IRENA
International Renewable Energy Agency

PERU
RENEWABLES READINESS ASSESSMENT 2014

About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low carbon economic growth and prosperity.

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About RRA

A Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions and identifies the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders. While the RRA helps to shape appropriate policy and regulatory choices, each country determines which renewable energy sources and technologies are relevant and consistent with national priorities. The RRA is a dynamic process that can be adapted to each country's circumstances and needs. Experience in a growing range of countries and regions, meanwhile, has allowed IRENA to continue refining the basic RRA methodology. In June 2013, IRENA published a guide for countries seeking to conduct the process in order to accelerate their renewable energy deployment.

For more information visit www.irena.org/rra or e-mail rra@irena.org

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PERU

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FOREWORD

Over the past decade, Peru has experienced fast and sustained economic growth, which is expected to continue in the coming years. Yet this has produced an equally unprecedented increase in our energy requirements, with electricity demand growing at eight percent per year over the past few years. Energy, therefore, is a key element to sustain our economic growth. More than ever, we need safe and continuous supply, while also taking into consideration the social and environmental dimensions.

Over the past years, Peru has developed a legal and regulatory framework that promotes competition and investment in the sector, and more recently we have successfully developed mechanisms to promote the use of our vast renewable energy resources. Peru has been a pioneer of renewable energy auctions, and through this we have become one of the most important destinations for clean-energy investment in the region.

The Renewables Readiness Assessment (RRA) we have undertaken has been instrumental in identifying further actions that need to be taken to fine tune the renewable energy auction process in Peru, particularly in relation to identifying ways to enhance our preparatory activities as well as further improve the design of the auction process itself. The RRA has also provided insight on how to better complement rural electrification, and on how to improve our on-going efforts to foster the development of biofuel in the country.

As a strong supporter of IRENA's mission, Peru volunteered to host the first RRA in Latin America. This has been a very stimulating process, and the RRA methodology has proven to be an effective tool to identify the barriers to further deployment of renewable energy technologies. We hope that the experiences we gained in this process can also be of benefit during future applications of the RRA methodology in other countries in the Latin America region.

Special thanks are due to all national and international organisations and stakeholders in Peru that took part in RRA preparatory activities and discussions. In particular, we are grateful to IRENA for mobilising this activity and producing the Peru RRA Report.

Jorge Merino Tafur
Minister of Energy and Mines
Republic of Peru

FOREWORD

Latin American countries are seeking, increasingly, to meet their fast-growing energy needs through plentiful indigenous resources. But with the precise challenges and opportunities varying from country to country, the International Renewable Energy Agency (IRENA) has set out to provide technical support adapted to each particular context. The Renewables Readiness Assessment (RRA) process involves a holistic evaluation of a country's conditions and identifies the actions needed to overcome barriers to renewable energy deployment. This is a country-led process, with IRENA primarily providing technical support and expertise to facilitate consultations among different national stakeholders.

Since 2011, nearly 20 countries in Africa, the Middle East, Latin America and the Caribbean, Asia and the Pacific Islands have undertaken the RRA process, which generates knowledge of good practices and supports international cooperation to enable the accelerated deployment of renewable technologies. Peru, in keeping with its strong and consistent support of IRENA's mission, is one of these pioneering countries and the first to conduct such consultations in Latin America. The RRA in Peru also marks an important milestone as the first such assessment to focus on a middle-income economy with a comparatively well-developed renewable energy sector.

As the RRA highlights, Peru has taken ground-breaking steps in the development of renewable energy auctions and continues to strive to improve the process. Through greater coordination between government bodies and the private sector, moreover, infrastructure projects can be aligned with social and economic goals, while renewables can be promoted as an aspect of ongoing rural electrification.

IRENA would like to thank Minister Merino and his team for their patience and generosity in hosting this study. Their engagement and input have exceeded expectations, and we are grateful for their important contributions, which have resulted in valuable insights for further RRAs in the 2014-2015 period. Additionally, this report will feed into other IRENA regional work, including the initiative to promote geothermal energy development in the countries of the Andes region.

We sincerely hope that the outcomes of these RRA consultations will help Peru to fulfil its aim to scale up renewable energy. IRENA stands ready to provide continuing support to Peru in implementing the actions identified.

Adnan Z. Amin
Director General, IRENA

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ABBREVIATIONS

ADINELSA	Electrical Infrastructure Administration Company (Empresa de Administración de Infraestructura Eléctrica S.A.)
BCRP	Central Reserve Bank of Peru (Banco Central de Reserva del Perú)
COES	Committee for the Economic Operation of the Electric System (Comité de Operación Económica del Sistema)
COFIDE	Financial Development Corporation (Corporación Financiera de Desarrollo)
DGE	Directorate-General for Electricity (Dirección General de Electricidad)
DGER	Directorate-General for Rural Electrification (Dirección General de Electrificación Rural)
DGH	Directorate-General for Hydrocarbons (Dirección General de Hidrocarburos)
EU	European Union
FONER	Rural Electrification Improvement Project (Proyecto de Mejoramiento de Electrificación Rural mediante Fondos Concursables)
GART	Office for Tariff Regulation (Gerencia Adjunta de Regulación Tarifaria)
GDP	Gross Domestic Product
GW	Gigawatt
GWh	Gigawatt-hour
IDB	Inter-American Development Bank (Banco Interamericano de Desarrollo)
IPP	Independent Power Producer
IFC	International Finance Corporation
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
KfW	Reconstruction Credit Institute (Kreditanstalt für Wiederaufbau)
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hours
MINAG	Ministry of Agriculture of Peru (Ministerio de Agricultura del Perú)
MINEM	Ministry of Energy and Mines of Peru (Ministerio de Energía y Minas del Perú)

MW	Megawatts
OSINERGMIN	Supervisory Organisation for Investment in Energy and Mines (Organismo Supervisor de la Inversión en Energía y Minería)
ProInversión	Peruvian Investment Promotion Agency (Agencia de Promoción de la Inversión Privada)
PPA	Power Purchase Agreement
PUE	Productive Use of Energy
PV	Photovoltaic
RRA	Renewables Readiness Assessment
SEIN	National Interconnected Electric Grid (Sistema Eléctrico Interconectado Nacional)

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Executive Summary

The Republic of Peru is the third largest country in South America after Brazil and Argentina, with a great diversity of ecosystems, along with mineral and energy resources. With a population of 30.5 million and gross domestic product growing at a rate in excess of 6% per year over the past decade, Peru has been one of the more rapidly developing countries in the region. The Peruvian economy has expanded from USD 53 billion in 2000 to USD 197 billion in 2012, making it the 48^{th} largest economy in the world. This economic expansion is expected to continue, mainly driven by investments in the mining and infrastructure sectors, as well as, increasingly by domestic consumption.

Oil and gas play a significant role in the overall energy matrix of Peru, accounting for over 70% of total primary energy supply. Hydro and thermoelectric power plants generate 98% of the electricity. Total electricity generation capacity in 2010 was in the range of 7 Gigawatts (GW). Most power plants are located in the centre of Peru, where historically most of the electricity demand was concentrated. However, in recent years, electricity demand has been growing quite rapidly in the north and south of the country, as these two regions are increasingly becoming the new poles of development. New generation and transmission capacity is being built to cover the increasing regional electricity demand. Transmission lines could be also further developed to integrate Peru with neighbouring countries, as there is potential for regional electricity trade. Peru has an electrical interconnector with Ecuador, and in the future could also extend an interconnection to Brazil.

High rates of economic growth have led to a substantial increase in energy demand, creating new opportunities to invest in energy infrastructure. The Ministry of Energy and Mines (MINEM) has calculated that electricity demand will grow at an average annual rate of 8.8% per year up to the year 2017. In order to keep up with these increasing energy needs, Peru has to step up investment in electricity generation be more than USD 5 billion by 2016. These investments are expected to bring an additional capacity of 4 300 MW, including 1 400 MW of hydro and 600 MW non-hydro renewables.

Peru has vast renewable energy resources that remain largely unexploited. There are abundant solar, biomass, wind and geothermal resources, in addition to the substantial hydropower potential. Thus, in a context of increasing electricity demand, renewable energy could play a significant role, further securing the necessary energy to fuel the economic expansion while preserving the environment.

Peru has started to promote investment in renewable energy, encouraged by a new economic development vision integrating social inclusion and environmental care. The decree for the promotion of investment in renewable energy generation (Legislative Decree No. 1002) sets a target of up to 5% of the national energy demand for 2008-2013 to be covered by renewable energy generation, without the inclusion of hydropower plants. This process has been facilitated by a well-defined legal structure based on the Electricity Concessions Law, which sets the legal framework for activities in the electricity sector, unbundling the generation, transmission and distribution utilities and enabling participation by the private sector.

Peru's conditions for investment in the electricity sector and efforts to promote renewable energy technologies have been recognised in various publications, including Climate Scope, the annual report by the Inter-American Development Bank (IDB) and Bloomberg New Energy Finance (BNEF) that assesses investment climate for clean energy development. In the latest edition of this report, Peru was ranked fourth out of 26 countries in the Latin American and Caribbean Region.

Rapid and sustained economic development has resulted in a decrease in poverty. However poverty and lack of access to basic services such as electricity remain a challenge, particularly in rural Peru. Renewable energy technologies, with their modular characteristics, could have an important role in reaching isolated communities and providing basic services. The 2013-2022 National Rural Electrification Plan produced by MINEM, in concordance with an Energy Universal Access Plan, establishes a policy for the sector with the aim is to raise the rural electrification rate from 87% to 95% by 2016. A tender for 500 000 solar photovoltaic systems for rural electrification was announced in 2013. Peru's Renewables Readiness Assessment (RRA), conducted in cooperation with the International Renewable Energy Agency (IRENA), has produced a holistic evaluation of the country's conditions, and identifies the actions needed to overcome barriers to renewable energy deployment.

Peru has been one of the pioneers in the region in implementing renewable energy auctions, which have helped to promote biomass, wind, solar and small hydropower plants. The first two renewable energy auctions awarded almost 1 400 gigawatt-hour (GWh)/year of renewable power from solar, wind and biomass and 281 MW from small hydro, attracting total investments of almost USD 1.5 billion. The results of a third auction process were recently announced; this resulted in the award of 16 hydropower projects with a total energy supply of 1 278 GWh/year.

