Among them were as follows:

- **Establish a formal platform for discussion of low-carbon energy policy** among all the stakeholders of the energy sector. Periodical workshops or seminars, publications of special studies, use of social media and other tools can be used to disseminate information and promote discussion.
- **Enhancing monitoring and evaluation of the implementation of low-carbon energy policies.** Inadequate monitoring and evaluation mechanisms make it difficult to assess the impact of renewable energy policies accurately. The lack of data for solar water heater deployment, off-grid renewable energy, cogeneration, and distributed generation.

- **Identifying the sectors, processes, and actions that could contribute most to reach a low-carbon economy in Peru**, to understand the challenge and implications of the NDC goals.
- Because the production of hydrogen is promising in Peru, it is recommended to **consider initially collocating hydrogen production and market offtakes (customers)[1].**
- **Invest in energy storage technologies, such as advanced batteries, to store excess energy during peak production times and release it during periods of low production.** This approach would help mitigate the impact of intermittency and contribute to a more stable energy grid. This initiative requires updating the relevant regulatory framework of the electricity market accordingly.
- In relation to Peru's plans to increase low-carbon transportation, **consider a long-term plan for transportation decarbonisation including a target of reducing greenhouse gas (GHG) emissions over time.**
- **Consider reviewing the current tariff structures and regulatory frameworks to incentivise the injection of surplus energy from distributed renewable energy into the grid.** To ensure the sustainability of distributed generation (DG) integration, the current regulatory framework should be revisited.

[1] Current gray hydrogen users are likely to be the initial adopters of clean hydrogen. The demand for clean hydrogen as a fuel is expected to increase in the coming years.

Summary of Recommendations

1. Institutional Context

Recommendation 1: Strengthen the collaboration of several institutions in the development, implementation, and follow-up of low-carbon energy policies with long-term vision. This collaboration requires the definition of roles and responsibilities and the establishment of communication channels that can be used during the different stages of implementation of the low-carbon energy policies that ensure that all the institutions involved have the same overarching goals and vision and that potential synergies and conflicts have been identified. The National Policy Guide published by the Strategic National Planning Centre provides a good reference for the methodology that can be implemented. Leadership of these efforts should be defined by Peru. Typically, they are carried out by the institution in charge of energy policies, but despite leadership, the goal is strengthening collaborative capability among different institutions.

Recommendation 2: Long-term prospective studies, spanning 30 to 50 years into the future, provide valuable insights into the potential opportunities and risks for the development of the energy sector, considering that energy infrastructure requires several years to be developed and several years of lifespan. Given that Peru has the capability to produce those medium- and long-term studies, it is recommended to publish periodic preliminary analyses (every two or three years) to guide the discussion in the energy sector. Events that may have a short-term impact, such as temporary disturbances in the energy market, should be addressed in other types of studies. It is important to recognise that these studies do not predict the future; rather, they serve as tools to assist policymakers in decision-making.

Recommendation 3: Further to the formal collaboration platform for low-carbon energy policy involving all the energy sector stakeholders. MINEM should organise periodic workshops, seminars and publications of special studies to collaborate with the discussion. Additionally, the use of social media and other communication tools can be used to effectively disseminate information and promote discussion.

Recommendation 4: Revise the existing policies to verify consistency and coherence. This will help to identify problems that can be avoided in the design of future measures.

Recommendation 5: Enhancing coordination and collaboration between the energy efficiency and energy planning units of MINEM and the various entities of the public sector within and outside of MINEM.

Data monitoring and management

Recommendation 6: Data collected should be coordinated, and cooperation should be enhanced. A Ministerial level of directives could be issued for MINEM as lead agency to collect data from relevant agencies, for example power generation and consumption data from COES, macroeconomic information from Ministry of Economy and Finances, etc. Data sharing should be enhanced to ensure consistency, especially in calculating goals.

Recommendation 7: Cooperation with other interested parties should be strengthened to assist the government in making policies related to low-carbon energy policies. As mentioned in the earlier recommendation, MINEM should be the lead agency to collect the needed information to ensure that effective low-carbon policy goals are developed.

Recommendation 8: Increase collaboration/coordination with other international organisations, especially for capacity building. The respective units of the government that are responsible for low-carbon energy development should assess the requirements of its workforce and review the need for training across the board. There are several international capacity building programs which can be availed for free. This is important in view of the rapid changes in the energy sector and the increasing penetration of new energy products and technologies.

Recommendation 9: Establish ministerial regulation on data collection and management, ensuring accountability for each relevant agency, big energy consumer, key private and government-owned company when it comes to the provision of data and information on low-carbon energy supplies.

Recommendation 10: Develop strategies to gather data from challenging sectors to understand the behavioural patterns of end-user energy consumption, such as the rural areas, public transport, or informal sectors. Collaboration with Peru's National Institute of Statistics and Informatics can aid in developing these strategies, incorporating methods such as surveys and utilising local government data.

Recommendation 11: Upgrade the infrastructure in communication technology (hardware, software and so forth) including the development of human resources and capacity building for central data and information on low-carbon energy supplies.

2. Low-carbon energy goals, targets and strategy

Recommendation 12: We highly recommend identifying the sectors, processes, and actions that could contribute most to reaching a low-carbon economy in Peru. To understand the challenge and implications of the NDC goals, it is suggested to provide a clearly defined reference scenario with the identification of the detailed contribution from each sector. The energy sector contributions can be estimated by MINEM.

Recommendation 13: It is important to use the marginal abatement cost curve (MAC) as a tool to prioritise the most cost-effective actions. Once the analysis is available, it would be easier to define a low-carbon roadmap by defining the first measures, which are the most cost-effective, and identifying the first movers to start with. Moreover, after identifying those measures, it would be recommended to set a policy framework and governance to assess progress on their implementation. Having a measurement reporting and verification system helps to track the results, outcomes, and impacts of this low-carbon energy strategy.

Recommendation 14: Consider specific strategies for the use of natural gas and decarbonisation path.

Recommendation 15: Installing greater renewable energy capacity.

Recommendation 16: Adopting a more aggressive strategy in transport.

Recommendation 17: Assessing the possibility of further potential instruments. There is a set of potential instruments that are harder to implement and require transversal technical and political consensus. We suggest carefully assessing some of these, such as among others, carbon or green taxes, cap-and-trade schemes for industries and power plants, etc.

3. Green hydrogen plans and programs

Recommendation 18: Focus initially on potential major hydrogen off-takers.

- e.g., ammonia and synthetic chemicals/fuels for export.
- Promotes rapid supply chain development and economies of scale.

Recommendation 19: Consider initially collocating hydrogen production and market offtakes (customers).

- Delivery infrastructure and storage are costly without large-scale demand.

Recommendation 20: Consider initially collocating hydrogen production with renewable power sources (off-gird)

- For low-cost power, it improves the economics of hydrogen production.

Recommendation 21: Consider transportation applications of hydrogen that share common infrastructure in the near term.

- e.g. large transit buses and heavy truck fleets that come back to the depot for refuelling.
- Lower cost due to economies of scale and high infrastructure utilisation.
- Consider hydrogen liquefaction and liquid hydrogen delivery for distributed vehicle markets for low-cost delivery and fuelling.

Recommendation 22: Consider synergies with planning for other energy sectors.

- e.g., synergies of green hydrogen production with planning of renewable power generation expansion, and potential of electrolysers to provide grid ancillary services.
- e.g., making natural gas pipelines compatible with hydrogen for future utilisation without the need for major retrofits.

Recommendation 23: Consider using existing techno-economic analysis (TEA) and life cycle analysis (LCA) tools to evaluate cost trajectories and potential GHG emissions reduction towards achieving targets for various hydrogen production and delivery pathways, and various end-use applications.

- Use publicly available tools, e.g., H2A, HDSAM, GREET, etc.

- To inform decarbonisation strategies, hydrogen roadmap development, deployment plan and policymaking.

4. Renewable energy sources (hydropower, ocean energy, geothermal, solar and wind)

Recommendation 24: Invest in energy storage technologies, such as advanced batteries, to store excess energy during peak production times and release it during periods of low production. This approach would help mitigate the impact of intermittency and contribute to a more stable energy grid.

Recommendation 25: Develop and implement smart grid technologies. These technologies can enhance grid flexibility, enable real-time monitoring, and facilitate efficient management of energy distribution. By investing in grid upgrades, Peru can better accommodate the integration of renewable energy and ensure a more reliable and resilient energy system.

Recommendation 26: The Peruvian government should establish clear, transparent, and long-term policies that provide incentives for renewable energy development. This may include mechanisms such as feed-in tariffs, tax credits, and regulatory frameworks that support the seamless integration of renewable energy into the existing energy landscape.

Recommendation 27: Peru should encourage public-private partnerships, offer financial incentives, and explore innovative financing models. By creating a favourable investment climate, the economy can attract more funding for renewable energy projects and alleviate the financial burden on developers, thereby accelerating the transition to sustainable energy sources.

Recommendation 28: Peru should establish research and development initiatives, promote collaboration between industry and research institutions, and provide support for pilot projects. This approach will enable the economy to address technological uncertainties, validate the performance of new technologies, and foster their integration into the mainstream energy landscape.

Recommendation 29: Comprehensive community engagement strategies are essential. These strategies should include education and awareness programs to address concerns, involve local communities in decision-making processes, and ensure a more favourable reception of renewable energy projects. By actively engaging with communities, Peru can build trust, garner support, and promote the successful implementation of renewable energy initiatives.

Recommendation 30: Regional-specific mapping methodologies should be developed, accounting for the diverse geographical features and resource availability.

Recommendation 31: Peru should invest in advanced data collection technologies, satellite imagery, and ground-based measurements. Collaborating with international organisations and leveraging open-source data can enhance the accuracy and reliability of the mapping process.

- A regular reconnaissance survey should be conducted across the regions in Peru. Potential RE sources may still be untapped.

Recommendation 32: Peru needs to enhance the National Energy Policy of Peru 2010-2040 to include a clear target to support NZE by 2050 and enhance the D.L. N° 1002 (May 2008) to include a clear timeline and increased target until 2050.

Recommendation 33: Peru needs to introduce financial incentives, subsidies, and microfinance programs to make clean cooking technologies more affordable. Collaborate with international organisations for funding support.

Recommendation 34: Peru needs to establish a centralised authority or task force (MINEM) dedicated to coordinating renewable policies including biomass and clean cooking initiatives. Encourage interagency collaboration to ensure a unified approach.

Recommendation 35: Peru needs to implement robust monitoring and evaluation systems to track the adoption of renewable technologies, assess environmental impacts, and measure health improvements as well as regularly update policies based on evaluation results. Institutions that can be involved in this task can be the Ministry of Energy, OEFA, the Ministry of Health, and others.

5. Low-carbon transportation/ mobility

Recommendation 36: Develop professional and technical training to accommodate the deployment of new technologies.

Recommendation 37: Consider developing a more detailed emissions inventory for on-road transportation by vehicle class and fuel use (e.g., cars, light trucks, heavy trucks, etc.)

Recommendation 38: Consider a long-term plan for transportation decarbonisation including target GHG emissions reduction over time.

Recommendation 39: Consider fuel economy (energy efficiency) improvement and hybrid powertrains in the near term.

Recommendation 40: Consider electrification of transportation planning along with grid expansion/upgrade planning.

Recommendation 41: Consider electro-fuels (e-fuels) for hard-to-decarbonise transport applications, e.g. aviation, marine and agriculture/mining vehicles.

Recommendation 42: Consider using vehicle simulation tools (e.g., FASTSim) to evaluate vehicle efficiency benefits of electrification for road transport strongly impacted by the duty cycle for various on-road transport applications can also inform onboard storage requirements and vehicle cost premiums over conventional vehicles.

Recommendation 43: Consider using existing techno-economic analysis (TEA) and life cycle analysis (LCA) tools to evaluate cost trajectories and potential GHG emissions reduction towards to achieve vehicle/fuel cost and emissions targets.

- use publicly available tools, e.g., H2A, HDSAM, HEVISAM, GREET, etc.

- evaluate alternative decarbonisation options based on total cost of ownership (TCO)

Recommendation 44: Consider using the above tools to develop marginal abatement cost curves (MACC) to inform decarbonisation strategies, electrification roadmap development, deployment plan and policy making.

Recommendation 45: Consider vehicle fleet turnover rate in achieving decarbonisation targets and goals.

Recommendation 46: Consider electro-fuels (e-fuels) as an indirect electrification option for hard to decarbonise transport applications.

- e.g., synthetic fuels (ammonia, methanol, FT fuels) for non-road applications (e.g., marine, aviation, mining and agriculture equipment, etc.)

Recommendation 47: Enhance regulatory framework to ensure the safe and efficient operation of charging infrastructure of electric vehicles. This regulation includes ensuring compliance with proper safety codes, technical specification, and implementing guidelines for grid integration to manage the impact of EV changing on distribution networks.

7. Power supply system (Regulation and infrastructure)

Recommendation 48: Revise the National Energy Policy to align with global commitments and technological advancements.

Recommendation 49: Consider reviewing the current tariff structures and regulatory frameworks to incentivise the injection of surplus energy from distributed renewable energy into the grid.

Recommendation 50: Empower the distribution sector and foster collaborative DG integration planning.

Recommendation 51: Formulate and implement a comprehensive National Electromobility Plan. The plan can be developed by the Ministry of Energy in collaboration with other institutions, such as the Ministry of Transport and Telecommunications and the Ministry of Environment, as seen in Chile. Alternatively, a more central authority, such as the State Council in China, can oversee the plan, as demonstrated by China's New Energy Vehicle Industrial Development Plan for 2021 to 2035.

Recommendation 52: Adopt flexible grid planning and embrace multi-scenario approaches.

APEC PEER REVIEW ON LOW-CARBON ENERGIES (PRLCE)

PART 1: Background Information

*This part of the report was contributed by the government of **Peru** and includes basic information on renewable energy and the main institution associated with energy in the economy. The main purpose of this part is to provide the reader with the context within which the review team based its recommendations.*

The report shows various aspects of renewable energy, including current policy and objectives and renewable energy activities.

A. Overview

Peru is in western central South America, surrounded by Ecuador and Colombia to the north, Brazil to the east, Bolivia to the southeast, Chile to the south, and the Pacific Ocean to the west. It has a land area of approximately 1.28 million square kilometres, making it the 19th largest economy in the world. Peru's geography is diverse, featuring coastal deserts, highland mountains (including the Andes), the second highest in the world, and the Amazon rainforest. The intricate interplay of geographical diversity makes it distinguished by its biodiversity and abundant natural resources.