The first two auction processes successfully demonstrated that an auction-based mechanism could be utilised for transparent and efficient procurement of renewable energy, securing Peru's participation in the global renewable energy market and contracting significant quantities of renewable electricity at competitive prices. Peru has taken significant steps in the development of renewable energy auctions and is currently one of the leading countries that have developed and held successful auctions. However, there are opportunities to further enhance planning and preparatory activities, as well as, the design of the auction process.

To make Power Purchase Agreements (PPA) more bankable, more flexible terms of energy delivery could be considered, taking into account renewable energy generation characterised by intermittent or seasonal production. PPA contracts could be based on quotas for the supply of power based on the average of three years, while capacity building to equip local banks for technology risk assessment could help to ease renewable energy financing.

It might also be important to consider the centralisation of auctions, as large power rounds are likely to foster increased competition and international interest. Large power rounds could potentially lower tariffs and have a positive impact on local manufacturing. However, given the considerable amount of investment that would be required, such auctions could attract limited participation by domestic companies. In this context, it might be important to evaluate the trade-off between conducting one large auction round or spread this contracting over different auctions carried out at different times.

Another issue to consider is the inclusion of additional scoring criteria, incorporating local-content requirements, allowing reinvestment and job creation by promoting a market for local manufacturing of equipment and components for renewable electricity generation. Based on international experiences, one option for future auctions could be to consider a technology-neutral approach, where independent power producers (IPPs) using different renewable energy technologies are eligible to participate in the same auction process. When adopting a technology-neutral approach, it is necessary to evaluate the trade-off between policy objectives (diversification of the energy mix, promotion of selected technologies) and how to enhance competition.

Combining different types of renewable resources in hybridisation strategies can achieve more effective management of resource and output variability. Peru could consider a portfolio of non-dispatchable resources with complementary production patterns: wind and small hydro; wind and solar; wind and biomass; biomass and small hydro.

In terms of rural electrification, Peru has made remarkable efforts to improve its electrification rate. The national electrification rate has increased from 55% in 1993 to 87.2% in 2012. The National Rural Electrification Plan 2013-2022 provides strategic direction to provide access to electricity to 6.2 million people in the next 10 years. Peru is undertaking efforts to increase access to energy via auctions for solar photovoltaic systems, grid extension, mini-grids with hydro, solar and wind.

A final part of this report includes an evaluation of the biofuels situation in Peru. Given that domestic demand for liquid fuels has been steadily growing, particularly as a result of the increased pressure for public transport, biofuels could represent a renewable energy alternative to fossil fuels in the transport sector.

The Regulation for Biofuel Commercialisation sets mandatory requirements for the blending percentages of ethanol (7.8%) with gasoline, and biodiesel (5%) with diesel (Diesel B5). To satisfy the increasing demand for biofuels, refining companies procured their supplies from national and international markets, price and availability of product being important parameters in the decision-making process.

KEY RECOMMENDATIONS

As a result of the Renewables Readiness Assessment, the following recommendations have been made to foster the deployment and sustainable use of renewable energy resources in the country:

a) For the design of renewable energy auctions, it is recommended to undertake more effective long-term planning with clear long-term policy goals. This will provide a strong signal of intent, attract global IPPs and encourage equipment manufacturers to develop the local industrial base in Peru.

b) Fine tune the design of the renewable energy auction process to secure the participation of experienced developers and also mitigate the risk of aggressive bidding.

c) Consider the size of auction rounds, local-content requirements, hybrid systems and technology neutral auctions to reduce the administrative costs and maximise the benefits of the auction process.

d) In order to increase the intake of renewables into the grid, it is recommended to identify areas with high potential, and to conduct impact studies on the adoption of high shares of renewables in those part of the grid.

e) In the case of rural renewable energy, it is recommended to achieve greater coordination between actors, promote productive uses of energy throughout the system and conduct capacity-building activities on the ground.

f) For biofuels, it is recommended to provide an enabling policy framework, which facilitates setting up business models that promote local market development for biofuels.

g) Undertake periodic updates of solar and wind resource assessments. This information would facilitate decision-making and encourage accelerated deployment of renewable energy in Peru.

I. INTRODUCTION

BACKGROUND

The Republic of Peru is on the western coast of South America. It borders Ecuador and Colombia to the North, Brazil to the East, Bolivia to the South-East, Chile to the South and the Pacific Ocean to the West (figure 1). Peru has an arid coast, mountainous highlands and tropical forest. It is the third largest country in South America after Brazil and Argentina, and extends over 1.28 million square kilometres (km^2) with a large diversity of ecosystems, mineral and energy resources.

Peru has a population of almost 30.5 million, mostly concentrated in the capital city, Lima (Instituto Nacional de Estadística Informática, (INEI), 2013). With a Gross National Income per capita of USD 5 580 in 2012, Peru has been at the forefront of economic development in the region (World Bank, 2012). It has consistently high gross domestic product (GDP) growth rates (6.3% in 2012). Over the last decade, the Peruvian economy has expanded from USD 53 billion in 2 000 to USD 197 billion in 2012, making it the 48^{th} largest economy in the world (World Bank, 2012). According to the Global Economics Ranking, Peru will have moved up to become 26^{th} largest economy by 2050 (CNN, 2012).

Despite uncertainty in the international markets in 2013-2014, Peru is expected to maintain its position as one of the faster growing economies in the region and to grow at sustainable rates of 5.7-6.4% (Sociedad Agente de Bolsa, (SAB), 2013). This will be driven by an increasing domestic consumption and public and private investment, particularly in the construction and mining sectors.

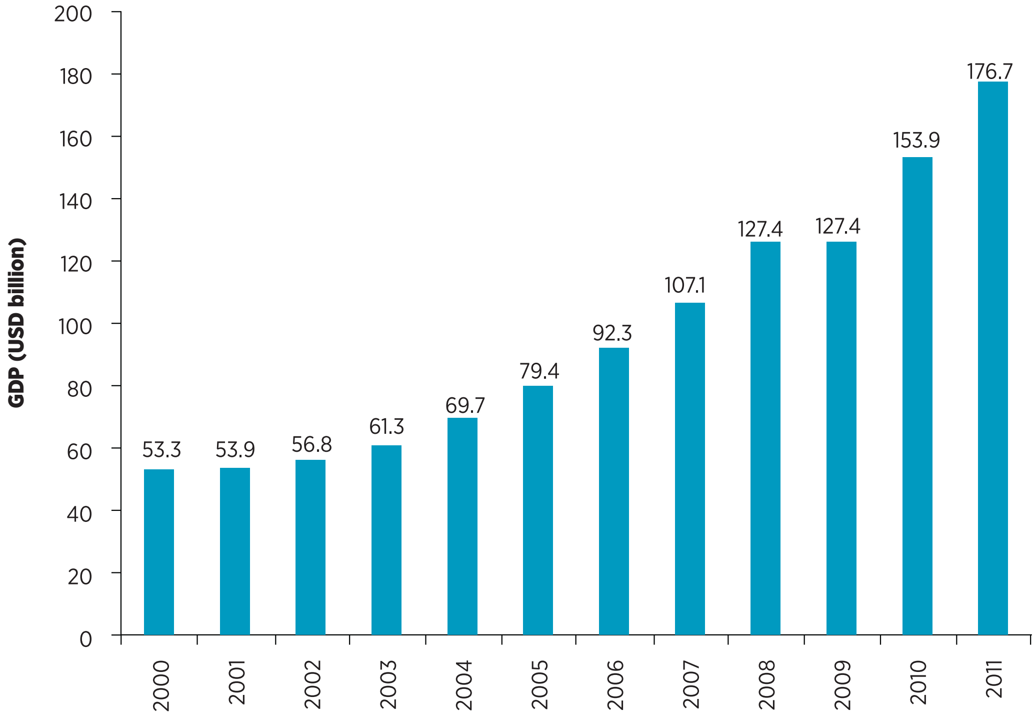
Peru offers many investment opportunities and options. The mining, finance, communication, industry and energy sectors are the five main targets of foreign direct investment. They represented 87.2% of the stock in December 2011 according to the Peruvian Investment Promotion Agency (ProInversión), 2012. Box 1 gives an overview of high growth sectors.

Market-friendly policies with sound fiscal management and a commitment to macroeconomic stability have contributed to sustained economic growth. National statistics show that in 2011, the non-financial public sector boasted an economic surplus of 1.9% of GDP. Meanwhile, inflation is estimated to be steady at 2% in 2013-2014 (Banco Central de Reserva del Peru, (BCRP), 2013). Peru is also well positioned in the world market, since it has signed free trade agreements with major economies.

Figure 1
Map of the Americas, showing the geographic location of Peru

Figure 2

Peru: Gross domestic product, 2000-2001 (USD billion)



Source: Central Reserve Bank of Peru (BCRP)

Box 1

Growth sectors

Mining: Peru is consistently ranked as the top producer of gold, silver, zinc, lead and tin and is the second highest producer of copper in the region. Over the last decade, this sector has expanded substantially, and this has been one of the drivers of energy demand.

Agriculture: new irrigation and agricultural projects will double the 90 000 hectares currently farmed for the export of agricultural products.

Fishing: the cold Humboldt Current means Peru is home to one of the world's greatest fisheries. There is a trend towards product diversification.

Natural gas: in 2011, natural gas production reached 11.4 billion cubic meters. Some areas with good oil and gas potential have not been explored yet (26.6 million hectares).

Information and Communication Technology (ICT) services: there are ICT Enterprise Solution centres in 15 574 locations, creating 29 665 direct jobs. Exports have tripled in five years (Cámara del Pacifico, 2012).

These include the United States, Canada, China and South Korea, as well as regional markets like the European Union (EU), Asia-Pacific Economic Cooperation, and Andean Community of Nations. This allows Peru to increase its GDP growth through exports.

Global markets have recognised the economic achievements of Peru and its economic outlook. In 2013, Standard & Poor's upgraded Peru to the category BBB+, due to the country's improved capacity to register steady growth, and reduced vulnerability to external shocks (El Comercio, 2013a).