Peru's economy experienced notable growth during the past decade. This growth was driven by the growth of economic sectors such as mining, agriculture, manufacturing, and services. The mining industry plays a crucial role in its economic growth, as Peru is a major global producer of minerals like copper, gold, and silver. Agriculture also contributes significantly, with products like coffee, blueberries, avocados, and asparagus being important exports. The services sector, including tourism, has also shown substantial growth. However, this growth has decelerated during the last years due to several factors, including the COVID-19 pandemic and political instability.

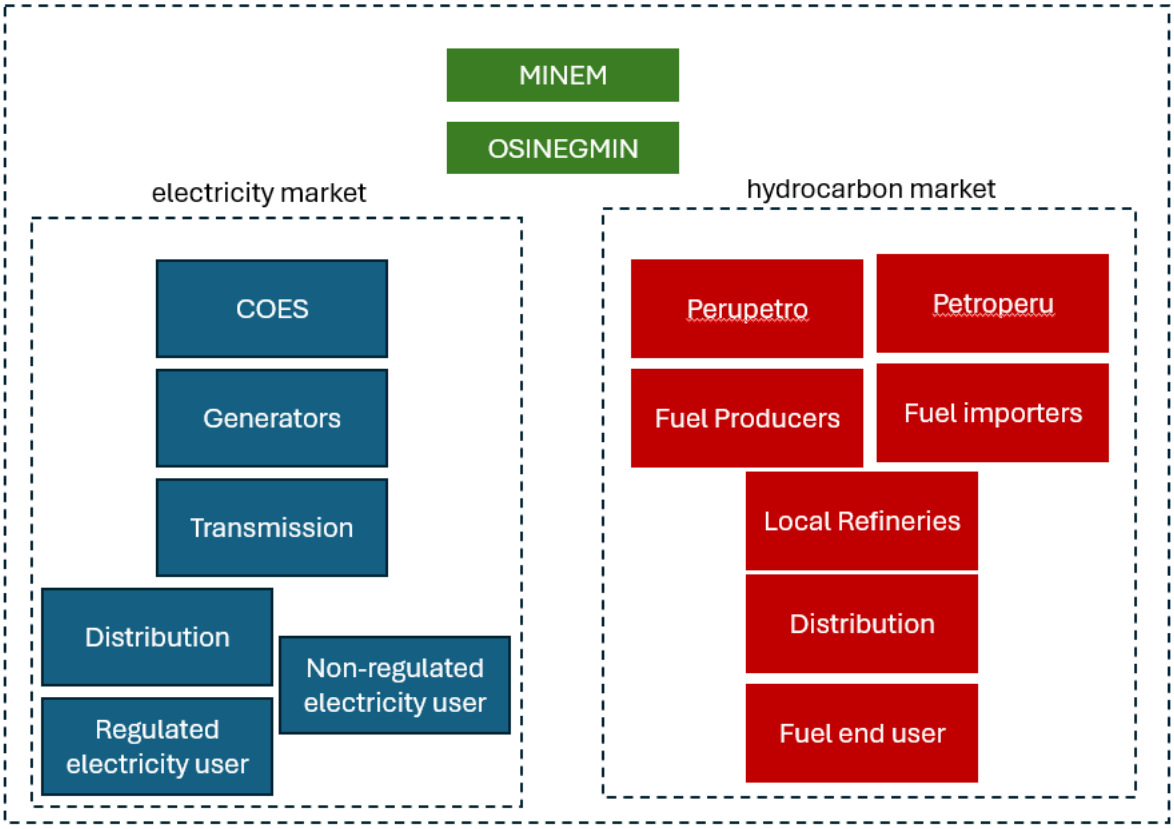
In March 2020, after the first cases of COVID-19 were reported in Peru, the government imposed compulsory social isolation, which required most people to stay at home most of the time and restricted various activities such as services and commerce. This severely impacted Peru's economy. However, Peru’s economy is still robust, and growth is expected in the near future.

Peru’s power generation comes primarily from hydroelectric power due to the presence of rivers in the Andes and the Amazon basin. This renewable energy source has been a significant contributor to the economy's energy supply. Additionally, Peru possesses some natural gas reserves, which are used in energy transformation including electricity generation (50%), exports (30%), and domestic demand (20%). The main domestic use of natural gas beyond power generation is in transport (in natural gas-fuelled vehicles, followed by buildings. Peru is also working on exploiting its domestic renewable energy potential, such as solar in the Southern regions of Peru and wind power in the Northern regions.

a) Institutional Framework

The Peruvian energy sector operates within a specific institutional framework that includes various government bodies, regulatory entities, and organisations responsible for overseeing and managing different aspects of the energy industry. The main institutions are:

Figure 1● Schematic of key stakeholders in the Peruvian Energy Sector



1. Ministry of Energy and Mines (MINEM):

The Ministry of Energy and Mines is the central government body responsible for formulating and implementing energy and mining policies in Peru. Since 2017, MINEM is divided into three vice ministries: the Vice Ministry of Electricity, the Vice Ministry of Hydrocarbons, and the Vice Ministry of Mining.

MINEM plays a key role in planning and promoting the development of the energy sector, including fostering the efficient use of energy resources and strengthening energy security.

2. Supervisory Body for Investment in Energy and Mining (OSINERGMIN):

OSINERGMIN is responsible for regulating, supervising, and overseeing energy and mining activities to ensure compliance with technical, and safety. It also promotes fair competition and consumer protection within the sectors.

OSINERGMIN has also developed rules that have effects on the energy market. For example, the new methodology to estimate the firm capacity of renewable energy plants in 2019.

3. Peruvian Electric System Administrator (COES):

The Peruvian Electric System Administrator is responsible for coordinating and ensuring the reliable and efficient operation of the domestic electricity system. COES coordinates

the operation of the generation, elaborates the binding transmission plan and the long-term transmission plan, and monitors the balance between supply and demand.

4. Perupetro:

Perupetro is a government-owned agency responsible for promoting, negotiating, and supervising exploration and exploitation contracts for the activities of hydrocarbons in Peru. Key responsibilities include the following:

Promoting investment in oil and gas exploration and production and negotiating contracts with private companies.

Monitoring and regulating the activities of companies involved in hydrocarbon exploration and production to ensure compliance with government laws and regulations.

Additionally, there are other institutions that although their activities are not exclusively focused on the energy sector, their responsibilities have direct influence on the development of energy projects.

5. Ministry of the Environment (MINAM):

The Ministry of the Environment plays a role in ensuring that energy projects and activities adhere to environmental regulations and sustainability standards. Two institutions attached to MINAM are key to ensure an environmental sustainability of the development and operations of energy projects: the National Service of Environmental Certification for Sustainable Investment (SENACE) that is responsible for evaluating and approving Environmental Impact Assessments (EIAs) for investment projects in Peru and the Environmental Assessment and Control Agency (OEFA) that is responsible for the supervision, monitoring, and enforcement of compliance with environmental regulations across various sectors including energy.

6. Financing Development Corporation (COFIDE):

COFIDE is the development bank of Peru whose objective is promoting sustainability. It also contributes to the diffusion of renewable energy and energy efficiency by facilitating access to credits and adequate technical support for energy projects. COFIDE has implemented COFIGAS, a program designed to promote the conversion of vehicles from gasoline to natural gas as well as to finance the relevant infrastructure. It has also implemented BIONEGICOS, a program focused on new projects that involve small and micro businesses with initiatives related to energy efficiency and renewable energy.

7. Private Investment Promotion Agency (ProInversión):

ProInversión is a specialised government institution attached to the Ministry of Economy and Finance that is responsible for promoting private investment in Peru by managing the privatisation of government assets, promoting public-private partnerships (PPPs), and facilitating private sector involvement in infrastructure and development projects, including the ones in the energy sector.

b) Characteristics of the electricity market in Peru

There are several government-owned and private companies that play significant roles in implementing policies and initiatives to meet the economy's energy-related goals, however, since the big reform of the energy sector at the beginning of the last decade of the previous century, Peru has initiated a movement towards a liberalised energy sector, introducing market-oriented reforms to promote competition, attract private investment, and enhance efficiency in its energy industry. Key characteristics of the Peruvian energy sector are the following:

Market Opening: Peru has implemented measures to open its energy market to private sector participation. This has led to the establishment of competitive markets for electricity generation and supply.

Independent Regulation: Regulatory bodies, such as OSINERGMIN, oversee and regulate the energy sector to ensure fair competition, set technical standards, and protect consumer interests.

Generation and Distribution: The generation and distribution of electricity have become more open to private investment and competition. Independent power producers are allowed to enter the market and supply electricity to the grid.

This indicates that Peru has demonstrated a preference for market-driven initiatives to shape the energy sector. However, Peru has sometimes used other mechanisms to achieve its objective.

Between 2008 and 2012, Peru used the renewable energy auction as the mechanism for developing renewable energy projects to diversify the energy fuel mix and reduce reliance on fossil fuels. These auctions involved competitive bidding processes where renewable energy developers submit proposals to supply a certain amount of electricity generated from renewable sources to the grid. Almost all renewable energy projects that are operating in the domestic electricity grid by mid-2023 were developed using this mechanism. In recent years, new projects solar and wind power plants have been developed independently from these auctions, mostly related to some demand projects such as mining.

c) Energy Situation

c.1 Total primary energy supply

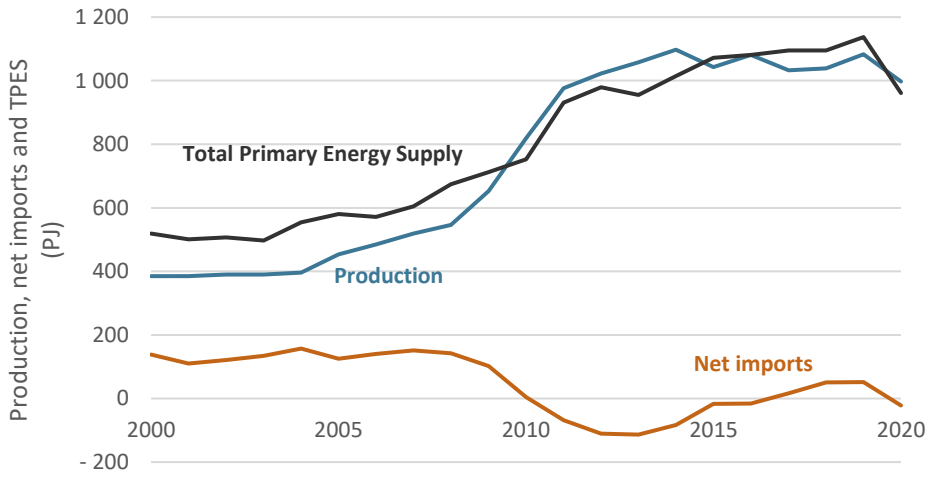
Energy statistics in 2020 show the pandemic's impact on the Peruvian energy system. Strict lockdowns and restrictions on several economic activities, such as transport, were imposed, affecting fuel demand and supply.

Oil production was reduced, especially in some oil blocks located in the Amazon basin where production was suspended. Oil production fell by almost 25% during 2020. Additionally, Petroperú, the economy-owned oil company, suspended operations in the North Peruvian Oil pipeline that transports crude oil from the jungle to the coast because of the implementation of upgraded safety measures against the pandemic and social conflicts that appeared at the end of the year.

On the other hand, associated natural gas liquids and natural gas production fell 10% during the same period. Consequently, Peru's total primary energy production (TPES) fell 7.9% in 2020 from 2019 levels, reaching 961 PJ (Expert Group on Energy Data Analysis [EGEDA], 2022).

However, due to the drastic reduction in domestic fuel demand, imports of oil and oil products were reduced, and Peru became a net energy exporter for the first time since 2016 (APERC, 2023) *(Figure 2).*

Figure 2 ● Peru's energy supply, production, and net imports (PJ), 2000 to 2020



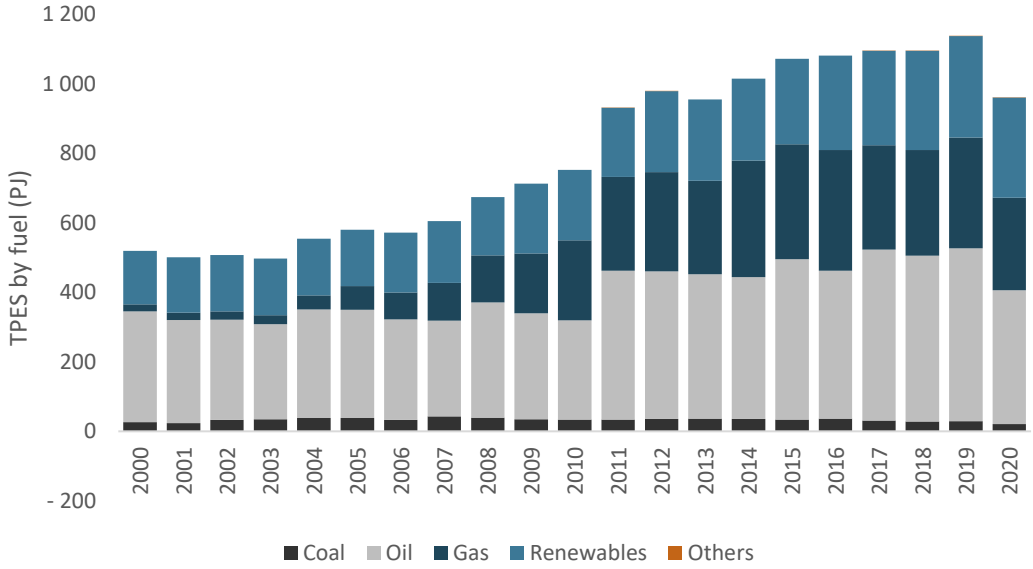
Source: APERC, 2023

The energy supply from renewable energy was affected the least, as it was reduced only by 1.2%, falling from 292 PJ in 2019 to 288 PJ in 2020 (EGEDA, 2022). Renewable energy is used mainly in electricity generation where these power plants have priority in dispatching electricity to the grid. Another important use of renewable energy is for cooking in the residential sector.

Additionally, the gas supply decreased 16%, from 319 PJ in 2019 to 266 PJ in 2020, and the oil supply decreased 23%, from 497 PJ in 2019 to 385 PJ in 2020.