In terms of the business environment, the International Finance Corporation (IFC) Doing Business Report 2013 ranked Peru second in Latin America and 42nd worldwide out of 189 economies (IFC, 2013). The ranking aims to provide an objective measurement of business regulations and their enforcement, based on a number of different parameters.[1] According to the latest report, Peru has maintained its position as a good place for doing business with particularly high ratings for the investor protection parameter, for which the country was ranked 13th globally.

ProInversión indicates that several economic groups from all regions of the world have operations in Peru. The main capital contribution sources are the United States, Spain and the United Kingdom. In 2012, there was an increase of nearly 24% in private investment compared to the previous year, amounting to USD 42.8 billion (ProInversion, 2013). Investment flows are expected to continue increasing in the coming years in various sectors including mining, communications, energy, finance and manufacturing. Key sectors within the manufacturing industry include metalworking, construction materials and textiles.

High economic growth rates in Peru have led to a substantial rise in energy demand, creating new opportunities to invest in energy infrastructure. It is expected that the growth in electricity demand will increase fourfold by 2030 from 4 500 megawatts (MW) in 2011. An average growth in Peru of 13% is expected during the first five years according to the Ministry of Energy and Mines (MINEM) in 2012. Electricity demand is driven by industrial sectors, which represent 55% of total demand. Electricity demand from these sectors is expected to continue growing in the coming years, mainly driven by the expansion of mining. These rapid changes in the electricity market have provided an opportunity for Peru to further diversify its electricity mix to create a sustainable, cost-effective and environmentally sound generation matrix. Renewable energy could play a significant role in this process as there are vast solar, hydro, wind, biomass and geothermal resources that remain largely unexploited.

In recent years, Peru has started to promote investment in renewable energy, encouraged by a new economic development vision integrating social inclusion and environmental care into all productive activities. The Law for the Promotion of Investment in Renewable Energy Generation[2] grants competitive advantages to projects for renewables.

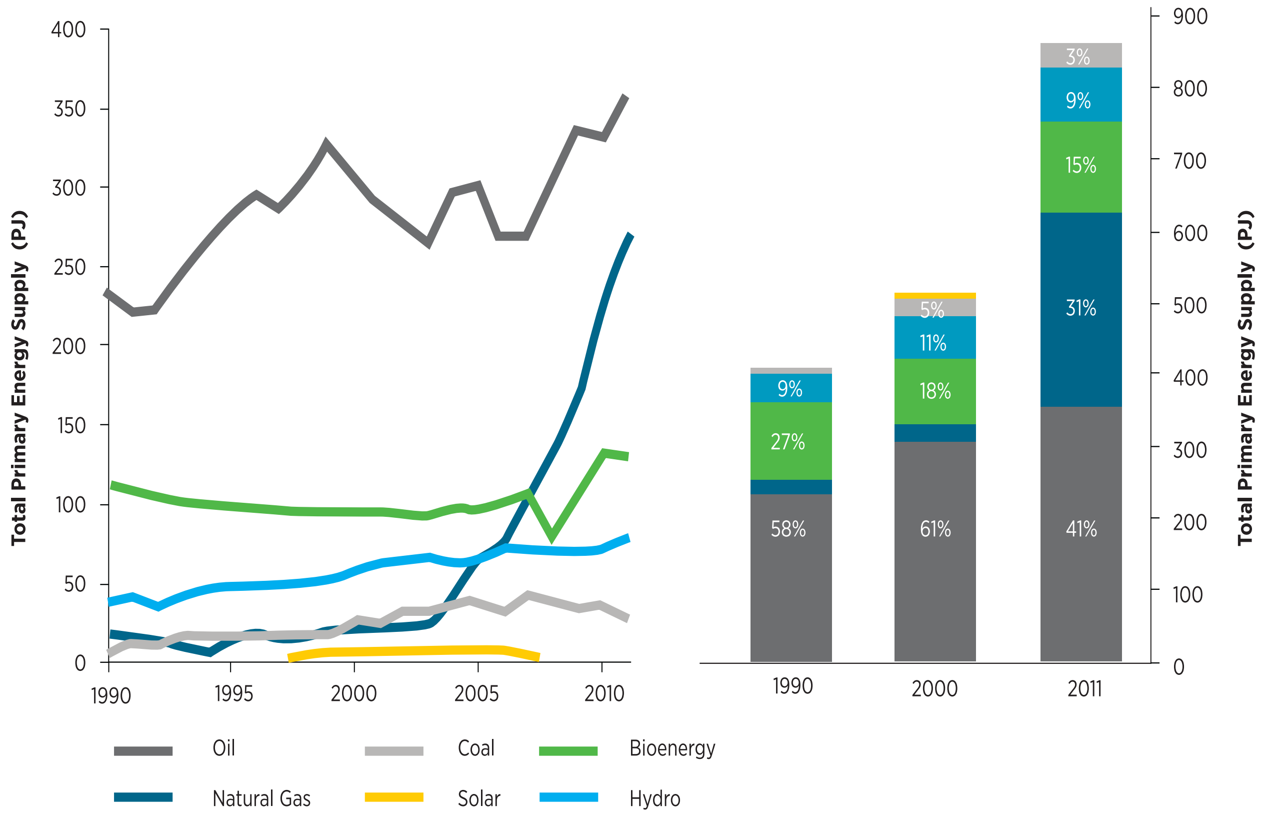
Peru was placed fourth out of 26 countries evaluated in the region in Climate Scope

1 According to the IFC, the parameters include: the process, time and costs of starting a business, construction permit application, electricity connection, property registration, credit approval, investor protection, tax payment, cross-border trading, contract enforcement and debt restructuring.

2 Ley de Promoción de la Inversión en Generación de Electricidad con el uso de Energías Renovables (Law for the Promotion of Investment in Electricity Generation using Renewable Energy) (Legislative Decree 1002).

Figure 3

Peru: Total primary energy supply by fuel



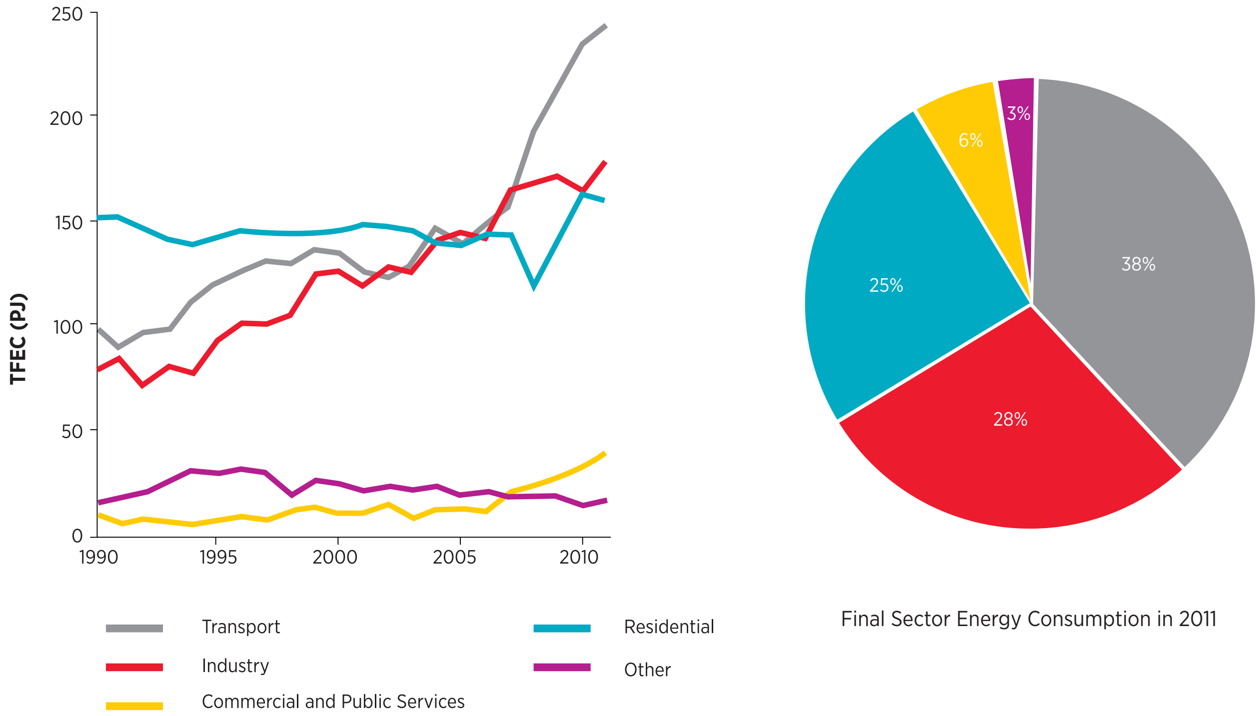
Source: International Energy Agency (IEA)

2013. This is jointly published by the Inter-American Development Bank (IDB) and Bloomberg New Energy Finance (BNEF). It contains an index assessing the investment climate for clean energy development. The best score for Peru in Climatescope 2013, where it came second, was in the Clean Energy Investments and Climate Financing parameter. This report also indicates that cumulative clean energy investment in 2012 amounted to USD 1.22 billion, equivalent to the same amount of investment made in 2006-2011. This consisted mainly of wind, solar and small hydro projects (Climatescope, 2013).

Sustainable rates of economic growth over the last decade have had a positive impact on poverty reduction. However, in 2011 extreme poverty was at 6.3%, and was particularly concentrated in rural Peru and more specifically the Sierra region (INEI, 2013).

Studies have shown a strong correlation between poverty levels and access to basic services including electricity (ESMAP and the German Society for International Cooperation, (GIZ), 2013). The present administration is making significant efforts to raise access to electricity in rural areas under the umbrella of its social inclusion strategies. As a result of their modular characteristics, renewable energy technologies (especially solar, small hydro and biomass) could play an important role in satisfying energy requirements in rural Peru.

Figure 4
Peru: Total final energy consumption by sector



Source: International Energy Agency (IEA)

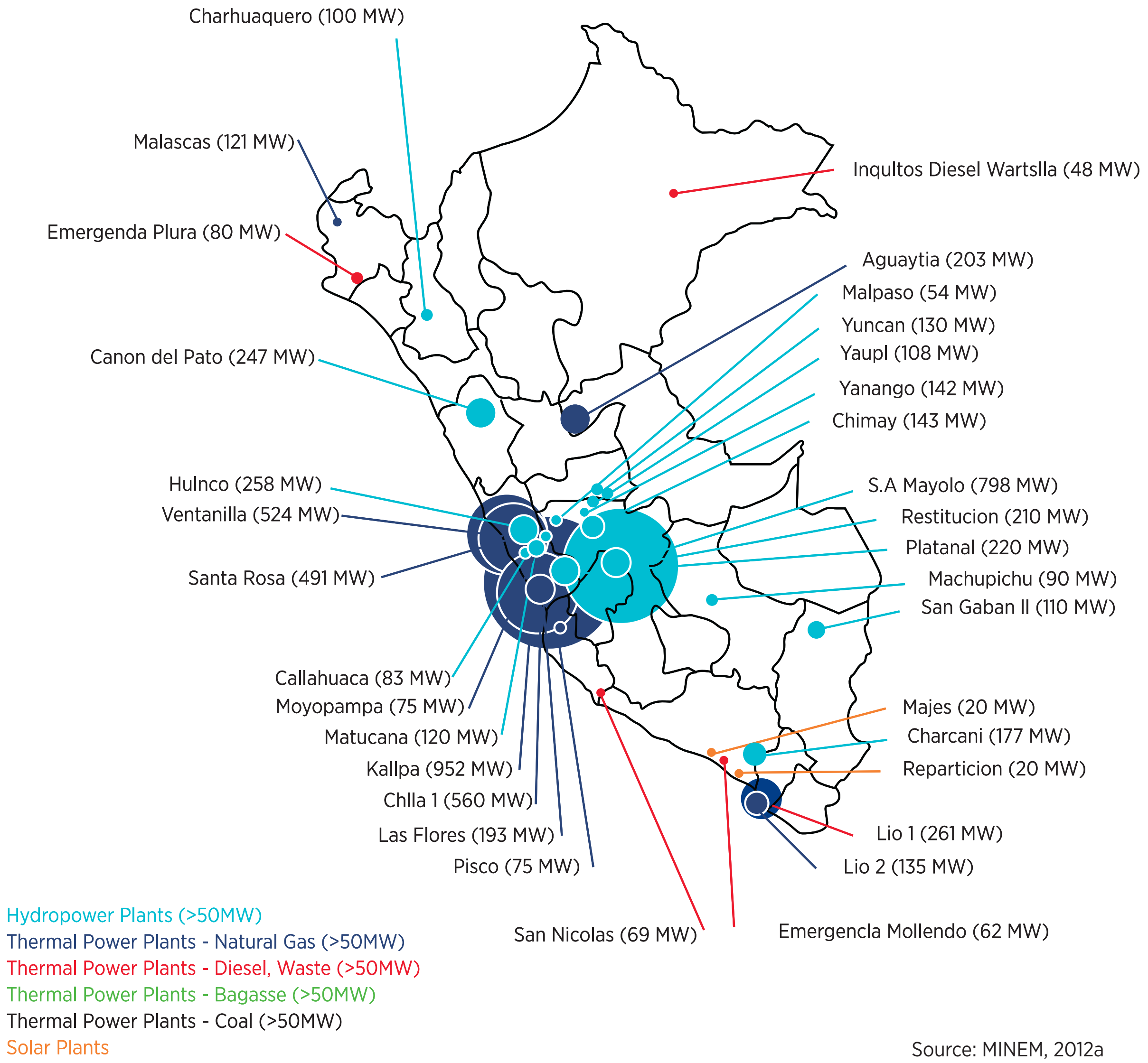
The 2013-2022 National Rural Electrification Plan in concordance with an Energy Universal Access Plan, produced by MINEM, has established a sectoral policy. Its aim is to raise the rural electrification rate from 87% to 95% by 2016. This means an average annual increase of 4.1%. For this, MINEM has announced tenders for 500 000 solar photovoltaic (PV) systems for rural and isolated areas.

ENERGY SECTOR

Over the last decade, the rapid expansion of the economy has led to an equally rapid and sustained increase in the use of most energy sources. Figure 3 shows the trends in Peru's Total Primary Energy Supply (TPES) in 1990-2010.

In 20 years, Peru's TPES doubled from 408 petajoules (PJ) in 1990 to 805 PJ in 2010. Fossil fuels (oil, natural gas and coal) dominate the TPES, accounting for 75%. This was followed by bioenergy accounting for 15% and large hydro for 9%. Other forms of renewable energy (including solar and wind) accounted for 0.03% (IEA, 2013). By sector, total final energy consumption (TFEC) is dominated by the transport industry and residential sectors, transport being the fastest growing sector.

Figure 5
Existing power generation capacity by source



Source: MINEM, 2012a

Peru's renewable energy resources are vast and diverse. However, the rapid increase in the use of natural gas since the Camisea Gas Project began, has had an impact on renewable energy technology deployment (IFC, 2011).

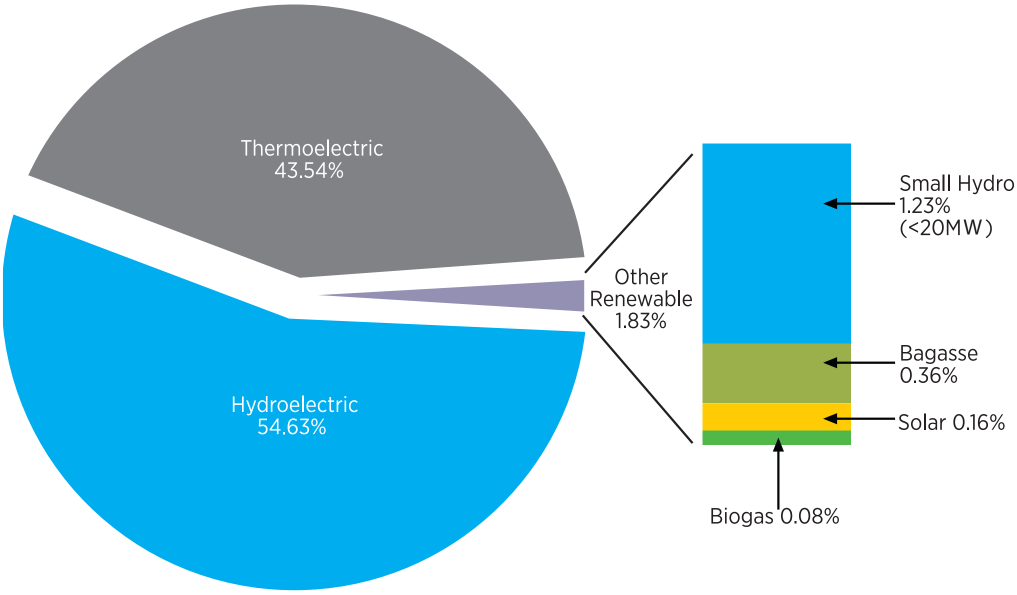
However, this trend could change, given the priority accorded to energy diversification and the positive economic results of clean energy initiatives. These showed significant reductions in the costs associated with the use of these technologies in power generation.

ELECTRICITY SECTOR

The Peruvian electricity market has matched the country's economic growth and development. According to MINEM, the total installed generating capacity connected to the National Interconnected

Figure 6

Electricity production by technology, 2012



Source: ProInversión, 2013

Electric Grid (SEIN) in 2013 consisted of 23 hydropower plants with a total capacity of 3 270 MW and 32 thermal power stations with a total capacity of 5260 MW (MINEM, 2014). Figure 5 shows a breakdown of the main generation plants.

As a result of the renewable energy auction, four solar plants with a total capacity of 80 MW (Panamericana Solar, Tacna Solar, Majes Solar and Solar Distribution) were operating by 2013 according to Peru's Supervisory Organisation for Investment in Energy and Mines (OSINERGMIN).

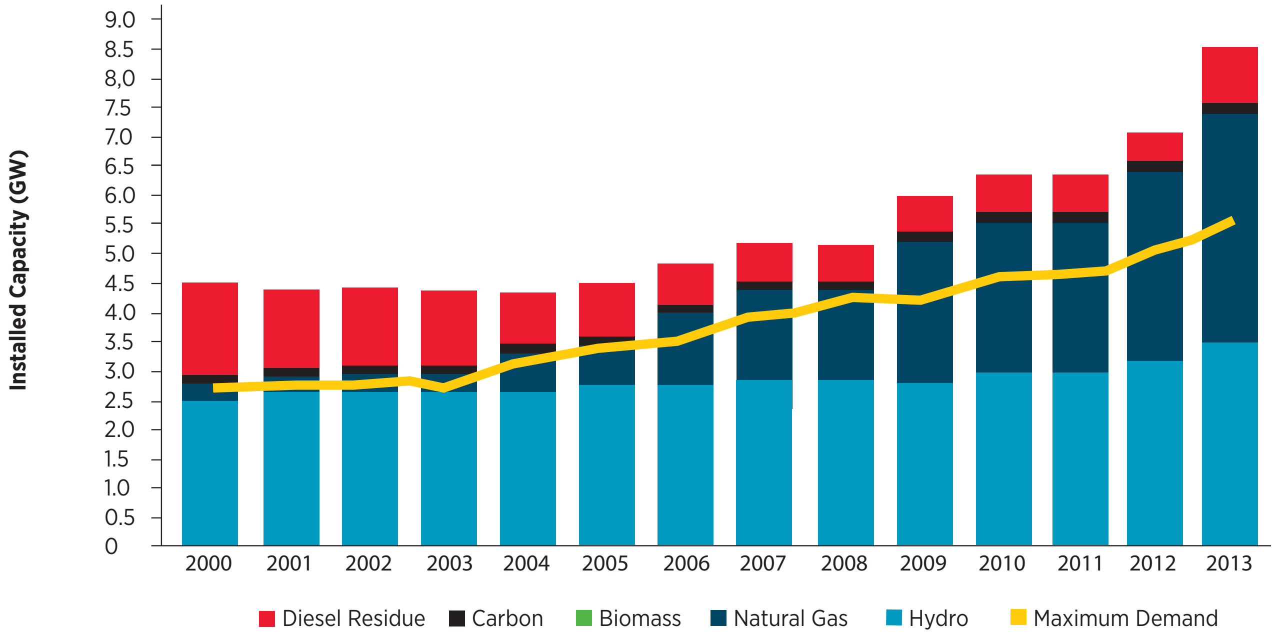
The power plants connected to SEIN represent 87% of the Peruvian market. The remaining 13% is produced by self-generation companies. They are not included in the overall figure, but are part of the total installed generating capacity.