On the other hand, the coal supply was reduced by 8 PJ in 2020 from 29 PJ in 2019, representing a decrease of 30%, although coal represents just 2% of the total primary energy supply *(Figure 3)*.

Figure 3 ● Peru's energy supply by fuel (PJ), 2000 to 2020



Source: APERC, 2023

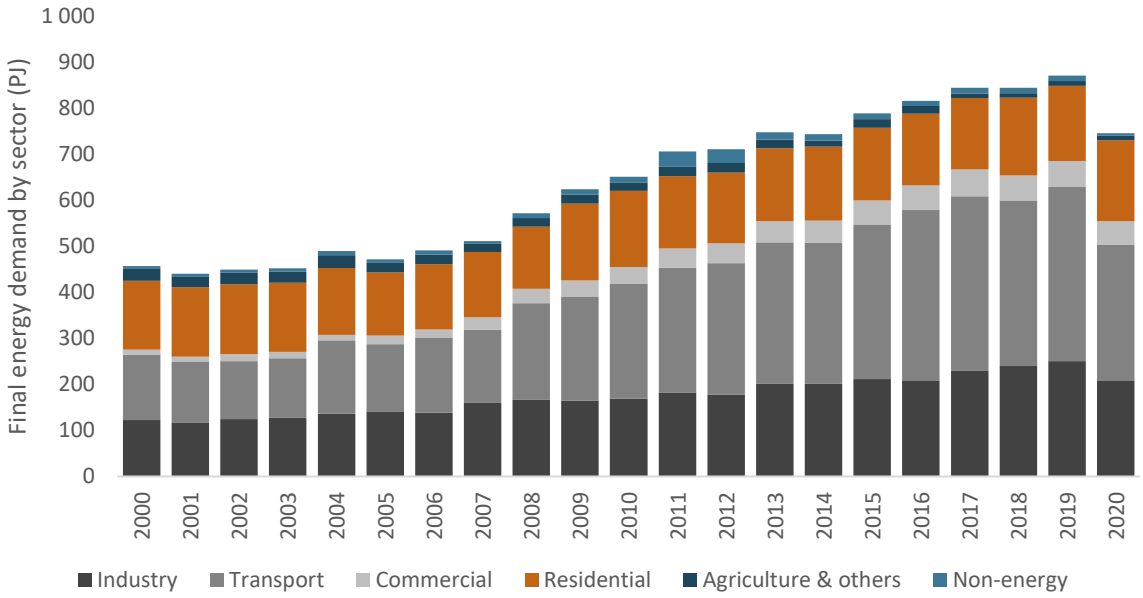
The Peruvian electricity energy mix was historically characterised by a significant reliance on hydroelectric power, accounting for approximately 85% and the rest was supplied by diesel, fuel oil and coal power plants until 2004. After the discovery of the natural gas reservoir in Camisea in the Peruvian jungle, the largest natural gas reservoir in South America, there was a substantial shift towards natural gas-based power generation. As of the 2021 Peru Energy Balance report, hydropower plants contributed 56% of electricity generation, while natural gas-fuelled power plants, predominantly of the combined cycle type, constituted 37%. Solar and wind sources collectively comprised 5%, followed by 1% from biomass and biogas, and the remainder from fuel oil, diesel, and coal power plants.

c.2 Total final consumption (including non-energy)

Energy demand in the residential sector grew 7.7% from 163 PJ in 2019 to 176 PJ in 2020. This growth was higher than the average annual rate of 0.6% in the previous decade and was the result of compulsory social isolation and the implementation of teleworking and distance education.

Energy demand in the other sectors was reduced drastically. Transport, the main energy consumer, decreased 22% from 377 PJ in 2019 to 295 PJ in 2020. This was a consequence of the measures of immobilisation implemented by Peru that restricted travellers' long-distance trips, closed international borders, reduced local transport capacity to 50% and promoted teleworking. *(Figure 4)*.

Figure 4 ● Peru's final consumption by sector (PJ), 2000 to 2020



Source: APERC, 2023

Industry energy demand was reduced by 17% from 251 PJ in 2019 to 207 PJ in 2020. Several industrial activities were suspended or restricted because new safety protocols needed to be implemented before activities could be resumed.

The commercial sector, which includes public and private services, also reduced its energy consumption by 9.2% from 57 PJ in 2019 to 51 PJ in 2020. The sector gradually resumed activities in accordance with the government calendar.

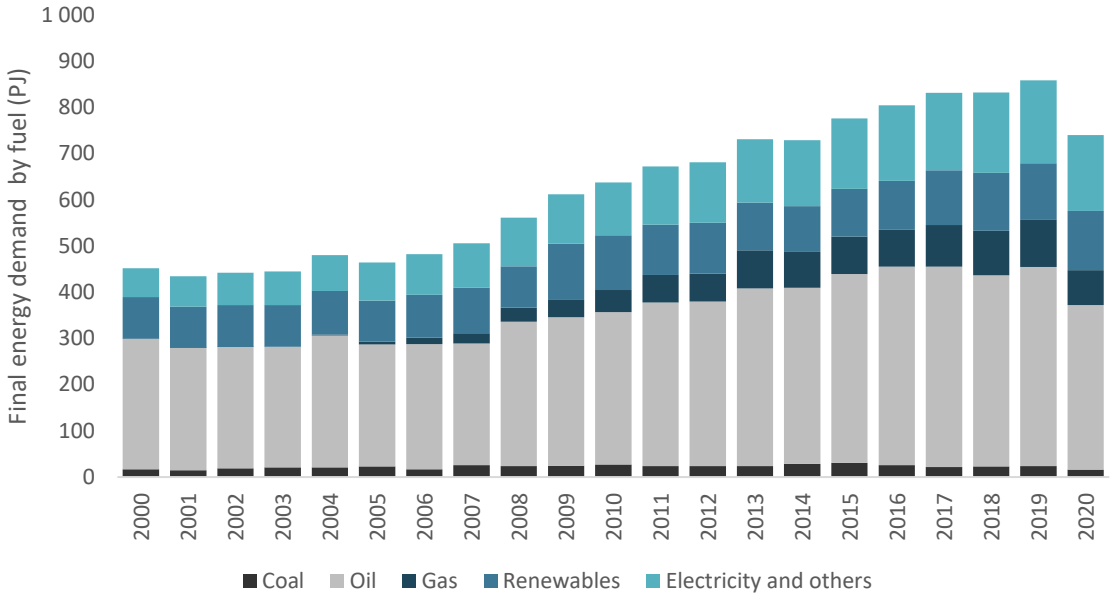
Despite the serious restrictions imposed on transport, this sector was the main energy consumer in 2020, using 40% of total energy. Industry consumed 28% and was the second largest consumer, while the residential sector consumed 24% and was the third main energy consumer in Peru. The main difference between Peru and APEC concerns the share of transport. In APEC, transport represented 25%, but industry was 34%, indicating the importance of the industrialised economies in defining APEC's final energy consumption.

Another important difference is observed in the share of non-energy, which includes the use of fuels as raw materials for non-energy products such as lubricants. In APEC, non-energy use represents 13% of final energy consumption while in Peru it is 0.7%.

c.3 Final energy demand (excluding non-energy)

Demand for all fuels except for renewable energy was reduced in 2020. Coal demand was reduced by 33%, oil and oil products demand by 17% and natural gas demand by 26%. In contrast, renewable energy demand increased by 4.2%. This trend is explained by a decrease of activities in the industry and commercial/services sectors, and restrictions in transport. Increased demand for renewables is indicated by the estimated increase in traditional biomass consumption in the residential sector *(Figure 5)*.

Figure 5 ● Peru's final energy demand by fuel (PJ), 2000 to 2020

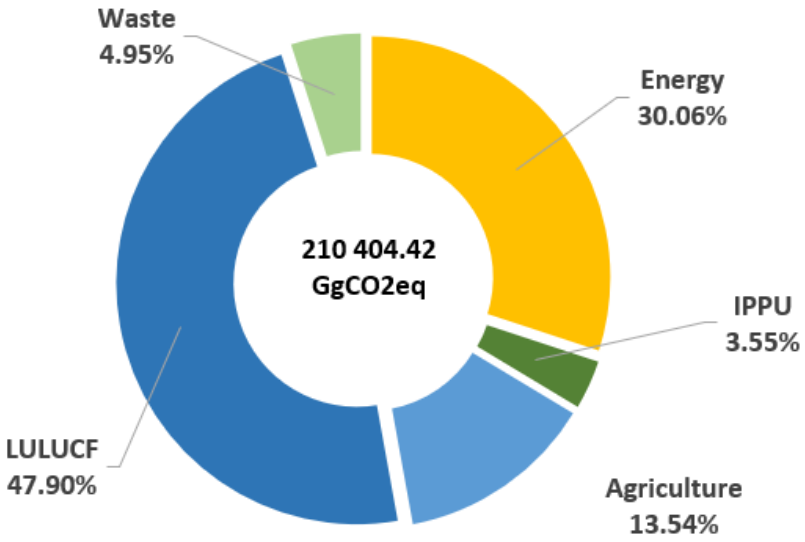


Source: APERC, 2023

c.4 Emissions

Peru's 2019 Greenhouse Gases Inventory reveals that the sectors that contribute the most to GHG emissions are *Land use, Land-use Change, and Forestry* (LULUCF) with a share of 47.9%, e*nergy* with 30.1%, and *agriculture* with 13.5% (MINAM, 2019). The main contributors to the emissions are transport (40.6%), energy industries (20.1%), and fugitive emissions from oil and gas production (16%), while other activities account for 23.3% of GHG emissions.

Figure 6 ● Emission gas distribution by sector in Peru, 2019



Source: MINAM, 2019

In particular, the electricity sector is responsible for around 8% of emissions, given that most of the generation is mainly hydros and combined-cycle natural gas fuelled power plants.

Peru is committed to the promotion of Low-Carbon Energy, which is reflected in its Nationally Determined Contributions (NDCs). These contributions aim to comply with the agreements and decisions of COP 19, which were ratified during COP 20.

The following section formed part of the peer review on the measures associated with energy in Peru's NDCs. It shows the accomplishments and difficulties faced by Peru's low-carbon energy goals, targets, and strategy and provides recommendations accordingly. Both targets and progress were evaluated based on the insights shared in the peer review sessions and additional information gathered from public documents.

B. Main Energy Policies

The National Energy Policy 2010-2040, currently under revision, provides the key principles supporting the development of Peru’s energy sector. These principles include reliable and accessible sustainable energy to support Peruvian economic growth. Later, energy policies and initiatives are aligned with this vision, emphasising the sustainability of energy resources.

On the other hand, the Ministry of the Environment has issued policies emphasising environmental sustainability. While covering multiple sectors, these policies have a significant impact on Peru’s future energy landscape.

The main characteristics of these policies are described as follows:

a) National Energy Policy 2010-2040, Supreme Decree N°064-2010-EM

This energy policy establishes the government legal framework, with emphasis on the promotion and protection of private investment, minimising social and environmental impacts and encouraging energy markets, as well as promoting energy efficiency and development of renewable energies at local, regional and government levels. The most important objectives of the energy policy are the following:

- To achieve a diversified energy fuel mix, with emphasis on renewable sources and energy efficiency by incorporating a variety of sources, including hydroelectric, natural gas, oil, and renewable energy (solar, wind, and biomass). This diversification of fuels aims to reduce dependence on a single energy source and enhance energy security.
- To develop a competitive energy supply.
- To achieve universal access to energy supply. Peru has aimed to expand energy access, especially in rural and remote areas. This includes initiatives to extend electricity coverage to underserved communities and promote clean cooking solutions.

- To promote the highest efficiency in the supply chain and the use of energy.
- To achieve self-sufficiency of energy supply.
- To develop an energy sector with minimum environmental impact and low-carbon emissions within a sustainable development framework.
- To develop the natural gas industry and promote its use in domestic activities, transportation, commerce, and industry, as well as efficient electricity generation. Natural gas has become an important component of Peru's fuel mix. The Camisea Gas Project, one of the largest in South America, has significantly increased the availability of natural gas for electricity generation, and domestic consumption.
- Strengthening the institutional framework of the energy sector.
- To integrate the Peruvian energy market with energy markets in other economies in South America.

b) Law N° 27345

This Law aims to declare the promotion of the Efficient Use of Energy (UEE) of economywide interest to ensure the supply of energy, protect the consumer, promote the competitiveness of the economy and reduce the environmental impact negative impact of the use and consumption of energy and Supreme Decree 053-2007-EM which aims to regulate Law No. 27345, Law for the Promotion of the Efficient Use of Energy, in order to promote the efficient use of energy in the economy, contributing to ensuring the supply of energy, improve the economy's competitiveness, generate exportable balances of energy, reduce the environmental impact, protect the consumer and strengthen awareness in the population about the importance of the Efficient Use of Energy (UEE).

c) Framework law for Climate Change, Law N° 30754, and its Regulation, Supreme Decree N°013-2019-MINAM

The Framework law on Climate Change, enacted in 2018, and its subsequent regulation, published in 2019, establish a comprehensive set of principles, approaches, and overarching provisions of actions to face the challenges of climate change. The objective is to effectively coordinate, integrate, design, implement, report on, monitor, evaluate, and communicate public policies pertaining to the holistic, participatory, and transparent administration of climate change adaptation and mitigation measures. These measures serve the purpose of diminishing the economy’s susceptibility to climate variability, harnessing prospects for low-carbon economic growth, and fulfilling the commitments made by the government within the ambit of the United Nations Framework Conventions.

The Law designates the Ministry of the Environment as the government authority and leader to manage the actions to face climate change and incorporates climate changes as an integral component of the planning at the three levels of government: economy-wide, regional, and local.

Additionally, the law asks for the creation the high-level level commission on climate change, a multisectoral commission that will propose mitigation and adaptation action plan towards 2050. This commission oversees the elaborating technical reports on the

NDC every five years that will be presented to the United Nations Framework Convention on Climate Change. The commission was created in 2020.

d) Environmental National Policy towards 2030. Supreme Decree N°023-2021-MINAM

This document defines and guides the actions of the economy, regional, and local government entities, the private and public sectors until 2030 and establishes the objectives, strategies, services, and activities aimed at addressing the critical problems that affect the environment and sustainability of Peru's development.

The policy aims to safeguard the goods and services offered by ecosystems, recognising that a reduction in access to these resources can threaten economic development and environmental policies.

One of the priority objectives of the Environmental National Policy is to achieve 100% of the emissions reduction goal set up in the NDC. The goal is to reduce 30% of greenhouse gas emissions with respect to the Business-as-Usual Scenario by 2030. An extra 10% of emissions reduction will depend on international cooperation.

e) Law establishing Climate Emergency as an Economic Interest. Supreme Decree N°003-2022-MINAM

The Supreme Decree declares the economy climate emergency of general interest, to urgently execute measures to implement climate action in accordance with the provisions of the Nationally Determined Contributions for the year 2030. Moreover, it delineates priority avenues designed to bolster climate emergency initiatives, encompassing climate governance, climate change education, human rights, climate justice, and other pertinent domains.

Among the most important directives entrusted to the energy sector, this document indicates that the Ministry of Energy and Mines, in coordination with the Ministry of the Environment, must ensure the use of non-conventional renewable[2] in the electricity fuel mix. This use must follow the conditions of competitiveness and efficiency. The requirements for additional non-renewable energy capacity should be a result of the dynamics of supply and demand in the electric market. This norm also set a projection that non-conventional renewable energy will constitute 20% of the electricity mix by 2030 if competitive and efficient conditions are achieved.

Furthermore, the decree delegates to the Ministry of Energy and Mines the task of reforming the regulatory framework of the electricity sector, specifically with the aim of augmenting the utilisation of non-conventional renewable energy sources. In an additional role, the Ministry of Energy is entrusted with the design of programs geared toward promoting the advancement, application, and production of green hydrogen technologies.

[2] Non-conventional sources of renewable energy in the Peruvian legislation are defined as solar, wind, biomass, tide, and geothermal energy. Hydropower plants with capacity less than 20MW are also considered as part of this group.

f) Final Report of the Multisectoral Working Group- Nationally Determined Contributions (NDCs)

The process of preparing the Nationally Determined Contributions (NDCs) started in 2014 when the Peruvian Government established a temporary multisectoral commission. The commission was responsible for preparing the technical proposal, with the Ministry of Environment serving as the technical secretariat and president of the commission. The technical report was then submitted to the UNFCC in 2015.

Peru revised its Nationally Determined Contribution (NDC) in December 2020 for the period between 2021 and 2030. The previous NDC from 2015 aimed to reduce GHG emissions by 20% below the Business as Usual (BAU) level, with the help of public and private resources fostered by the Peruvian Government. This was the non-conditional proposal, while a 10% extra reduction was conditional to international financing and the existence of favourable conditions. Taking a step forward, the new NDC updated the target to a 30% reduction in GHG emissions. The commitment still includes an additional 10% reduction conditional on the availability of international support. The table below shows a comparison between the 2015 NDC and the 2020 NDC *(Table 1)*.

Table 1 ● Comparison of Peru's submitted NDC

Item	Metrics	NDC 2015	NDC 2020
BAU 2010	$MtCO_2eq$		170.6
BAU 2030	$MtCO_2eq$		298.3
GHG considered		CO_2, CH_4 and N_2O	CO_2, CH_4, N_2O and HFC
Mitigation Goal submitted non-conditional)		20% reduction by 2030	208.8 $MtCO_2eq$ maximum emissions by 2030
Mitigation Goal submitted (conditional)		20% reduction by 2030	179.0 $MtCO_2eq$ maximum emissions by 2030
Goal submitted (non-conditional)			
Compared non-conditional goal - Reduction by 2030	Percentage	20%	30%
Compared non-conditional goals - Reduction by 2030	$MtCO_2eq$	59.66	89.5
Compared non-conditional goals - Maximum emission by 2030	$MtCO_2eq$	238.64	208.8
Goal submitted (conditional)			
Compared conditional goal - Reduction by 2030	Percentage	30%	40%
Compared conditional goals - Reduction by 2030	$MtCO_2eq$	89.49	119.3

Item	Metrics	NDC 2015	NDC 2020
Compared conditional goals - Maximum emission by 2030	$MtCO_2eq$	208.81	179

Source: Government of Peru, 2023

Peru updated its NDCs in 2020. The Multisectoral Working Group determined 91 adaptation measures and 62 mitigation measures that aim to reduce GHG emissions on 30% (a limit of 208,8 $MtCO_2eq$) by 2030, or 40% (a limit of 179,0 $MtCO_2eq$) if international collaboration is obtained. Land Use, Land-use Change, and Forestry are responsible for more than half of the emissions of Peru and energy sector is responsible for 30% of the emissions. However, 38% of them mitigation measures are the responsibility of the energy sector.

Some adaptation measures relevant for the energy sector are the following:

- Increase of the renewable energy share in the total energy mix
- Renewable electricity supply to remote off-grid areas.
- Increase energy efficiency in residential, and public lighting.
- Increase of energy efficiency in industrial sector
- Promotion of energy efficiency labelling
- Energy audits in the public sector
- Improvement efficiency in new buildings
- Promotion of Clean cooking, to replace traditional biomass stove with less contaminant alternatives such as improved stoves or LPG.

Table 2 ● Number of measures and mitigation contributions to Peru's NDC by categories

Topic	Types of measures included	Number of measures	Potential reduction ($MtCO_2eq$) by 2030
Energy management	• Renewable Energy Combining. • Supply of electricity with renewable energy resources in off-grid areas. • Cogeneration • Distributed Generation. • Replacement of heating equipment	19	9.243
Renewable Energy	• Transformation of the lighting market in the Residential Sector. • Replacement of public appliances • Appliance labelling • Energy Audits in the Public Sector. • Replacement of appliances	5	0.762

	• Clean Cooking. • Energy management measures in the industrial and commercial sector		
Sustainable transport	• Promotion of Natural Gas Vehicles (NGV) - for light vehicles. • Promotion of the use of cleaner fuels. • Management of public system transportation • Promotion of electric vehicles economy-wide. • Promotion of Liquefied Natural Gas (LNG) for cargo transportation of the natural gas massification project. • Labelling for Light Vehicles.	14	6.935
Total		38	16.94

Source: Government of Peru, 2023

g) National Plan for Adaptation for Climate Change of Peru, Ministerial Resolution No. 096-2021-MINAM

The National Adaptation Plan is an action plan to strengthen the resilience of its people, ecosystems, livelihoods, and economies to the current and predicted impacts of climate change. It is considered a foundation for the updates to the National Strategy for Climate Change.

This document proposed thirteen strategic actions for adaptation, and among the proposed actions, the efficiency of hydric resources and energy planning are the most relevant for the energy sector.

h) National Industrial Development Policy, Supreme Decree No. 016-2022-PRODUCE

One of the primary objectives of this policy is to enhance the productivity of manufacturing industries. It recognises that incorporating circular economy principles and promoting the adoption of energy efficiency and renewable energy will significantly contribute to achieving this objective.

i) Legislative Decree for the Promotion of Investment for the Generation of Electricity with the Use of Renewable Energies, Legislative Decree No. 1002

This Law, enacted in 2008, declares that production of electricity from renewable sources of energy a general priority.

This legislation, along with its associated regulations and complementary statutes, provides the legal framework governing the promotion and regulation of power generation

using Renewable Energy Resources (RER). Notably, it identifies biomass, wind, solar, geothermal and tide energy are considered renewable energy resources. Hydropower is also classified as renewable energy if the power plant's installed capacity does not exceed 20 MW.

Additionally, the law establishes a target for the share of renewable energy in the total electricity demand. Initially set at 5%, this target was meant to be updated every 5 years, but it has not been updated.

j) Technical Regulation of Energy Efficiency Labelling, Supreme Decree No. 009-2017-EM

The decree applies to energy-using equipment, namely the following: household lamps, domestic refrigeration appliances, boilers, three-phase induction motors, inductors with squirrel-cage rotors, household washing machines, household tumble driers, air conditioners, and domestic water heaters.

Designated to promote energy efficiency by providing energy information to the users, this decree established technical specifications and ranges of energy efficiency that the equipment must show in the labels.

k) Supreme Decree that approves provisions to promote the development of energy audits, Supreme Decree No. 011-2021-EM

This norm aims to promote the development of energy audits and certification for energy auditors to promote energy efficiency public institutions and private sector. It establishes that government-owned institutions must carry out energy-audits every two years with certified energy auditors.

l) Supreme Decree that establishes measures related to the sulphur content in Diesel, Gasoline and Gasohol for its commercialisation and use and simplifies the number of Gasoline and Gasohol, Supreme Decree No. 014-2021-EM.

Starting from 1 July 2022, this decree simplifies the range of gasoline types available for commercialisation, permitting the sale of diesel B5 and gasoline with a sulphur content of less than 50 ppm.

m) National Competitiveness and Productivity Policy, Supreme Decree No. 345-2018-EF

Enacted in 2018, the National Competitiveness and Productivity Policy is a key policy framework that aims to enhance Peru's competitiveness and productivity. This policy includes the government plan that outlines priority objectives, including promoting environmental sustainability in economic activity operations.

n) Law for the Promotion of Efficient Use of Energy, Law No. 27345

This law aims to declare the promotion of Efficient Energy Use (UEE) as a matter of economywide interest to ensure energy supply, protect consumers, foster economic competitiveness, and reduce the negative environmental impact of energy use and consumption.

o) Regulation of Law N Law No. 27345, Supreme Decree No. 053-2007-EM

This norm aims to regulate Law No. 27345, the Law for the Promotion of Efficient Use of Energy, in order to promote efficient energy use in the economy, contributing to ensuring energy supply, improving competitiveness, generating energy export surpluses, reducing environmental impact, protecting consumers, and raising awareness among the population about the importance of Efficient Energy Use.

p) Supreme Decree No. 026-2010-EM

This norm establishes the functions of the DGEE regarding the promotion of efficient energy use, promotion of renewable energies, and energy planning, as well as proposing energy policy.

C. References

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APEC PEER REVIEW ON LOW-CARBON ENERGY POLICIES (PRLCE)

PART 2: REVIEW TEAM REPORT

This part 2 of the report presents the PRLCE Team's conclusions and recommendations about low-carbon energy policies and programs in Peru.

A. Institutional Context

a) Achievements

Achievement 1: Peru has established organisations and institutions with, at least, formal capacity to play relevant roles in the design and implementation of effective low-carbon policies.

- CEPLAN is a specialised technical organisation in Peru that leads the National System of Strategic Planning.
- MINAM (Ministry of Environment) designs, executes and supervises the economy and sectoral environmental policies.
- OEFA (Environmental Assessment and Control Agency) is responsible for the supervision, monitoring, and enforcement of compliance with environmental regulations.
- MINEM (Ministry of Energy and Mines) that designs and executes the policies regarding the Energy Sector. MINEM is divided into three vice ministries: electricity, hydrocarbons, and mining.
- OSINERGMIN, the energy sector regulator, although it is attached to the President of the Council of Ministers.
- COES that operates the National Interconnected Electric System.
- Other ministries

Achievement 2: Stakeholders of the energy sector acknowledge the importance of low-carbon energy and decarbonisation in the development of a future, reliable, and sustainable energy sector. These stakeholders have identified problems and barriers, and some of them are proposing solutions. Among the common problems identified by several institutions are the following:

- Update of regulatory framework
- Establishing ancillary services market
- Lack of an approved and implemented distributed generation regulation that allows its integration into the electric grid[3].

Achievement 3: There are ongoing efforts to address some of the challenges identified to expand the use of low-carbon energy. MINEM is currently working on the development of the long-term energy plan, green hydrogen roadmap, updating the electricity regulatory framework and developing a white book for the electric sector, among others.

[3] A proposed regulation was published but the regulation has not received final approval yet.

Achievement 4: MINEM, in the General Directorate of Energy Efficiency, has a long-term energy planning unit that can provide energy statistics and long-term prospective studies that are essential for the design of effective low-carbon energy measures and policies.

Achievement 5: MINEM has implemented an educational program that trains elementary public schools to teach energy efficiency and energy sustainability to their students. This program aims to increase awareness of these topics in the Peruvian students and the public.

b) Challenges

Challenge 1: Despite the existence of different institutions, efforts seemed fragmented and uncoordinated which can lead to inefficiencies, overlapping of responsibilities, conflicting goals, and missed opportunities, among other problems. Different levels of understanding of some concepts such as decarbonisation, renewable energy, energy efficiency may also cause confusion among different institutions and stakeholders.

The division of the Ministry of Energy and Mines into sub-ministries for electricity and hydrocarbons can hinder communication and coordination. A notable consequence is that the General Directorate of Energy Efficiency, responsible for designing energy efficiency policies and planning for the entire energy sector, including hydrocarbons, falls under the sub-ministry of electricity.

Challenge 2: Despite the existence of an energy policy for 2040, there is not a comprehensive medium and long-term vision of the energy sector that guides the energy sector discussion and priorities. Such a vision will allow for the adequate prioritisation of measures or actions based on criteria such as cost and effectiveness. For example, measures to expand low-carbon energy in the transport sector can be more cost-effective than some other proposed measures for the decarbonisation of transport.

Challenge 3: The Energy Planning Unit at the Ministry of Energy and Mines produces valuable information, including prospective studies of the energy sector under various scenarios. This information is crucial for discussions within the Peruvian energy sector because this information provides valuable insights into the energy system. Most of this information has not been published because the scenarios are constantly updated to incorporate new information and the effects of recent events. Given that prospective studies are not predictions of the future, their main value lies in the conclusions drawn, such as the identification of main trends, potential risks, and investment requirements. Therefore, it is essential to analyse delaying publication of the results to update the prospective studies which will significantly alter the main conclusions of the studies.

Challenge 4: Lack of a platform or channels that foster dialogue among different actors in the energy sector. Establishing clear communication channels and platforms for low-carbon policy discussion can help strengthen policymakers' capability to design adequate policies by filling some gaps that may exist in them. Additionally, it may increase transparency and, consequently, increase trust among the actors in the energy sector.

c) Recommendations

Recommendation 1: Strengthen the collaboration of several institutions in the development, implementation, and follow-up of low-carbon energy policies with long-term vision. This collaboration requires the definition of roles and responsibilities and the establishment of communication channels that can be used during the different stages of implementation of the low-carbon energy policies that ensure that all the institutions involved have the same overarching goals and vision and that potential synergies and conflicts have been identified. The National Policy Guide published by the Strategic National Planning Centre provides a good reference for the methodology that can be implemented. The leadership of these efforts should be defined by Peru. Typically, they are carried out by the institution in charge of energy policies, but despite leadership, the goal is strengthening collaborative capability among different institutions.