The high level of concentration of power generation capacity in the centre of the country is shown in figure 5. Demand has increased rapidly, but the expansion of grid infrastructure has in the past not matched the power demand requirements. This means that transmission is at present operating almost at maximum capacity, particularly in the country's southern and northern corridors. This adds to the challenges of raising power generating capacity in these areas, which are expected to become the new poles of development. To relieve this situation, investments in grid infrastructure are now under way.

For example, the 513 km high voltage Lima-Trujillo transmission line was commissioned in November 2012. In addition, the Private Investment Promotion Agency (ProInversión) is working on 2 561 km of new power lines of 500 kilovolts (kV) and 1 482 km of 220 kV, respectively. This will cost USD 1 029 million (Sector Electricidad (Electricity Sector), 2012) and will improve transmission capacity in Peru. Problems related to the condition and stability of the grid are explained in detail in this report.

Figure 7

Growth of power capacity and maximum demand



Source: MINEM, 2014

According to the Committee of Economic Cooperation of the Electric System (COES), electricity generation in 2012 amounted to 37 321 gigawatt-hours (GWh), 6% higher than in 2011 (35 217 GWh). It was dominated by hydropower plants, accounting for 55% of total production (ProInversión, 2013). These plants depend on water sources such as rivers and lagoons fed by precipitation and glaciers, whose availability is reduced between May and November (the dry season).

The accelerated retreat of Andes glaciers due to climate change could in the coming years become a new factor potentially reducing the availability of water resources. It is likely to become a key consideration in electricity planning (ESMAP, 2011). Most of the remaining electricity (43%) was generated by thermal sources. Finally, renewable energy provided the remaining 1.83%. Figure 6 presents the electricity production by type (ProInversión, 2013).

In 2003-2010, national power demand increased from 2 965 MW to 5 575 MW at an average annual growth rate of 6.5% (MINEM, 2014). The rapid electricity demand increase, is accompanied with increased power generation capacity. According to figure 7, maximum demand increased by 88% in ten years, whereas generation grew only by 94.5%. MINEM has forecasted an average annual demand growth of 8.8% in 2013-2017 (Nicho, 2013). For 2017, peak demand is expected to amount to 8 058 MW. This means an additional 500 MW power plants will be required every year for the next four years (MINEM, 2012a).

It is expected that in the next three years, electricity generation capacity will increase by 2.25 GW (COES, 2012a). This capacity will come from large projects in the pipeline, such as the hydroelectric plants Cerro del Aguila (502 MW), Cheves (168 MW), Quitaracsa (112 MW), and the combined cycle thermoelectric power plants Fenix (534 MW) and Santo Domingo de los Olleros (196 MW) (MINEM, 2012b). A full list of future generation projects can be found in Annex 8.

As a result of its geographical location, Peru also has the potential to become a regional energy hub in future. Peru has an electrical interconnector of 220 kV with Ecuador. In October 2012, an interconnection agreement was signed by these two countries that will enable the construction of a 500 kV interconnector between them. In future, Peru could also extend its national grid by 500 kV through an interconnection with Brazil (COES, 2012b).

Investment in electricity generation in Peru will have been raised to USD 5 billion by 2016. Capital invested in 2013-2016 is expected to generate 4 300 MW of additional capacity. This could mean that the electricity supply could keep up with national economic growth. According to MINEM, new installed electricity capacity will include 1 400 MW hydro, 1 400 MW thermal, 800 MW cold reserve and 600 MW non-hydro renewables by 2016 (MINEM, 2012b).

Two cold reserve power plants were commissioned in the third quarter of 2013, adding 800 MW (Bessombes, 2013). Natural gas from the Camisea field has driven the development of gas power plants to an average annual rate of 16%. However, the limited supply of natural gas for power generation at present prices, coupled with limited pipeline capacity to transport natural gas from Camisea, could affect power supply. Renewable energy can help meet growing electricity demand in Peru. The country has over 25 000 MW of non-hydro renewable energy potential. This can be exploited to complement natural gas and large hydro generation to meet the projected growth in electricity demand.

RENEWABLE ENERGY

Peru has significant renewable energy resources, although very little has been used. There are abundant solar resources in the South, as well as on the coast and in the highlands. There are significant wind resources along the central, northern and southern coastlines. Large areas with geothermal potential have been identified throughout the highlands, with significant volumes in the volcanic area of the South. Peru also has massive water availability, and this could be further exploited for power generation.

In the last decade, policies have been introduced to promote and implement renewable energy projects. International commitments, the need for a more diverse energy matrix and awareness of the need to manage climate change have driven these initiatives.

In 2010, MINEM called the first renewable energy auction for electric power generation, with successful results. A total of 887 GWh/year were awarded to two biomass projects, three wind projects and four solar PV projects. In addition, contracts were awarded to 17 hydroelec-

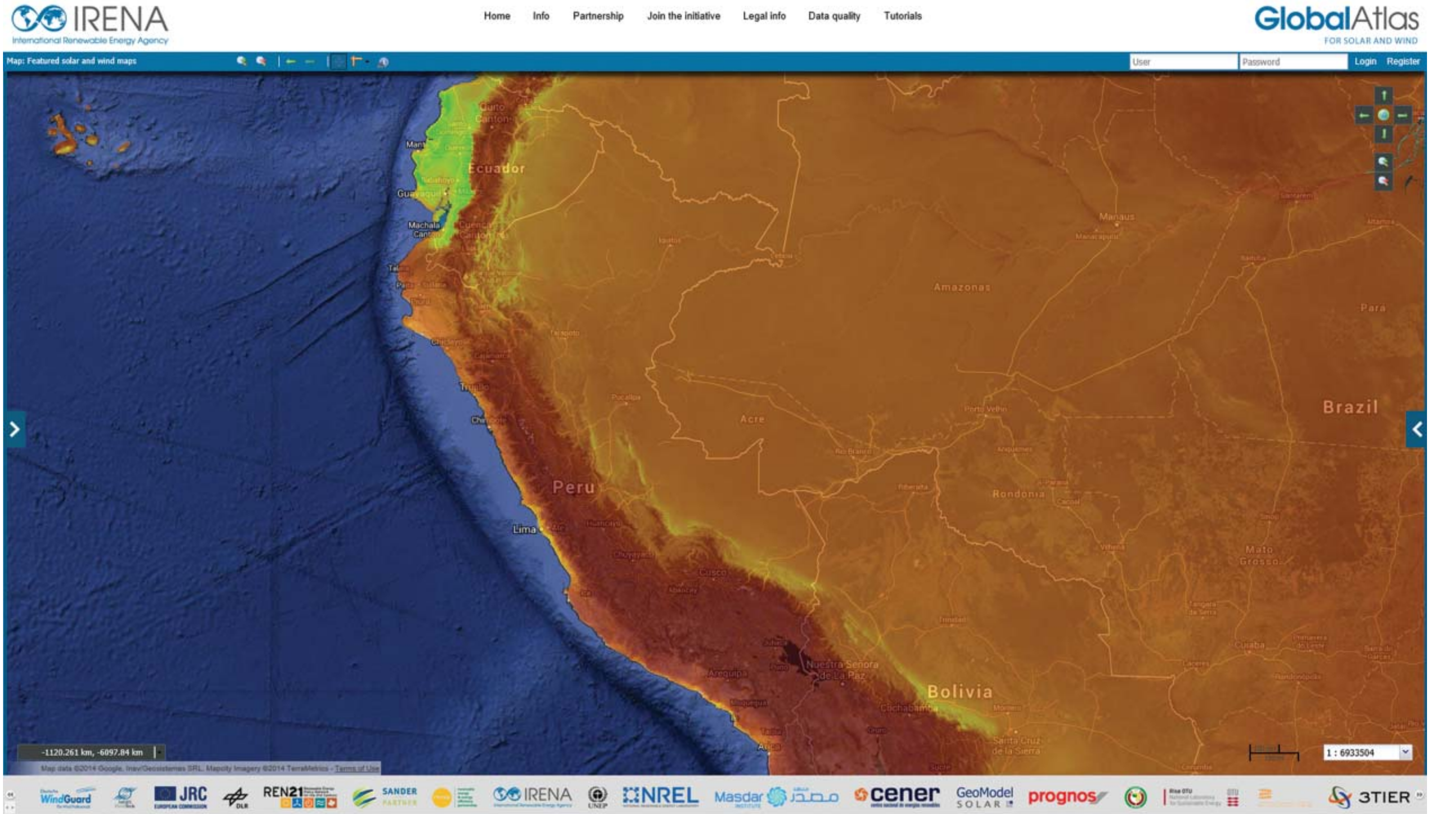
Table 1
Renewable energy potential 2012-2020

Hydropower(i)	69 445 MW
Wind(ii)	22 450 MW
Geothermal(iii)	3 000 MW

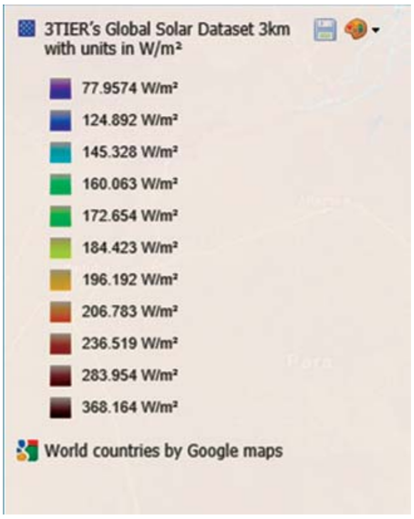
Source:
(i)Directorate-General for Rural Electrification (DGER)-MINEM, World Bank and Global Environmental Facility, "Peru Hydro Atlas"
(ii) DGER-MINEM, Peru Wind Atlas
(iii) Battocletti & Associates, Inc. (1999) "Geothermal Resources in Peru

Figure 8

Map of Peru's solar resources from the Global Renewable Energy Atlas



tric projects amounting to 180 MW. In 2011, a second auction took place with equally successful results: 472 GWh/year were awarded to biomass, solar and wind and 680 GWh/year to small hydro. In August 2013, MINEM announced a third auction for 320 GWh/year biomass and 1 300 GWh/year hydropower generation (OSINERGMIN, 2010, 2012, 2013b), the results of the third auction are presented in this report. OSINERGMIN has already set the price for future geothermal power auctions, which will be called by MINEM over the next four years. The following section outlines the renewable energy resource potential in Peru. The renewable energy resource atlas can be found in annex 1.