Recommendation 2: Long-term prospective studies, spanning 30 to 50 years into the future, provide valuable insights into the potential opportunities and risks for the development of the energy sector, considering that energy infrastructure requires several years to be developed and several years of lifespan. Given that Peru has the capability to produce those medium- and long-term studies, it is recommended to publish periodic preliminary analyses (every two or three years) to guide the discussion in the energy sector. Events that may have a short-term impact, such as temporary disturbances in the energy market, should be addressed in other types of studies. It is important to recognise that these studies do not predict the future; rather, they serve as tools to assist policymakers in decision-making.

Recommendation 3: Further to the formal collaboration platform for low-carbon energy policy involving all the energy sector stakeholders. MINEM should organise periodic workshops, seminars and publications of special studies to collaborate with the discussion. Additionally, the use of social media and other communication tools can be used to effectively disseminate information and promote discussion.

Recommendation 4: Revise the existing policies to verify consistency and coherence. This will help to identify problems that can be avoided in the design of future measures.

Recommendation 5: Enhancing coordination and collaboration between the energy efficiency and energy planning units of MINEM and the various entities of the public sector within and outside of MINEM.

B. Data monitoring and management

Given the rapid changes in the energy sector, including the increasing penetration of new energy products, technologies, and policies, the existence of quality data is of the utmost importance. Data collected provide important information on global energy development market trends and help in developing plans for economies, among other things. After obtaining the necessary data, the next challenge is compiling and maintaining them.

During the peer review in Peru, it was observed that the economy has made significant achievements in terms of data collection and management.

a) Achievements

Achievement 6: It clearly indicated the importance of data in Peru's plans and programs. Both the government and the private sectors have managed their respective data well and were able to analyse the current energy situation.

Achievement 7: The agency is building its own capacity to understand and analyse its data and incorporate it into governmental plans and visions.

b) Challenges

Challenge 5: While all relevant agencies and private sectors manage their respective data, cross-sector/agency collaboration seems lacking in harmonising their understanding of the existing data and how these data are used in developing government plans and visions.

Challenge 6: While some agencies can provide capacity building in analysis on their own, MINEM and other relevant agencies still need additional training capabilities to cope with the increasing penetration of new and renewable energy products and technologies.

Challenge 7: Each line ministry developed related energy plans, which may cause a mismatch. Communication and consultation among the different energy stakeholders may not have been sufficient.

Challenge 8: Data locations are diverse, and specific data users or agencies may probably have different understandings of the data (which is important for calculating indicators, e.g., fuel economy, emissions, etc.).

Challenge 9: Enhancing monitoring and evaluation: Inadequate monitoring and evaluation mechanisms make it difficult to assess the impact of renewable policies accurately. The lack of data for solar water heater deployment, off-grid renewable energy, cogeneration, and distributed generation.

- Without reliable data, it is challenging to identify areas for improvement and measure the success of interventions.

c) Recommendations

Recommendation 6: Data collected should be coordinated, and cooperation should be enhanced. A Ministerial level of directives could be issued for MINEM as lead agency to collect data from relevant agencies, for example power generation and consumption data from COES, macroeconomic information from Ministry of Economy and Finances, etc. Data sharing should be enhanced to ensure consistency, especially in calculating goals.

- Data should be available anytime for all the energy stakeholders to use/for reference.

Recommendation 7: Cooperation with other interested parties should be strengthened to assist the government in making policies related to low-carbon energy policies. As mentioned in the earlier recommendation, MINEM should be the lead agency to collect the needed information to ensure that effective low-carbon policy goals are developed.

- Develop a monitoring system or a team that monitors the progress of achieving the energy goal through the data collected. Improve communications across government agencies to ensure that each agency is aware of what another agency is doing.

Recommendation 8: Increase collaboration/coordination with other international organisations. especially for capacity building. The respective units of the government that are responsible for low-carbon energy development should assess the requirements of its workforce and review the need for training across the board. There are several international capacity building programs which can be availed for free. This is important in view of the rapid changes in the energy sector and the increasing penetration of new energy products and technologies.

Recommendation 9: Establish ministerial regulation on data collection and management, ensuring accountability for each relevant agency, big energy consumer and key private and government-owned company when it comes to the provision of data and information on low-carbon energy supplies.

Recommendation 10: Develop strategies to gather data from challenging sectors to understand the behavioural patterns of end-user energy consumption, such as the rural areas, public transport, or informal sectors. Collaboration with Peru's National Institute of Statistics and Informatics can aid in developing these strategies, incorporating methods such as surveys and utilising local government data.

Box B.1: Household Energy Consumption Survey: The Philippines case

Household Energy Consumption Survey (HECS) is an economywide undertaking designed to collect and update data on residential energy consumption patterns and preferences. Presents data that can be utilised by both government and nongovernment agencies, as well as the academe for in-depth research and studies. In the HECS 2011 version, it is found that fuelwood was most commonly used for cooking by more than half of households in the Philippines (54% of the total households in 2011 and 55% in 2004) (DOE, 2011).

The 2023 HECS is now ongoing (PSA, 2024).

Recommendation 11: Upgrade the infrastructure in communication technology (hardware, software and so forth) including the development of human resources and capacity building for central data and information on low-carbon energy supplies.

- Needs to provide an overview of common standard practices that maintain consistency and comparability across each agency.

C. Low-carbon energy goals, targets, and strategy

Based on Peru's third Biennial Updated Report (Government of Peru, 2023) and the presentation shown during the peer review sessions, significant progress has been made since 2015. Peru has made strides in implementing regulations and tools that can support the implementation of measures previously presented.

a) Achievements

Achievement 8: The "Framework Law for Climate Change" (LMCC) was enacted by Supreme Decree N° 30754 in 2018, and its regulation was approved by Supreme Decree N°013-2019-MINAM in 2019. This law requires Peru, across its three levels of government, to design and implement measures in the form of programs, projects, and activities towards GHG emissions reduction, and increasing carbon sequestration and sinking carbon sequestration, and sinks in a collaborative and participatory manner. According to the LMCC regulation, mitigation measures are actions that should be taken by both government and non-government actors, aiming to decrease GHG emissions and increase removals, ultimately contributing to low-carbon development in the long term. In summary, we recognise this instrument as a crucial means of defining roles and coordinating different public institutions around the NDC energy measures.

Achievement 9: The enactment of the technical Regulation of Energy Efficiency Labelling (Supreme Decree N° 009-2017-EM) in 2017. This law mandates that certain appliances must include technical specifications related to their energy consumption, reducing the economy's carbon intensity. As a result of this regulation, we have confirmed the implementation of labelling standards, as well as studies to monitor the Minimum Energy Performance Standards (MEPS) and the possible addition of new appliance labels.

Achievement 10: Peru has made significant efforts to promote energy audits in the public sector. It has introduced a regulation, the Supreme Decree N° 011-2021-EM enacted in 2021, which encourages these audits. Additionally, the Peruvian government is now considering funding energy audits for the private sector using public funds as the next step.

Achievement 11: Significant progress was made in the industrial sector. The National Industrial Development Policy (Supreme Decree N. 016, enacted in 2022) has been instrumental in promoting energy management and the use of renewable energy in manufacturing industries. Several measures have been implemented to reduce carbon emissions in industries such as Food, Steel, Metalworking, Chemical, Foundry and Refining, and Cement and Clinker. For instance, the use of waste-derived fuels as a substitute for fossil fuels in clinker production furnaces, the reduction of nitrous oxide emissions in the Nitric Acid Manufacturing Industry, and the establishment of an Eco-industrial Park project aimed at reducing resource consumption, among others.

Achievement 12: Peruvian efforts to promote cogeneration and the use of liquefied natural gas (LNG) instead of gasoline and oil for cargo transportation. Since 2009, cogeneration has been promoted, leading to the authorisation of seven thermic plants. On the other hand, the promotion of LNG has gained momentum with various regulations such as Ministerial Resolution N. 127-2021 (issued by the Ministry of Energy and Mining/DM) and Directorial Resolution N. 486-2021 (issued by the Ministry of Energy and Mining/DGH).

b) Challenges

As in all emerging economies, it is challenging to strike a balance between low-carbon strategies and policies that can reduce GHG emissions while also bringing social and economic benefits that will not put at risk to the economic development in Peru.

Based on the peer review sessions and complementary documents reviewed we have identified the following design and implementation challenges.

Challenge 10: It is crucial to develop a reference scenario (BAU) in Peru to understand the contribution of each sector to GHG emissions and the result that specific actions could mean to assess comprehensively the extent to which low-carbon solutions could replace the existing technologies. Although the NDC documentation provides specific targets, it is not clear the level of ambition of the target proposed and presented during PRLCE and how the measures presented are effective to achieve these targets. Therefore, the emphasis should be placed on developing a bottom-up reference scenario as a means to evaluate the ambitions and effectiveness of the mitigation measures.

Challenge 11: The lack of analytical inputs, such as a marginal CO_2 abatement cost curve, could have helped the government to assess and prioritise measures related to GHG mitigation. In simpler terms, it seems that the government has not defined its measures based on cost-effectiveness or analysed quantitatively how is the maximum feasible penetration of its GHG mitigation measures. Having this information could help them to create a coherent decarbonisation roadmap, where measures would be prioritised based on their effectiveness, and it could also clearly state the roles and responsibilities of institutions and the required funding or resources needed to accomplish their objectives. This information could avoid putting effort into expensive measures with low impact, which is precisely what we have confirmed could happen with some measures presented during the sessions in Peru.

Challenge 12: It is important to have a well-designed monitoring system to know if measures to reduce carbon emissions are meeting their commitments. Currently, there is no evidence of such a system in place. Therefore, it is crucial to develop a monitoring system tied to clearly defined governance. This system should track the impact of each low-carbon policy and provide indicators to measure progress. By doing so, it will be easier to know if any measures require adjustment or deeper updates. As a result, this will help them meet their targets efficiently and effectively.

Challenge 13: At the institutional level, there is apparently a lack of clearly defined and well-known goals by public institutions. For instance, the Ministry of Energy and Mines

has highlighted that the NDC's mitigation measures comprise 18 measures that contribute to a 14.76 $MtCO_{2\text{-eq}}$ reduction, while the 2020 NDC report has 38 measures contributing to a 16.94 $MtCO_{2\text{-eq}}$ reduction.

Challenge 14: it is not clear how much is the level of political priority on this matter from all key civil servants within the government. While the team responsible of electricity system policies and markets mentioned the recent establishment of a commission that will assess the decarbonisation goals under a whole system lens, this was not even mentioned by the teams responsible for hydrocarbon policies within the Ministry of Energy and Mines.

c) Recommendations

Given the challenges that Peru faces in meeting its low-carbon energy goals and targets, the Peruvian government must adopt a more aggressive strategy to promote and implement renewables. This could create new job opportunities and help with local development. Fortunately, the private sector is enthusiastic about installing renewables in isolated systems or promoting the use of electric cars and is willing to contribute to this effort.

In particular, it is important to note the potential contribution of distributed generation. The 2020 NDC recognises distributed generation as a crucial component of the plan, but the regulatory framework required for its implementation is advancing slowly. Furthermore, the private sector appears to be more committed to embracing distributed generation with renewable resources than the public sector.

Therefore, in this section, we would like to give the following recommendations:

Recommendation 12: We highly recommend identifying the sectors, processes, and actions that could contribute most to reaching a low-carbon economy in Peru. To understand the challenge and implications of the NDC goals, it is suggested to provide a clearly defined reference scenario with the identification of the detailed contribution from each sector. The energy sector contributions can be estimated by MINEM.

Recommendation 13: It is important to use the marginal abatement cost curve (MAC) as a tool to prioritise the most cost-effective actions. Once the analysis is available, it would be easier to define a low-carbon roadmap by defining the first measures, which are the most cost-effective, and identifying the first movers to start with. Moreover, after identifying those measures, it would be recommended to set a policy framework and governance to assess progress on their implementation. Having a measurement reporting and verification system helps to track the results, outcomes, and impacts of this low-carbon energy strategy.

Following are some hierarchical recommendations from urgent and needed in the short term to long term.

Recommendation 14: Consider specific strategies on the use of natural gas and decarbonisation path.

- Despite having gas today, it is important to emphasise that local gas is a transition fuel toward decarbonisation. How quickly the transition happens should consider the lifespan of fossil fuel plants currently planned and in operation, as well as the costs of renewables and their projections. Therefore, all strategies and policies considered need to be designed under this scope.
- We suggest evaluating the decarbonisation of the entire power system, with a particular focus on demand. Relying solely on the Net Zero scenario that considers only the electricity system is not a safe approach. It may lead to excessive planning of renewable energy capacity, storage, and grid reinforcement needs, which in turn will inflate the decarbonisation costs.
- We would like to emphasise that decarbonisation can also be an opportunity for economic growth, creating new businesses, jobs, and local development. Furthermore, distributed generation and distributed energy sources should be assessed from the perspective of diversifying sources for flexibility and energy security. Finally, a focus should be placed on the opportunity for clean energy access in rural and remote areas.

Recommendation 15: Installing greater renewable energy capacity.

The government needs to take action to overcome the barriers that hinder the development of renewable energies. This is especially important because the value of renewable energies in the distribution sector is often underestimated. The government should focus on both interconnected and isolated areas. It is recommended to set goals for the deployment of renewable energy, with targets and steps identified based on the local context. This context should consider the low and steady demand that is expected to increase significantly, as well as the significant presence of fossil fuels in the generation matrix. Additionally, significant market and policy barriers were observed, which need to be removed to increase the deployment of renewable energy promptly before the phasing out of fossil fuels from generation.

Recommendation 16: Adopting a more aggressive strategy in transport.