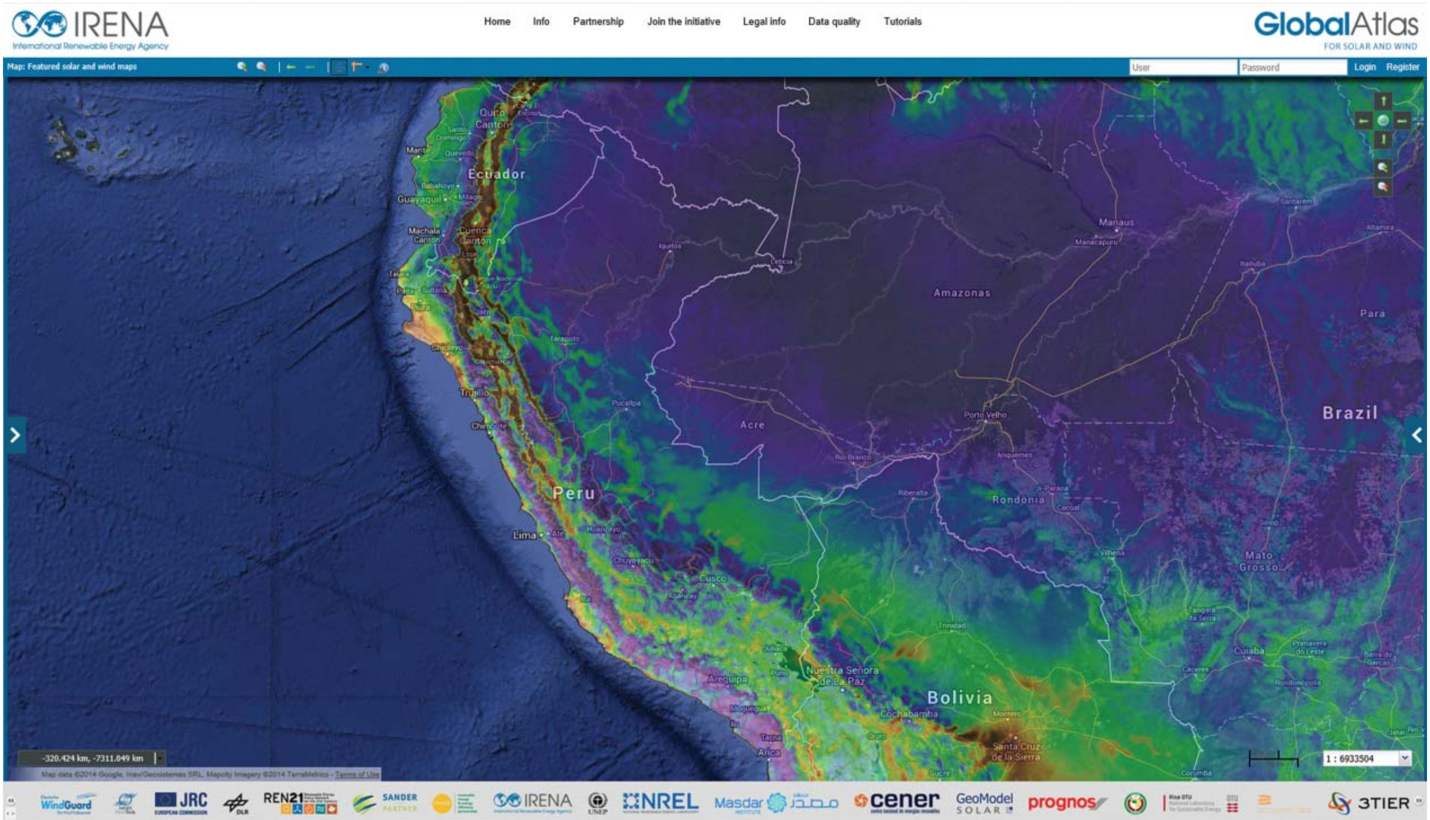
www.irena.org/globalatlas

SOLAR ENERGY

The solar atlas of Peru, figure 8, shows that the region with the highest solar resource is along the southern coast in Arequipa, Moquegua and Tacna. The annual average daily irradiation is around 250 watts per square metre (W/m²).

Figure 9

Map of Peru's wind resources from the Global Renewable Energy Atlas



WIND ENERGY

The following wind atlas, in figure 9, shows the wind resource at 80 metres. It has been estimated that Peru has a wind power potential of 77 000 MW,[3] of which over 22 000 MW can be exploited (Mendoza, 2012).

Despite this significant potential, present wind energy supply at interconnected system level is very limited. To date, only two demonstration wind turbines have been installed by the state, and this was in the 1980s and 1990s. Nevertheless, nearly 1 000 GWh/year of wind power will be added over the next few years as part of the auction process in Peru.

The National Rural Electrification Plan for 2013–2022 includes small off-grid wind projects. A total investment of USD 38 million[4] will benefit 167 communities by 2022.

www.irena.org/globalatlas

3 Excluding offshore areas
4 Peruvian Sol (PEN); PEN 106.4 million. Exchange rate PEN/USD= 2.78

GEOTHERMAL ENERGY

Peru forms part of the Pacific Ring of Fire, characterised by frequent tectonic movements. The geothermal atlas can be found in annex 1. It shows the location of six areas with geothermal potential (Vargas and Cruz, 2010). Most geothermal potential is concentrated in Cajamarca, Huaraz (Ancash and La Libertad), Churin (in Lima, Pasco and Huanuco) and the Central zone (in Huanuco, Huancavelica and Ayacucho). It is also concentrated in a chain of volcanoes in Ayacucho, Apurimac, Arequipa, Moquegua and Tacna and finally Puno and Cusco.

At the request of MINEM in 2011, the Japan International Cooperation Agency (JICA) completed a master plan for the development of geothermal energy in Peru. This plan evaluated 61 potential geothermal fields in the six regions. It concluded there was a geothermal potential of around 3 000 MW (Mendoza, 2011). The study found that 13 of these fields have substantial power, amounting to approximately 800 MW. By defining the power and location of geothermal fields, the master plan provided a guide for future project implementation. MINEM received requests for further exploration of 40 fields. Access has been granted to 14 of these because they met the requirements.

HYDROPOWER

Hydropower potential has been estimated at 70 000 MW, mostly concentrated in the Cuenca del Atlántico (Mendoza, 2012). The hydro atlas can be found in annex 1. Small hydropower plants connected to SEIN generated almost 500 GWh/year in 2012 (ProInversión, 2013). During the first two renewable energy auctions, small hydro projects (under 20 MW) were awarded for a total capacity of 282 MW (OSINERGMIN, 2012).

BIOENERGY

Peru currently produces first generation liquid biofuels and potential biomass resources for the production of second generation biofuels. The suitable crops for ethanol production in Peru are sugar cane and sorghum. Although oil palm, white pine nut, jatropha, castor bean, soybean, peanut and sunflower all have potential as biodiesel feedstock (SNV- Research Institute of the Peruvian Amazon (IIAP), 2007).

In 2011, the Food and Agriculture Organisation (FAO) published the 'State of the Art and Bioenergy News in Peru'. This report indicates that the only oilseed produced at commercial scale is the African oil palm, which is produced in certain areas of the Amazon. The white pine nut and castor bean are adaptable to various climatic zones, so it is expected that their production will increase to commercial scale.

A National Plan for the Promotion of Oil Palm was established, aiming to increase production to 50 000 hectares by 2011. This level of production has been achieved and the plan is being updated and extended to 2020. Of the 50 000 hectares now under cultivation, approximately 20 000 are owned by corporations and the rest by small producers, who cultivate on average five hectares per family.

Peru has the potential to install 177 MW in conventional biomass power plants and 51 MW in biogas plants (Mendoza, 2012). This is based on 2009 values for agro-industrial and forestry residues for bioenergy for electricity production. The installed capacity at the moment is almost 28 MW (Mendoza, 2011).

Meanwhile, 160 GWh/year of biopower was awarded during the first two renewable energy auctions (OSINERGMIN 2010, 2012).

Rio Urubamba, an Amazon tributary, winding through the Sacred Valley, Peru.
Photo: World Water Forum

II. Renewables Readiness Assessment

The Renewables Readiness Assessment (RRA) is a holistic evaluation of a country's conditions and identifies the action needed to overcome barriers to renewable energy deployment. The RRA includes all renewable energy services, including on-grid and off-grid electricity, biofuels for transportation and other applications such as heating and cooling. However, it is up to each participating country to determine which renewable energy sources and technologies are relevant and consistent with national priorities.

The RRA methodology means completing a set of templates designed to capture the key concerns relating to present policy, regulations, finance, operations and maintenance. The existing business models for the development of renewable energy have a major bearing on the assessment.

The RRA is led by the particular country being assessed, which also owns the report emerging from the assessment. This sets the RRA apart from other assessment processes led by international organisations. IRENA offers its support during the RRA, but it is the action and insight evolving through a country-owned process that provides the key to rapid deployment. An RRA also facilitates a coordinated approach and priority setting. This can inform future bilateral and multilateral discussions with international and regional agencies, financial institutions and the private sector concerning the implementation of initiatives emerging from the RRA.

With the support of IRENA, individual countries have access to a global network, giving them the capacity to follow up on initiatives and exchange experiences. Peru held the first RRA in Latin America and the first in a middle-income emerging economy. The process started with a literature review of research in the energy sector and successive discussions that were held with MINEM-Directorate General of Electricity in March and May 2012. This allowed the RRA director and programme manager at MINEM to identify key stakeholders, select service-resource pairs (*e.g.,* electricity/solar) of relevance to Peru and match them to groups of stakeholders.