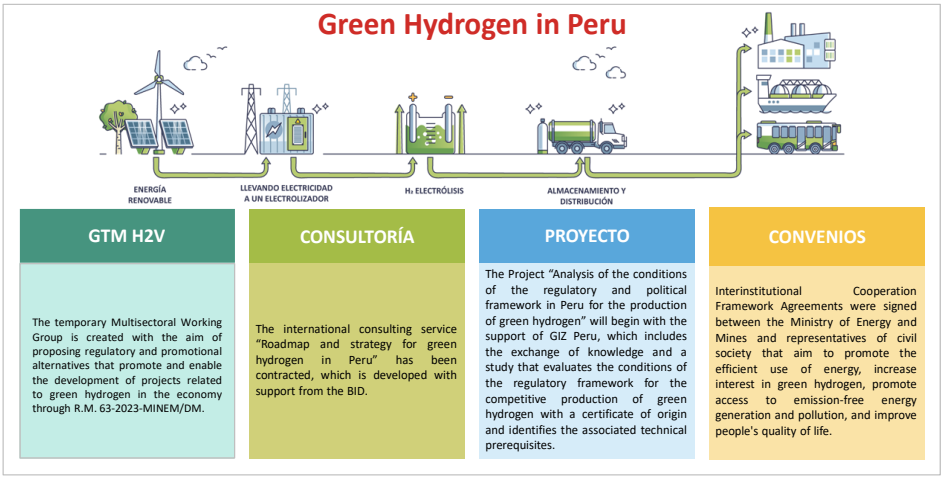
There have been some important advancements in transitioning from diesel and gasoline to natural gas, mainly due to the availability of cost-effective natural gas resources. However, there is still no clear plan on how to achieve the goal of decarbonising this sector, which is currently the most carbon-intensive within the energy industry according to GHG inventories. We suggest adopting a more aggressive strategy, especially since the private sector is already pursuing this shift.

Recommendation 17: Assessing the possibility of further potential instruments. There is a set of potential instruments that are harder to implement and require transversal technical and political consensus. We suggest carefully assessing some of these:

- Carbon or green taxes. Having Pigouvian-type taxes is critical to fostering a low-carbon economy.

- Cap-and-trade schemes for industries and power plants. These can also include permits regarding local pollutants, which may benefit the local population that could suffer the consequences of pollution from these power plants.
- Emission standards for specific industries.
- Schemes to collect funds from carbon emitters to foster not only reducing emissions from deforestation and forest degradation of the Amazona but also ecosystem restoration for carbon sequestration purposes.

D. Green Hydrogen plans and programs



Peru's hydrogen plan that is under development established specific directives for hydrogen development in addition to identifying resources for hydrogen production. The plan also lays out a vision for hydrogen development and describes ongoing activities. Peru's hydrogen plan focuses mainly on renewable (green) hydrogen production via water electrolysis, mainly because of abundant wind resources along the coast and solar resources in the south. While the current penetration of renewable wind and solar power in Peru is limited to a few percentage points, higher penetration of these intermittent resources may require energy storage to provide grid balancing services. Peru's vision for hydrogen production also identified nuclear and natural gas with carbon capture and sequestration (CCS) as potential pathways for low-carbon hydrogen production. Peru also has significant natural gas resources. However natural gas has not been the focus in the low-carbon hydrogen plan.

a) Achievements

Achievement 13: Peru's green hydrogen plan has identified and quantified the potential of renewable solar, hydro, wind and geothermal resources in various regions and their potential use for hydrogen production. The pathway of choice was water electrolysis which produces low-carbon hydrogen using renewable power generation from solar, wind, hydro, geothermal or biogas. Peru is developing maps to guide investors on areas where renewable energy projects can be developed more sustainably. These maps will be updated periodically.

Achievement 14: The plan also identified potential end-use applications for clean hydrogen such as trucks, heavy machinery, and miscellaneous long-route transportation.

Hydrogen production via electrolysis was also identified for its potential use in providing grid storage and thus allowing flexible generation and providing power in isolated areas not connected to the electric grid system. Heating for buildings and industries and hydrogen as input for refineries, chemical industries and steel production were potential other uses of low-carbon hydrogen. Blending with natural gas was identified as near-term use for low-carbon hydrogen with blend ratios up to 20% in current natural gas pipelines. The total domestic demand for hydrogen was estimated at 33-57 kilotonnes in 2030, 124-265 kilotonnes in 2040 and 195-611 kilotonnes in 2050. Finally, liquefying hydrogen and locking hydrogen in the form of synthetic fuels and chemicals (e.g., ammonia) was explored for export markets. The export market is estimated to absorb 220-400, 590-2080 and 1140-4250 kilo tonnes in 2030, 2040, and 2050, respectively.

Achievement 15: Peru issued several directives related to green hydrogen production and deployment. These include directives for developing technologies, using and producing green hydrogen, a strategic plan for hydrogen production from water for export and domestic use and a commission to propose regulatory and promotional alternatives to drive and enable the development of green hydrogen projects in the economy.

b) Challenges

The hydrogen plan identified the following challenges to the status quo of the energy system and proposed opportunities for clean hydrogen production in Peru.

Challenge 15: Peru's commitments to reducing GHG emissions.

- The High potential and quality of decentralised renewable resources (900 GW solar, 70 GW hydropower, 20 GW onshore wind, 3 GW geothermal) create opportunities for clean hydrogen.

Challenge 16: Electricity generation dependent on natural gas.

- Competitive costs of wind and solar technology create opportunities for clean hydrogen.

Challenge 17: Limited natural gas reserves.

- This opens opportunities for clean hydrogen deployment such as using seawater for electrolysis next to areas of high solar and wind energy resources.

Challenge 18: High volatility of imported liquid hydrocarbons due to international conflicts.

- This can foster the rapid advancement of energy storage technologies and the potential for hydrogen use in transportation applications.

Challenge 19: Difficulties in international financing for hydrocarbon exploration.

- Rapid advancement of energy storage technologies and potential for hydrogen use in transportation applications.

c) Recommendations

A comprehensive and coordinated transition plan from the current energy landscape to a low-carbon energy system, including hydrogen production is needed.

For renewable hydrogen production, there is a need to coordinate with power sector expansion into higher renewable penetration. Currently, renewable hydrogen production is relatively higher compared to other energy sources in Peru, such as natural gas, with hydrogen production via electrolysis in the near term between USD5-10/kg, which is an order of magnitude higher than current prices of natural gas. Given the abundance of natural gas in Peru, a transition plan for lower-cost clean hydrogen production may consider natural gas reforming technologies such as steam methane reforming, auto-thermal reforming and partial oxidation, along with CCS. Such a pathway, however, requires the identification of class II and class VI wells for CO_2 sequestration. The clean hydrogen production cost for the natural gas reforming pathways with CCS can be in the range of USD2-3/kg, given the current natural gas prices in Peru. Another emerging technology with the potential to produce low-carbon hydrogen from natural gas is methane pyrolysis, which sequesters the fossil carbon in solid form (e.g., carbon black or graphite), and thus avoids the need for CCS.

Producing hydrogen via water electrolysis can provide the growing need for grid ancillary services (e.g., frequency regulation) as the grid absorbs more of the intermittent renewables such as solar and wind power. Thus, coordination with the decarbonisation of the power sector can be of mutual synergetic benefit to both power and hydrogen production. To lower the cost of hydrogen production via water electrolysis using renewable power, the electrolysers should connect directly (i.e., off-grid) with a renewable power source (wind/solar) for low-cost power, thus lowering the cost of hydrogen. However, the intermittent nature of hydrogen production using solar and wind power would require the identification of low-cost H2 storage (ideally geologic storage such as salt caverns). Using aboveground or belowground physical storage (e.g., compressed tanks or pipes) can add USD1-2/kg_H_2 depending on the storage type, pressure, useable amount, ancillary equipment (e.g., compressors), and utilisation. Geologic storage (e.g., salt caverns) can be 10X cheaper but opportunistically requires large-scale hydrogen storage demand.

Major hydrogen markets in the near term are likely to export ammonia and synthetic fuels/chemicals. Thus, hydrogen production near ports will be attractive and will have synergy with wind and water resources as mentioned earlier. Hydrogen for road transportation applications (e.g., fuel cell vehicles) should target vehicles with high onboard storage requirements and energy efficiency ratio of ≥ 2 compared to conventional internal combustion engine vehicles such as transit buses and heavy-duty trucks since cars and medium-duty trucks will likely be battery powered for cost and infrastructure availability reasons. For non-road transportation (e.g., aviation and marine), hydrogen can be used for drop-in synthetic hydrocarbon fuel production but requires CO_2 sources, preferably of sustainable biogenic origin. Use of hydrogen for its energy value, such as for industrial process heat, building heating and power generation, will be much more

costly than using natural gas and will likely have a lower value proposition as the cost of green hydrogen production/storage must be <USD1/kg to compete with current low prices of natural gas.

The following are general recommendations to consider when developing a strategic plan for low-carbon hydrogen production and its end-use applications:

Recommendation 18: Focus initially on potential major hydrogen off-takers.

- e.g., ammonia and synthetic chemicals/fuels for export
- Promotes rapid supply chain development and economies of scale.

Recommendation 19: Consider initially collocating hydrogen production and market offtakes (customers).

- Delivery infrastructure and storage are costly without large-scale demand.

Recommendation 20: Consider initially collocating hydrogen production with renewable power sources (off-gird)

- For low-cost power, it improves the economics of hydrogen production.

Recommendation 21: Consider transportation applications of hydrogen that share common infrastructure in the near term.

- e.g. large transit buses and heavy truck fleets that come back to the depot for refuelling.
- Lower cost due to economies of scale and high infrastructure utilisation
- Consider hydrogen liquefaction and liquid hydrogen delivery for distributed vehicle markets for low-cost delivery and fuelling.

Recommendation 22: Consider synergies with planning for other energy sectors.

- e.g., synergies of green hydrogen production with planning of renewable power generation expansion, and potential of electrolysers to provide grid ancillary services.
- e.g., making natural gas pipelines compatible with hydrogen for future utilisation without the need for major retrofits

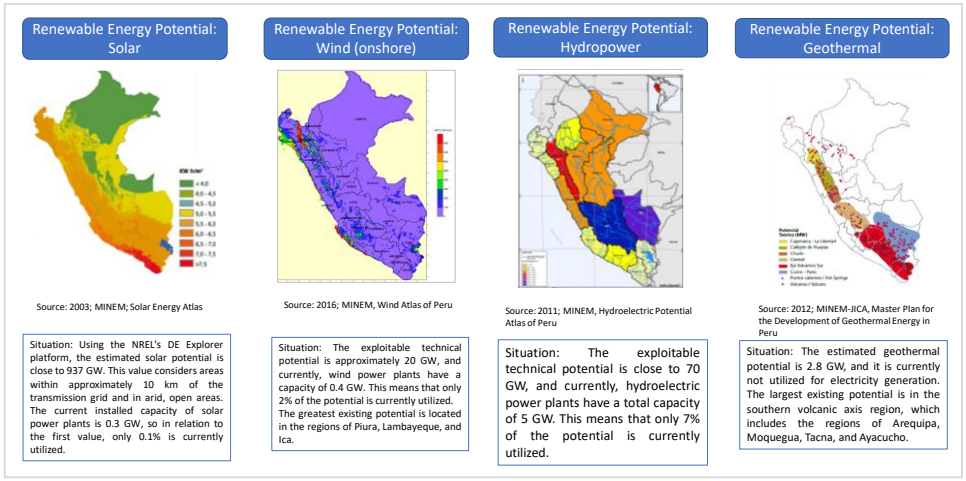
Recommendation 23: Consider using existing techno-economic analysis (TEA) and life cycle analysis (LCA) tools to evaluate cost trajectories and potential GHG emissions reduction towards achieving targets for various hydrogen production and delivery pathways, and various end-use applications.

- Use publicly available tools, e.g., H2A, HDSAM, GREET, etc.
- To inform decarbonisation strategies, hydrogen roadmap development, deployment plan and policymaking.

E. Renewable energy sources (hydropower, ocean energy, geothermal, solar and wind)

a) Achievements

While progress has been made, addressing infrastructure challenges, refining regulatory frameworks, and monitoring developments beyond 2022 to assess how these aspects evolve and impact the economy's landscape are crucial for the continued success of these initiatives. By implementing these recommendations, Peru can enhance its capacity to leverage renewable energy resources effectively, contributing to a more sustainable and resilient energy future.



It is worth noting that Peru has made progress in renewable energy capacity. In 2009, only 8.4 MW of non-conventional renewable energy was installed, but by 2023, the number had risen to 1 252 MW, with an annual growth rate of 9.87%. This capacity consists of 36 renewable energy projects, including 12 biomass power plants, 4 biogas power plants, 9 wind farms, and 11 solar power plants. Despite this growth, an important amount of electricity in Peru is still produced by natural gas, accounting for 42.5%, and hydropower accounting for 49%. Non-conventional renewables contribute only 5.6% of electricity generation, while other sources account for 2.1%. Although promoting natural gas over other fossil fuels is a sensible policy, given Peru's abundant reservoirs and low cost, it is important to remember that natural gas is still a transitional fuel, and renewables should eventually replace all fossil fuel power plants.

Achievement 16: Peru has made commendable strides in promoting a diversified, competitive, and sustainable energy sector. The focus on renewable energy, climate change adaptation, and energy efficiency positions Peru on a path towards a low-carbon future.

Achievement 17: Peru's efforts in embracing distributed generation and smart grid technologies demonstrate a commitment to a more sustainable and efficient energy future.

b) Challenges

Challenge 20: Intermittency and Reliability. One of the primary challenges faced in implementing renewable energy in Peru is the intermittency and reliability of sources such as solar and wind. The inherent variability of these sources can lead to fluctuations in

energy production, which poses difficulties in maintaining a consistent and reliable power supply.

- Such variability may result in grid instability, potentially affecting the overall reliability of the energy infrastructure.

Challenge 21: Grid Integration. The integration of renewable energy into the existing power grid presents another significant challenge. The current grid infrastructure may not be well-prepared to handle the decentralised and variable nature of renewable sources.

- The lack of preparedness may lead to technical challenges and grid instability.

Challenge 22: Inconsistent or unclear policies and regulations regarding renewable energy pose obstacles to its widespread adoption in Peru.

- The absence of stable and supportive policies creates uncertainties for investors and may deter private investment in renewable projects.

Challenge 23: Limited access to financing and high upfront costs represents formidable barriers to the successful implementation of renewable energy projects. The financial challenges associated with these projects can hinder their attractiveness to investors.

Challenge 24: The adoption of new and innovative renewable energy technologies can be slow due to technical challenges and uncertainties regarding their long-term performance.

- Scepticism about the feasibility and effectiveness of emerging technologies may impede their widespread acceptance.

Challenge 25: Inadequate community engagement and a lack of social acceptance can lead to opposition to renewable energy projects, particularly in rural areas.

- Without effective communication and consultation with local communities, there is a risk of encountering resistance that could delay or even prevent project implementation.

Challenge 26: Geographical Diversity. Peru's rich geographical diversity, encompassing mountains, jungles, and coastal regions, presents a multifaceted challenge in mapping renewable energy potential. Each distinct area offers different renewable resources, necessitating tailored mapping strategies.

- A uniform approach may fail to capture the nuanced variations in solar, wind, and hydroelectric potential across the economy.

Challenge 27: The limitation of reliable data, particularly in remote regions, poses a significant impediment to the accurate mapping of renewable energy potential.

- Incomplete or outdated data can lead to misguided decisions and inefficient resource allocation, hindering the development of a robust renewable energy sector.

Challenge 28: Renewable energy target in National Energy Policy of Peru 2010-2040. The policy emphasises a diversified energy matrix with a focus on renewables and efficiency. This aligns with global trends and the need to reduce reliance on fossil fuels. The integration of renewable energy sources and efficiency measures is crucial for long-term sustainability.

- It was observed that Peru currently does not have a mid- and long-term renewable energy target/timeline to be achieved, only mentioning a 5% quota for non-conventional renewable energies in the total electricity consumption. The absence of long-term renewable energy targets as well as the lack of a long-term schedule of auctions, induces elements of unpredictability of RES deployment in the economy.

Challenge 29: Biomass and clean cooking. The upfront cost of clean cooking technologies, such as improved cookstoves, may be prohibitive for low-income households.

- Affordability issues hinder widespread adoption, particularly in marginalised communities.

Challenge 30: Inadequate coordination among different government departments and agencies may result in fragmented policies and hinder effective implementation.

- Inconsistencies in policies can create confusion and impede the progress towards sustainable renewable energy deployment. Mitigation action, in this case RE figures, should come from MINEM, not MINAM.

c) Recommendations

Recommendation 24: Invest in energy storage technologies, such as advanced batteries, to store excess energy during peak production times and release it during periods of low production. This approach would help mitigate the impact of intermittency and contribute to a more stable energy grid.

Recommendation 25: Develop and implement smart grid technologies. These technologies can enhance grid flexibility, enable real-time monitoring, and facilitate efficient management of energy distribution. By investing in grid upgrades, Peru can better accommodate the integration of renewable energy and ensure a more reliable and resilient energy system.

Recommendation 26: The Peruvian government should establish clear, transparent, and long-term policies that provide incentives for renewable energy development. This may include mechanisms such as feed-in tariffs, tax credits, and regulatory frameworks that support the seamless integration of renewable energy into the existing energy landscape.

Recommendation 27: Peru should encourage public-private partnerships, offer financial incentives, and explore innovative financing models. By creating a favourable investment climate, the economy can attract more funding for renewable energy projects and alleviate

the financial burden on developers, thereby accelerating the transition to sustainable energy sources.

Recommendation 28: Peru should establish research and development initiatives, promote collaboration between industry and research institutions, and provide support for pilot projects. This approach will enable the economy to address technological uncertainties, validate the performance of new technologies, and foster their integration into the mainstream energy landscape.

Recommendation 29: Comprehensive community engagement strategies are essential. These strategies should include education and awareness programs to address concerns, involve local communities in decision-making processes, and ensure a more favourable reception of renewable energy projects. By actively engaging with communities, Peru can build trust, garner support, and promote the successful implementation of renewable energy initiatives.

Recommendation 30: Regional-specific mapping methodologies should be developed, accounting for the diverse geographical features and resource availability.

Recommendation 31: Peru should invest in advanced data collection technologies, satellite imagery, and ground-based measurements. Collaborating with international organisations and leveraging open-source data can enhance the accuracy and reliability of the mapping process.

- A regular reconnaissance survey should be conducted across the regions in Peru. Potential RE sources may still be untapped.

Recommendation 32: Peru needs to enhance National Energy Policy of Peru 2010-2040 to include clear target to support NZE by 2050 and enhance the D.L. N° 1002 (May 2008) to include clear timeline and increased target until 2050.

Recommendation 33: Peru needs to introduce financial incentives, subsidies, and microfinance programs to make clean cooking technologies more affordable. Collaborate with international organisations for funding support.

Recommendation 34: Peru needs to establish a centralised authority or task force (MINEM) dedicated to coordinating renewable policies including biomass and clean cooking initiatives. Encourage interagency collaboration to ensure a unified approach.

Recommendation 35: Peru needs to implement robust monitoring and evaluation systems to track the adoption of renewable technologies, assess environmental impacts, and measure health improvements as well as regularly update policies based on evaluation results. Institutions that can be involved in this task can be the Ministry of Energy, OEFA, the Ministry of Health, and others.

F. Low-carbon transportation/electromobility

Peru's urban transportation policy developed guidelines for integrated, socially and environmentally sustainable urban transport systems, under the concept of multimodality

of travel, in cities. The goal is to reduce emissions of local air pollutants and GHG, due to the change in the urban transportation system with PM2.5 and $CO_{2\text{-eq}}$ per capita as indicators. In 2022, Peru was the highest among Latin America and the Caribbean in PM2.5 emissions, while the Energy Policy Institute at the University of Chicago identified Lima as the city with the worst air quality in Latin America and estimated that the inhabitants of the city of Lima have a life expectancy of 2.2 years less due to poor air quality. Approximately, 58% of PM2.5 emissions are produced by vehicles, mainly buses and diesel trucks. Exposure to high levels of PM2.5 causes more than 10 000 deaths per year in Lima with an economic cost of these deaths amounting to USD12.8 billion. By 2030, the environmental pollution generated by the vehicle fleet is estimated to increase by 48%.

The total transportation GHG emissions in 2019 were 25 million metric tons (MMT), with 93% attributable to ground transport. In 2022, Peru spent USD7,865 million in the import of fuels and derivatives, such as diesel and derived oil, which can be saved with domestic production of electricity for use in electromobility.

a) Achievements

Achievement 18: Given the abundance of natural gas in Peru, natural gas vehicles are proposed to replace petroleum fuels for vehicles, which can provide lower cost and energy security by displacing imported diesel (68% of diesel is imported). Natural gas vehicles also provide lower air pollution, especially PM2.5, compared to diesel vehicles, and thus can significantly improve air quality. However, natural gas use in vehicles will have marginal impact on GHG emissions reduction.

The Automotive Association of Peru (AAP) developed a proposal to promote electromobility in Peru based on analysis of electrified vehicles and supporting charging infrastructure. The promotion policies proposed by AAP included specific tax incentives for plug-in and non-plugin hybrid vehicles based on model year, and for charging infrastructure, while proposing taxes on hydrocarbon use in automotives to reduce GHG emissions.

b) Challenges

The electromobility industry identified the following challenges and opportunities for electrifying the transportation system in Peru.

Challenge 31: Develop a sector strategy for “Carbon neutrality and resilience to climate change”. Form industry partnerships to coordinate the deployment of zero-emissions mobility.

Challenge 32: Commitment from the government to prioritise the creation of a legal and regulatory framework for sustainable transportation. This will facilitate strategic alliances between companies to generate investments.

Challenge 33: Develop transportation projects with zero-emission energy matrices: electromobility and green hydrogen. It is necessary to develop a diverse offering of vehicles and develop promotional activities and campaigns.

Challenge 34: The **c**urrent cost for electromobility is high, however, these costs are expected to be reduced in the future once the market has reached maturity and the costs become more stable and competitive.

Challenge 35: Update the MRV of mitigation measures. This may include implementing a fast-charging infrastructure network.

c) Recommendations

Use of natural gas in transportation, while providing economic, energy security and air quality benefits, does not provide major GHG emissions reduction from a life cycle analysis perspective since natural gas is a fossil hydrocarbon and methane emissions along gas supply chain have significant environmental impacts due to high global warming potential of methane. Since vehicle lifetime is usually higher than 15 years, adopting a policy that promotes natural gas in transportation may have a lasting effect due to the long time it takes for entire vehicle fleet to be replaced. Thus, any long-term decarbonisation plan should consider the fleet turnover rate when setting GHG emissions reduction targets.

Electromobility can reduce air pollutant emissions from vehicles, but the potential GHG emissions reduction will depend largely on the carbon intensity of the electricity generation mix used for battery recharging. Electromobility deployment will create additional load on the grid and thus should be coordinated with grid expansion and distribution system upgrade planning. Decarbonisation of the electric grid would automatically support the decarbonisation of transportation with electromobility adoption. However, plug-in battery electric vehicles will be more expensive in the near term compared to current internal combustion engine vehicles and alternative natural gas vehicles. Early deployment of battery electric vehicles should target cars and light trucks due to their relatively small onboard battery storage and less demand for fast charging infrastructure.

Conversely, battery electric vehicles will be less attractive for heavy trucks and non-road applications (due to large onboard storage requirements and the need for costly grid upgrades and fast charging equipment). As an alternative, hydrogen fuel cell vehicles can be more attractive for transit buses and heavy trucks due to their lower onboard storage cost, higher onboard energy density, and faster fuelling time, compared to battery electric vehicles.

The following are general recommendations to consider when developing a strategic plan for electromobility and transportation decarbonisation:

Recommendation 36: Develop professional and technical training to accommodate the deployment of new technologies.

Recommendation 37: Consider developing a more detailed emissions inventory for on-road transportation by vehicle class and fuel use (e.g., cars, light trucks, heavy trucks, etc.)

Recommendation 38: Consider a long-term plan for transportation decarbonisation including target GHG emissions reduction over time.

Recommendation 39: Consider fuel economy (energy efficiency) improvement and hybrid powertrains in the near term.

Recommendation 40: Consider electrification of transportation planning along with grid expansion/upgrade planning

Recommendation 41: Consider electro-fuels (e-fuels) for hard-to-decarbonise transport applications, e.g., aviation, marine and agriculture/mining vehicles.

Recommendation 42: Consider using vehicle simulation tools (e.g., FASTSim) to evaluate vehicle efficiency benefits of electrification for road transport strongly impacted by the duty cycle for various on-road transport applications can also inform onboard storage requirements and vehicle cost premiums over conventional vehicles.

Recommendation 43: Consider using existing techno-economic analysis (TEA) and life cycle analysis (LCA) tools to evaluate cost trajectories and potential GHG emissions reduction towards achieving vehicle/fuel cost and emissions targets.

use publicly available tools, e.g., H2A, HDSAM, HEVISAM, GREET, etc.

evaluate alternative decarbonisation options based on total cost of ownership (TCO)

Recommendation 44: Consider using the above tools to develop marginal abatement cost curves (MACC) to inform decarbonisation strategies, electrification roadmap development, deployment plan and policy making.

Recommendation 45: Consider vehicle fleet turnover rate in achieving decarbonisation targets and goals.

Recommendation 46: Consider electro-fuels (e-fuels) as an indirect electrification option for hard to decarbonise transport applications.

- e.g., synthetic fuels (ammonia, methanol, FT fuels) for non-road applications (e.g., marine, aviation, mining and agriculture equipment, etc.)

Recommendation 47: Enhance the regulatory framework to ensure the safe and efficient operation of the charging infrastructure of electric vehicles. This regulation includes ensuring compliance with proper safety codes and technical specifications and implementing guidelines for grid integration to manage the impact of EV charging on distribution networks.

Box F.1 Ultra Low Emission Zone: United Kingdom case

Efforts to combat air pollution in London go back to 2003. The city introduced a congestion change, that is, a fee applied to all vehicles driving within the city center. In 2019, the local government took a step further by implementing the world's first Ultra Low Emission Zone, where all drivers must abide by strict vehicle emissions standards or pay a fee. Revenue from the fee is then reinvested into the city's public transport system. It also complements a package of efforts, from investments in electric buses to low-emission school zones, aimed at aggressively reducing air pollutants across the city (WEF, 2021).

G. Power Supply System (Regulation and Infrastructure)

a) Achievements

Achievement 19: The National Energy Policy 2010-204 has been established and provides the foundation for implementing low-carbon energy development in Peru.

- The National Energy Policy 2010-2040 was approved under the Supreme Decree N° 064-2010-EM and has since established the foundational principles for Peru's energy sector. It calls for energy matrix diversification with a focus on the promotion of renewable energy sources and energy efficiency. Other key objectives include promoting competition in the energy market, ensuring universal access, and achieving self-sufficiency in energy-related activities. Building on this policy, the National Energy Plan 2014-2025 was introduced to assess sectoral policy measures and to identify investment projects that secure a competitive, reliable, and accessible energy supply for the medium-term period. These investment projects will prioritise conventional and unconventional clean energies, hydrocarbons, geothermal, and nuclear, to avoid any future energy shortages while simultaneously promoting regional sustainable development and integration.

Achievement 20: Peru aims to achieve a 20% share of non-conventional renewable energy in its electricity mix by 2030.

- In line with Supreme Decree Nº003-2022-MINAM, which declares a climate emergency of economic interest, Peru aims to increase participation of non-conventional renewable energies in electricity generation and other applications by 2030. Peru also actively pushing for advancements in related technologies as part of the adaptation and mitigation measures to combat climate change. This is demonstrated by promoting efficient energy use across major sectors, alongside the development and production of green hydrogen and putting more focus on electromobility, especially in urban areas.

Achievement 21: Peru has established enabling regulatory frameworks to promote renewable energy investments.

- Through key legislation such as Law No. 28832 for Efficient Development of Electric Generation (2006), Legislative Decree No. 1002 for Promotion of Investment for the Generation of Electricity from Renewable Energies (2008) and Legislative Decree No. 1221 for improving Distribution Regulation for Electric Energy Access (2015), Peru has established enabling regulatory frameworks to promote renewable energy investments. The legislation, along with its accompanying regulations provides clarity and increases investor confidence in Peru's low-carbon energy future. Further strengthening this commitment, the Ministry of Energy and Mines (MINEM) established the Multisectoral Commission for the Reform of the Electricity Subsector (CRSE) in 2019. This commission was tasked with identifying key areas for improvement within the electricity subsector's regulatory framework, specifically targeting increased competitiveness and incentivising the adoption of renewable energy resources technologies.

Achievement 22: Peru is actively developing infrastructure to support renewable energies.

- Peru is rapidly developing its domestic grid with a pipeline of projects of more than 16 000 MW to supply the National Interconnected System (SEIN) by 2028 through renewable energies and clean technologies. Further, Peru also focuses on installing and operating infrastructure for charging electric mobility as well as fostering green hydrogen technologies and projects.

b) Challenges

Challenge 36: Outdated National Energy Policy

- The urgent need to fight climate change and international commitments such as the Paris Agreement require greater emphasis on ambitious emissions reduction targets in the energy sector. The urgency for decarbonisation may not be adequately reflected in the National Energy Policy 2010-2040. Furthermore, the rapid evolution of renewable energy technologies, particularly in areas like solar and wind, may have outpaced the policy's projections and assumptions. As a result, the policy in its current state might not fully take advantage of these advancements.