Transmission tower
Photo Courtesy: Shutterstock

The stakeholders were chosen from key government ministries, the private sector, non-governmental organisations (NGOs) and academia. A comprehensive outline of these stakeholders is provided in annex 2. The Peru RRA workshop and assessment took place on 16-17 July 2012. In this two-day workshop, stakeholders were brought together to discuss the status of the renewable energy sector.

It is of particular importance to highlight and thank the following organisations for sharing their perspectives and insights during this workshop: MINEM, Ministry of Environment, Ministry of Agriculture, the Provincial Government of Puno, the Provincial Government of Arequipa, OSINERGMIN-Office for Tariff Regulation (GART), Financial Development Corporation (COFIDE), COES, Electrical Infrastructure Administration Company (ADINELSA), Financial Development Corporation (COFIDE), the Peruvian Renewable Energy Association, the National University of Engineering (UNI), Japan International Cooperation Agency (JICA), Development Bank of Latin America (CAF) and Scotiabank among others. Templates on the main barriers to renewables deployment in Peru summarising the workshop discussions can be found in annex 3. Further working party meetings and a technical visit to MINEM, the regulator OSINERGMIN and discussions with the private sector were conducted in the second semester of 2012 and first semester of 2013.

The RRA methodology has proved to be a significant tool that countries with emerging markets should use to assess requirements for deploying renewable energy. The RRA in Peru has yielded a number of outcomes, summarised in annex 5. It has provided a clear understanding of the renewable energy environment and allowed a range of stakeholders to get involved, become sensitised and to take ownership of renewable energy issues and concerns. It has also generated a range of necessary practical steps – not least the validation of rational and simple process and methodology.

III. Policy and regulatory framework

STRUCTURAL REFORM OF THE ELECTRICITY SECTOR

The electricity sector in Peru has been shaped by public sector investment and the active participation of the private sector. In the early 1990s, Peru's government issued a series of laws to promote private investment, highlighting the electricity sector as of national interest. The reform of the electricity sector started in 1992 with the promulgation of the Electricity Concessions Law,[5] which sets the legal framework for the activities in the electricity sector. The general objective of this law is to promote a pricing system for greater economic efficiency by setting up a tariff for end-users. The tariff takes optimal usage of available energy resources into account. Generation, transmission and distribution utilities were unbundled as a result of this law. It also engaged the private sector in these commercial activities (OSINERGMIN, 2009).

In 2006, the Law for Efficient Generation Development[6] came into force to complement the Electricity Concessions Law. The Law for Efficient Generation Development aims to guarantee efficient electricity generation, reducing the vulnerability of the Peruvian electrical system to price volatility and long blackout periods. It also provides the assurance of a competitive electrical tariff to consumers. In addition, it establishes two new different types of transmission systems, one for supplementary transmission and one for guaranteed transmission (OSINERGMIN, 2006).

INSTITUTIONAL SET-UP

Peru's electricity market comprises a variety of stakeholders from the public and private sector. National and regional public entities interact to develop the necessary legal and regulatory framework for creating the right conditions for attracting private investment. MINEM is the cornerstone of the institutional framework for renewable energy in Peru. The electricity market framework consists of 57 public and private companies engaged in generation, transmission and distribution and a regulatory body, OSINERGMIN. In contrast to other countries in the region, it also includes a private entity that manages the national grid, COES. Of the 57 companies, almost half are engaged in generation, 10% in transmission and 40% in distribution (MINEM, 2012a).

5 Ley de Concesiones Eléctricas (LCE) Law Nº 25844. D.S. 009-93-EM.
6 Law Nº 28832

NATIONAL ENTITIES

As the policy definition body, MINEM[7] develops regulations and standards in the energy and mining sectors, including those related to renewable energy. The policy and regulatory guidelines for conducting auctions for renewable electricity generation are set by MINEM. The key constituent divisions within MINEM are as follows:

Directorate-General for Electricity (DGE):[8] Grants the rights to carry out electricity-related activities. This includes the promotion of power projects, governance of central government policies on electricity subsector development, and proposals for Peruvian electricity standards.

Directorate-General for Rural Electrification (DGER):[9] Plans and promotes rural electrification activities in coordination with regional and local governments, as well as specialised private and public entities.

Directorate-General for Hydrocarbons (DGH) :[10] Provides authorisation for marketing biofuels.

Directorate-General for Energy-Related Environmental Affairs (DGAAE):[11] Evaluates and approves environmental studies of energy projects.

Supervisory Agency for Energy and Mining Investment (OSINERGMIN):[12] As the regulatory body, OSINERGMIN supervises and regulates activities in the energy and mining sectors, including the renewable energy market. The Office for Tariff Regulation (GART)[13] part of OSINERGMIN, calculates and proposes electricity tariffs. These need to be in compliance with existing regulations and to ensure the efficient operation of electricity utilities at the lowest cost to the consumer.

The Electrical Infrastructure Administration Enterprise (ADINELSA):[14] As a coordination agency, ADINELSA provides rural electrification services, manages electricity infrastructure (*i.e.,* wind power facilities) and assists local and regional governments in the electrification of remote communities.

The Committee for the Economic Operation of the Electric System (COES):[15] COES coordinates the operation of the national grid at minimum cost in the short, medium and long term. In addition, COES plans the development of SEIN transmission lines and manages the short-term market. COES is a technical entity comprising the owners of generation plants and transmission systems, whose installations are interconnected. The objective is to coordinate their operations at least cost, guaranteeing reliability of electrical energy supply and best use of energy resources.

REGIONAL AND LOCAL INSTITUTIONS

According to the Law for the Promotion of Investment in Renewable Energy Generation, MINEM is the national authority responsible for promoting projects that use renewable energy resources.

Nevertheless, regional governments can also promote the use of renewable energy resources within their territory. Regional governments are responsible for formulating, implementing, evaluating, monitoring and managing energy plans and policies within their own boundaries, in line with national policies and sector plans.

7 Ministerio de Energía y Minas (MINEM)
8 Dirección General de Electricidad.
9 Dirección General de Electrificación Rural.
10 Dirección General de Hidrocarburos
11 Dirección General de Asuntos Ambientales Energéticos.
12 Organismo Supervisor de la Inversión en Energía y Minería.
13 Gerencia Adjunta de Regulación Tarifaria (GART)
14 Empresa de Administración de Infraestructura Eléctrica.
15 Comité de Operación Económica del Sistema Interconectado Nacional

In addition, they are responsible for granting generation concessions for plants with an installed capacity of 500 kilowatts (kW) - 10 MW.[16] This includes renewable energy generation concessions and leading regional rural electrification programmes, under the National Rural Electrification Plan.

Finally, regional governments are responsible for land use planning. This includes the identification of suitable areas with high potential for power generation outside environmentally fragile zones.

For local government, the Municipalities Organic Law[17] aims to promote comprehensive and sustainable development of the community, enhancing public and private investment. This covers investments in renewable energy, as well as employment, ensuring the rights and equal opportunities of the population are fully exercised in accordance with national, regional and local development.

POWER MARKET STRUCTURE

The electricity market is the commercial interface between electricity generation, transmission and distribution utilities that supply electricity to final costumers.

In the case of Peru, it is composed of four units: the spot market, free market, regulated market and auction market. Figure 10 displays the interaction between the four units.

Generation companies have the option to sell electricity either to other generation companies or to distribution companies. In the first case, the energy and power transactions may occur within the spot market. Here, electricity rates are defined as equivalent to marginal cost values, which vary every 15 minutes in accordance with the dispatch of the national system.

A second option is to sell it into the free market based on free negotiations. The free market applies to transactions between generation and distribution companies as well as distribution to final customers. Maximum power demand from a free customer is 200 kW. Where users have maximum power demand of 200 kW-2.5 MW, they can choose between the free or regulated market.

In the regulated market, generating companies negotiate and sign contracts with distribution companies at a given price ceiling set by OSINERGMIN. Distribution companies can then sell electricity to customers with power demand of under 2.5 MW at rates and conditions existing in the regulated market. Finally, electricity purchase and sale in the auction market is, as the name indicates, set through auctions. This market is only accessible to generation companies selling electricity awarded to distribution companies in the auctions.

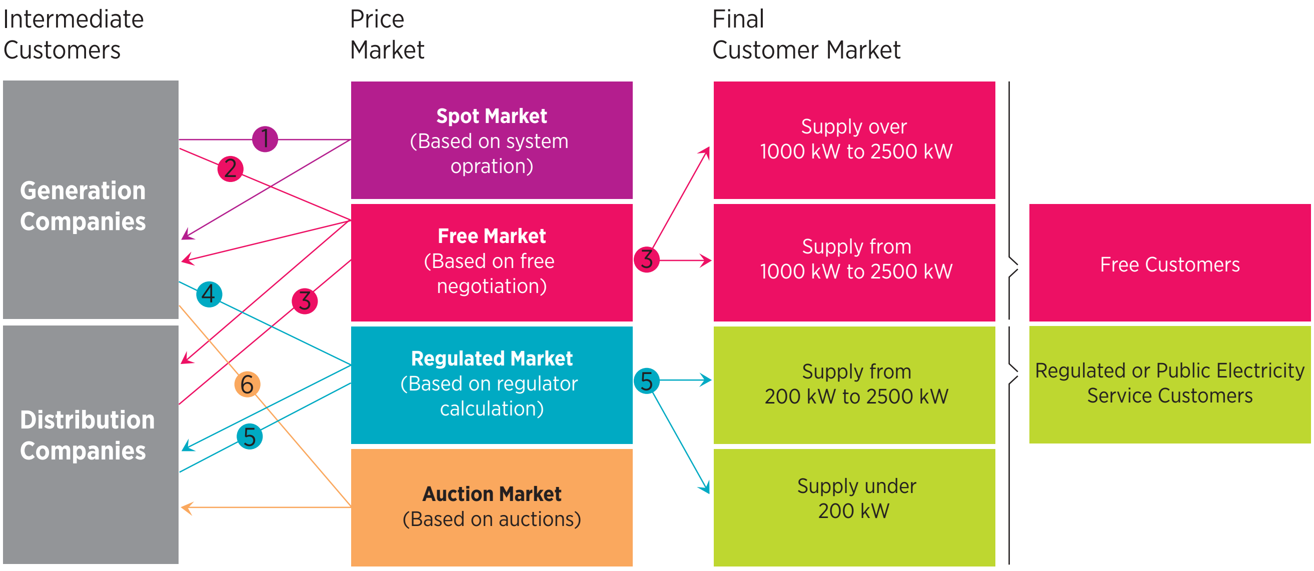
RENEWABLE ENERGY POLICY

Two legal instruments set the legal framework for the renewable electricity sector. These were Legislative Decree No. 1002 for the Promotion of Investment for Electricity Generation with the use of Renewable Energy[18] and the Regulation for Electricity Generation with Renewable Energy.