Challenge 37: The unfavourable distributed generation framework.

- The current regulatory structure may create barriers or disincentives to the injection of surplus energy from distributed renewable sources into the grid. Potential barriers may be unfavourable tariff structures, bureaucratic barriers, or lack of incentives for individuals and firms to invest in renewable energy systems. Disincentives in the current arrangement may lead to a low adoption rate for distributed renewable energy technologies. On the other hand, this may slow down the broader adoption of clean energy solutions, thus hampering progress toward sustainability goals and a low-carbon energy future.

Challenge 38: A mismatch between a robust transmission network and fragmented sub-transmission and distribution infrastructure might threaten the integration of distributed generation.

- While Peru's robust transmission network benefits from centralised planning and control under the Economic Operation Committee of the National Interconnected System (COES), its sub-transmission and distribution infrastructure, managed by individual concessionaires and distribution companies, requires further attention. The decentralised structure in which these individual entities operate these network, poses challenges as the energy landscape continues to evolve. These issues that need to be addressed include a delay in planned investment, an inconsistent approach to development, and potential gaps in the overall network. With the increase in the adoption of distributed generation technologies such as solar panels and small-scale wind turbines, it is necessary to provide further attention to the development and modernisation of sub-transmission and distribution infrastructure. These networks should adapt to support bidirectional energy flow and deliver reliability and stability in the grid.

Challenge 39: The absence of a National Electromobility Plan in Peru delays progress in electric vehicle (EVs) adoption and low-carbon transportation infrastructure.

- The absence of a National Electromobility Plan in Peru presents a significant challenge to the coherent development of low-carbon transportation infrastructure and the widespread adoption of electric vehicles (EVs). This absence creates uncertainty among stakeholders, hindering progress in transitioning to cleaner transportation. A key impact area is infrastructure development, where a well-structured plan would guide the strategic placement and expansion of charging stations, ensuring convenient accessibility, and mitigating range anxiety. Moreover, the absence of an economic plan affects investor confidence, as uncertainty surrounding future policies may deter investments in essential projects, research initiatives, and EV manufacturing.

Challenge 40: One-Dimensional Demand Forecasting and Capacity Expansion

- Current grid system planning in Peru, characterised by one-dimensional demand projection and capacity expansion plans are not enough to address the complexities of energy transition as well as uncertainties that come along with it. This one-dimensional approach has been inadequate in capturing the wide range of probable future scenarios, particularly in Peru, where free market energy consumption now surpasses those that are regulated. The fast transition towards a free market, especially with increased penetration in intermittent renewable energy sources, raises serious concerns relating to grid stability. Substantial investments into energy storage and modernising the grid is now becoming necessary to continue having a reliable power supply. However, traditional planning methods that do not consider the spectrum of plausible scenarios involving varying renewable energy adoption, behavioural shifts, and policy changes on the grid leave it vulnerable to future uncertainties. Such inflexible models risk locking Peru into inappropriate infrastructure expansions, leading to stranded assets, and wasted resources if actual conditions diverge from the assumed future.

c) Recommendations

Recommendation 48: Revise the National Energy Policy to align with global commitments and technological advancements.

- The current National Energy Policy (2010-2040) requires revision to reflect the urgency of combating climate change and the rapid evolution of renewable energy technologies. The revised policy is needed to align both global commitments and Peru's vision as detailed in the Strategic Plan for National Development (PEDN).

  Key priorities of the PEDN should therefore be reflected in the revised policy that supports the widespread adoption of solar energy with distributed generation systems and intensive utilisation of electric mobility. This coordinated approach will ensure policy coherence and maximise its impact.

  Furthermore, the revised policy needs to establish measurable standards and robust monitoring systems to track progress towards ambitious decarbonization goals across all sectors. It will ensure that both policy and regulations are effective in guiding Peru towards a sustainable future. This also is important as governments have usually found themselves in a "regulate and forget" trap whereby they pass regulations without constantly evaluating the effectiveness of such actions in real-life. To this extent, the revised policy should take on an 'adapt and learn' approach which includes succeeding iterative as well as flexible regulatory assessment cycles.

Recommendation 49: Consider reviewing the current tariff structures and regulatory frameworks to incentivise the injection of surplus energy from distributed renewable energy into the grid.

- The effective integration of DG systems, especially from rooftop solar, depends on a supportive regulatory regime that strikes a fine balance between empowering customers while maintaining grid stability and economic fairness. The two commonly used compensation mechanisms, net-metering and net-billing are known to play a key role in encouraging DG adoption; however, their long-term sustainability merits an in-depth review.

  The reliance on volumetric charges where customers only pay for what they use from the grid encourages energy production regardless of demand or market prices. This unsustainable approach burdens non-DG users with a disproportionate share of network costs while obscuring decisive price signals needed for efficient grid management. Such an approach separates energy compensation from its time of production, which eliminates the most important incentives for the producers to generate on peak hours.

  To ensure sustainability of DG integration, the current regulatory framework should be revisited. Adaptability is necessary to work through the challenges of DG integration in the future. By overcoming rigid structures and focusing on innovative pricing schemes, dynamic feed-in tariffs as well as time of use billing are only a few

among numerous other approaches that should be addressed to design a future proof energy system. This promotes a more open and market-based approach, with the price signals clearly communicated and stability of grid maintained.

Where incentivising DG deployment continues to be a policy goal, the most effective mechanisms are those that are transparent and targeted. Specific grant programs for DG investments or direct tax breaks are more straightforward and controllable than the indirect subsidies structured in tariffs. These direct support mechanisms ensure that the resources are allocated efficiently and encourage investment in areas with maximum impact.

Recommendation 50: Empower the distribution sector and foster collaborative DG integration planning.

- Peru's regulatory framework should evolve to empower the distribution sector because decentralisation plays an instrument in the energy transition. To address these issues, a two-pronged approach is required - transforming distribution companies into active players as Distribution System Operators (DSOs) and collaborative planning environment for the transmission, sub-transmission, and distribution networks.

  It is important for distribution companies to transcend their traditional role and be active DSOs. This is where the distributors will take proactive steps to manage the grid, ensuring that it is stable and resilient with an increasing DG penetration. DSOs should have the right tools and regulations to handle energy flowing in both directions, connect small-scale generators, and offer market-based solutions for grid services. This change requires adjusting existing regulations and creating new policies that encourage and back DSOs in carrying out their crucial tasks.

  Furthermore, a network planning approach should be robust and well-structured to ensure that seamless DG integration is achieved. This collaboration process should involve the distributors, the grid system operator (COES), and the regulator (OSINERGMIN), each with clear-defined roles and responsibilities to avoid bottlenecks and ensure coherence. In addition, alignment of the roles played by OSINERGMIN in both the backbone transmission as well as sub-transmission network development is essential in the sense of achieving consistency and improving coordinated oversight.

Recommendation 51: Formulate and implement a comprehensive National Electromobility Plan. The plan can be developed by the Ministry of Energy in collaboration with other institutions, such as the Ministry of Transport and Telecommunications and the Ministry of Environment, as seen in Chile. Alternatively, a more central authority, such as the State Council in China, can oversee the plan, as demonstrated by China's New Energy Vehicle Industrial Development Plan for 2021 to 2035.

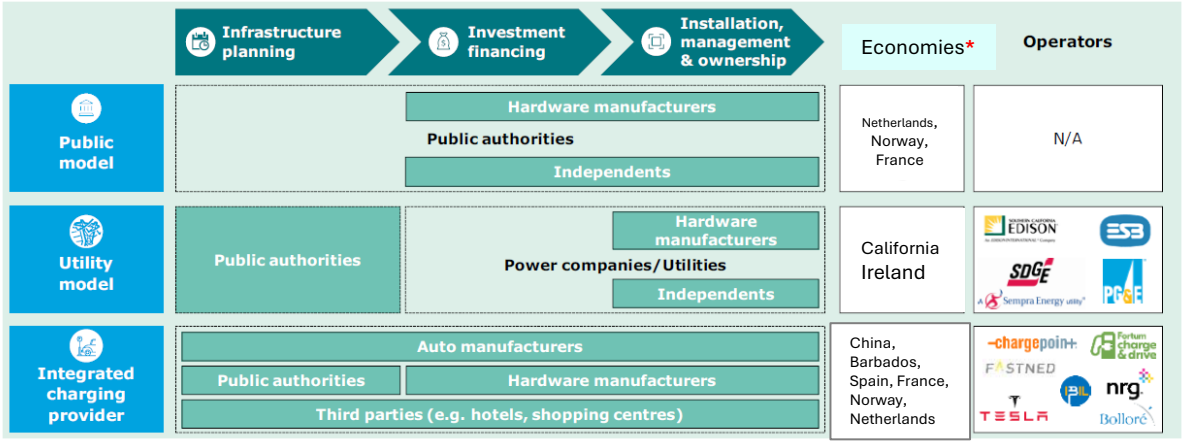
- Peru's journey towards electromobility requires a strategic and cost-effective approach focusing on the development of infrastructure. In this sense, the National Electromobility Plan is essential for steering Peru into accomplishing full EV

penetration by well-defined targets, strategic investments, as well as providing policy frameworks.

The plan should have ambitious yet realistic goals. These targets should clearly define what EV penetration is to be achieved and establish concrete goals of economy-wide charging infrastructure development along with some milestones for reporting purposes. Equitable access, both in the urban and rural landscapes, is extremely critical as publicly available charging points directly addresses one of the key concerns that have been a deterrent for EV adoption: range anxiety. With the charging stations' being within reach, users can conveniently charge their EVs just like refuelling a conventional vehicle hence ease of use integration.

Given such recognition of the critical role of such infrastructure, the plan should also include clear business models for publicly available charging points (*Figure 6*). Such models need to develop in parallel with regulatory guidelines to assure that these stations run properly and efficiently. This will not only enhance investor confidence and catalyse the development of a vibrant electromobility ecosystem but at the same time pave the way for the widespread EV adoption through mitigating range anxiety.

Figure 7● Main Business Models for EV Charging Infrastructure



Source: Inter-American Development Bank (IDB) (2021)

**Notes*: Title and flags were revised/removed in compliance with the APEC nomenclatures.*

Recommendation 52: Adopt flexible grid planning and embrace multi-scenario approaches.

- The path towards a low-carbon energy future for Peru demands navigating the complexities of the ongoing energy transition with agility and foresight. However, in doing so, flexible grid planning and multi-scenario approaches are indeed important.

  The long-term energy planning models, such as the plan for Efficient Energy Use to 2050, Electric System Expansion Plan to 2050, and Integrated Energy Plan to 2050 currently being developed show that Peru is committed towards realising the

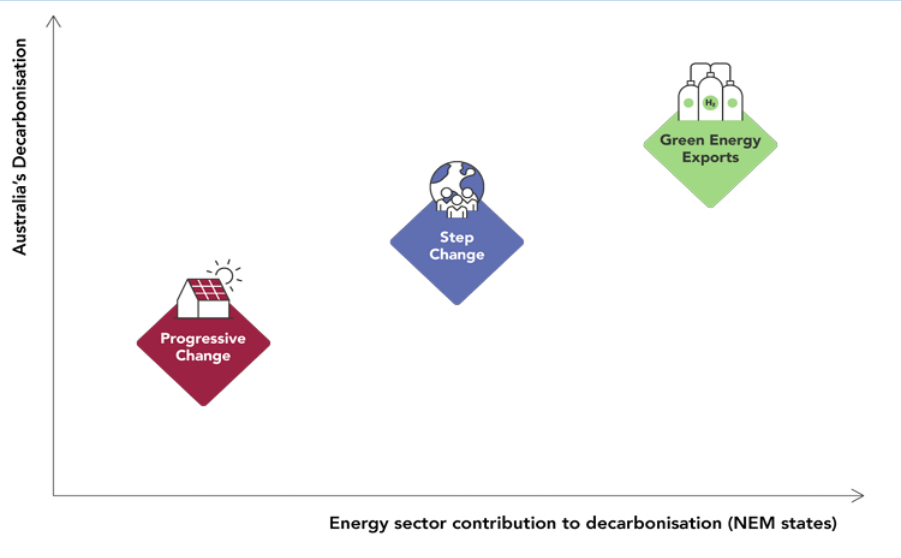
low-carbon energy vision. Integrating these plans effectively can guide Peru towards a sustainable and secure energy future.

In addition, multi-scenario modelling allows Peru to explore a range of potential futures, from optimistic to pessimistic, and prepare for a wider range of possibilities. This reduces the risk of being caught off guard by unexpected events and allows for more flexible long-term planning. This also will help to minimize the risk of stranded assets and underutilized resources, especially those involving publicly funded infrastructure.

Box G.1 AEMO's Future Energy Planning Scenarios: Australia case

The Australian Energy Market Operator (AEMO) has released its "2023 Inputs, Assumptions and Scenarios Report (IASR)," which includes future energy planning scenarios developed in collaboration with energy industry stakeholders. These scenarios (see *Figure 2* below) are used in AEMO's forecasting and planning analysis, including the 2024 Integrated System Plan (ISP). The IASR scenario set covers a range of plausible futures for energy demand and supply, with varying degrees of decarbonisation. AEMO emphasises that these scenarios are essential for informing government, industry, and consumers about the risks and opportunities associated with the energy transformation. The scenarios also play a crucial role in identifying investments in essential transmission infrastructure and renewable energy to connect regions of high-potential renewable energy to the load centres.

Figure 8 ● AEMO's 2023 IASR Scenarios



Source: AEMO (2023)

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6	Dr. Amgad A. Elgowainy	Senior Scientist and Distinguished Fellow at Argonne National Laboratory-**United States**
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6	María Valle Martínez	General Director of Environmental Affairs of Industry-Produce
7	Maribel Canchari Medina	General Director of the General Directorate of Environmental Affairs-Ministry of Housing
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9	Jorge Rodriguez Funegra	Vice-President-AEDIVE Perú
10	Paolo Chang Olivares	Technical Advisor OSINERGMIN
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15	Luis Torres	General Director of Rural Electrification-MINEM
16	Pedro Gonzalez Orbegoso	Director Novum Solar SAC

APPENDIX C: References

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