The first of these establishes the promotion of renewable energy resources as a national priority. It promotes the connection of renewable electricity to the national grid, SEIN, through regular auctions. It also sets a five-year rolling target share

16 For projects under 500 kW, concessions are not required, article 2 and 3 of Law Decree N° 25844.
17 Law Nº 27972
18 Defined as biomass, wind, solar geothermal, tidal and hydro (when the installed capacity is up to 20 MW).

Figure 10
Electricity market in Peru



Source: MINEM, 2012a

of energy demand to be met by electricity from non-hydro renewable energy resources.[19]

This decree was complemented by the Regulation for Electricity Generation with Renewable Energy[20] of the same year. This regulation determines the administrative procedure for announcing renewable energy auctions and granting concessions for the development of renewable power generation. It also sets the requirements for submitting, evaluating and awarding bids, as well as marketing procedures and renewable energy generation tariffs. Renewable energy benefits from fiscal incentives are summarised in box 2.

Peruvian Technical Standards (NTP) provides standards on renewable energy equipment for solar collectors, solar PV systems up to 500 watt-peak (Wp) and technical standards for biofuels. The Regulation for Biofuels Marketing[21] sets out the national requirements for biofuels marketing and distribution. It relates to quality standards for these products and the scope and functions of relevant institutions participating in the biofuels market.

Box 2

Fiscal incentives for renewable energy

Electricity generation through hydro, wind, solar, geothermal, biomass and ocean technologies are subject to an annual maximum accelerated depreciation of 20% on income tax. Accelerated depreciation applies to machinery, equipment, installation and operations and maintenance (O&M) necessary for grid-connected renewable energy plants.

Renewable energy generators are entitled to early recovery of Value Added Tax (VAT) for the sale of electricity (MINEM 2012a).

19 This excludes hydroelectric power stations
20 D.S. 050-2008-EM. The new Regulation was approved for D.S. N° 012-2011-EM
21 D.S. 021-2007-EM

Solar PV Plant in Peru
Photo Courtesy: MINEM Peru

Satellite picture of Lima city
Photo Courtesy: Earth Observatory NASA

IV. Renewable energy power in the grid

INTRODUCTION

Peru has made significant steps in promoting renewable energy in the electricity market with the aim of diversifying its electricity mix and reducing its dependence on fossil fuels. Renewable electricity can help meet rapidly growing electricity demand, which is forecast to increase at an average annual rate of almost 9% (Nicho, 2013). Furthermore, the Law for the Promotion of Investment in Renewable Energy Generation (Law no. 1002), sets a target of up to 5% of the national energy demand to be covered by renewable energy generation [22] between 2008-2013 (MINEM, 2012a).

Following the reform of the electricity sector in 2006, auctions were adopted in Peru as the preferred mechanism for introducing cost-effective electricity rates to users. The country is therefore already familiar with auction processes. It has perfected it for large hydropower and combined cycle natural gas power plants, and has now also introduced this mechanism for renewable energy.

Peru aims to promote biomass, wind, solar and small hydro using technology-specific auctions. The first two renewable energy auctions awarded nearly 1 400 GWh/year of renewable energy power to solar, wind and biomass and 281 MW to small hydro. This attracted a total investment of almost USD 1.5 billion. In 2013, Peru announced the third renewable energy auction. This covers 320 GWh per year of biomass and 1 300 GWh per year of small hydro (OSINERGMIN, 2013b).

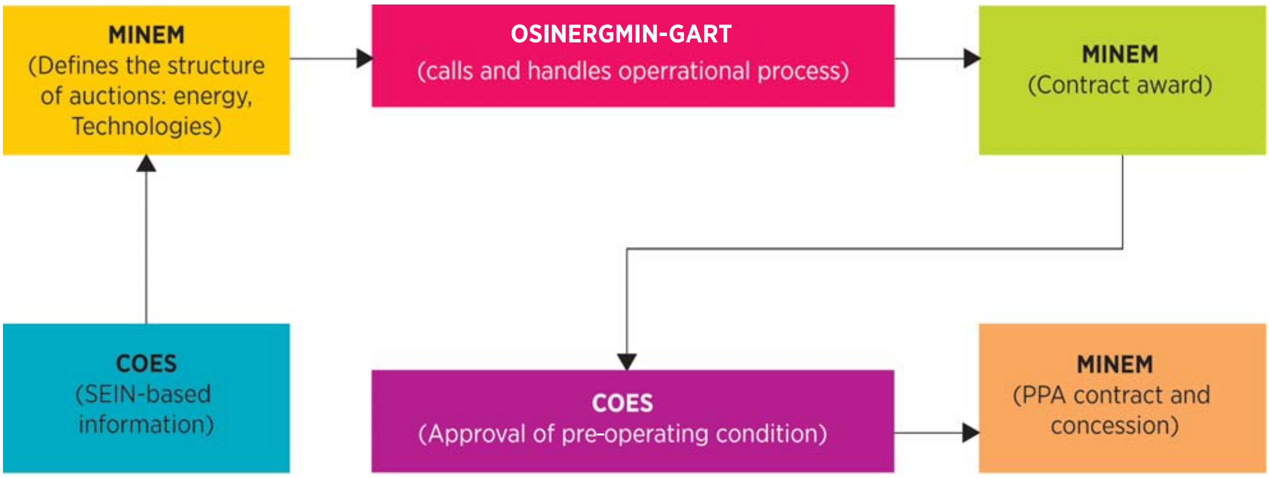
AUCTIONS

Peru is fine-tuning the auction design and process for renewable energy technologies by incorporating lessons learnt into the next round. There are ongoing discussions on the size of auction rounds, hybrid generation systems, local content requirements

22 Renewables energy resources are defined as biomass, wind, solar, geothermal and ocean, but exclude hydropower over 20 MW.

Figure 11

Flow chart - Renewable Energy auction design



Box 3

Technical and financial requirements

To participate in the auction process, bidders have to comply with strict technical requirements. These range from providing evidence of renewable resource investigations lasting at least one year, compliance with COES standards and equipment specifications and pre-feasibility studies.

Bidders are also required to submit various financial guarantees. They include a bid and a performance bond calculated per MW of capacity contracted and installed. This is to ensure that successful bidders sign the PPA, as well as installing the capacity in line with the agreed time schedule. In case of delays to the start of commercial operations of the plant, an automatic increase of 20% to the performance bond will be requested (IRENA, 2013a), provided the delay has not occurred due to accident or force majeure.

(LCR), and other considerations. The first two auctions were aligned to meet the targets set by the government and aim to introduce power from different renewable energy technologies into the grid. Independent Power Producers (IPPs) were invited to bid for power from biomass, wind and solar and also to set up small hydro plants.

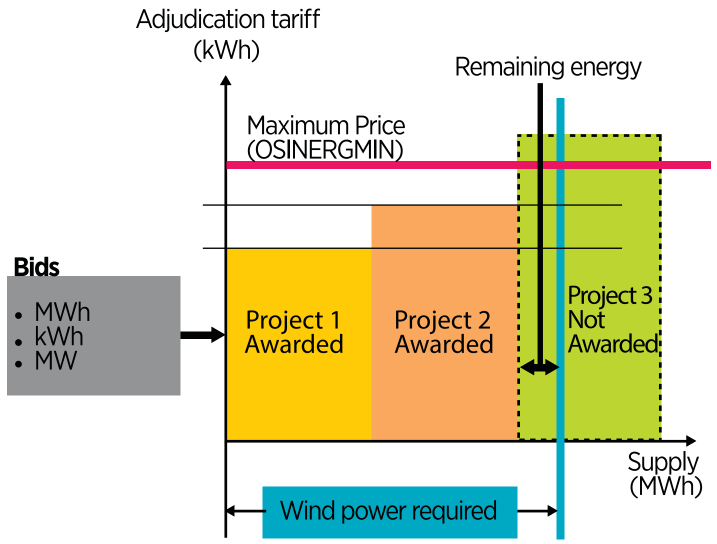
PROCESS

The renewable energy auction process involves three key entities, MINEM, OSINERGMIN-GART and COES. Their interaction is displayed in figure 12.

MINEM defines the structure of the auction, the quantity of energy requested and the allocation of that amount among the various renewable energy technologies (*i.e.*, the ministry sets a cap according to technology). The allocation takes the recommendations of the system operator, COES, into account in relation to the status of grid infrastructure and the variable power injection points in the grid.

The regulator OSINERGMIN-GART is responsible for conducting the auction and determines the price cap for each tech-

Figure 12
Evaluation process for a wind project



STEPS:

1º The maximum price is published

2º Envelopes are opened and projects are sorted by price offer, from lowest to highest, with those that exceed the maximum price being discarded

3º The committee verifies that MWs allocated do not exceed the power limits on the Toolbar Offer

4º If MWh offered are less than the energy required all bids are awarded

5º If the MWh offered exceeds the Energy Required, a partial adjudication is evaluated where the price offered is lower than the maximum price.

Source: Molinelli, 2011

nology. The price set takes a number of factors into consideration, such as the type of technology, project cost, cost of capital and reasonable rate of return. Box 3 presents a summary of the technical and financial requirements for participating in the auction process.

A typical renewable energy auction process in Peru takes approximately four months. A detailed schedule is presented in annex 6.

EVALUATION, AWARDED CONTRACT AND REMUNERATION

A steering committee composed of two members from the regulator and one from MINEM evaluates bids. The auction documents provide detailed procedures for contract award and selection. Contracts are awarded by economic merit, ranked according to how far they fall short of the auction price cap, until demand for the specific technology is met. Figure 12 provides an example of a bid evaluation process for a wind project.

Renewable projects have a guaranteed annual income. This is defined as net energy deliveries to the grid (up to the maximum awarded energy amount) multiplied by the tariff awarded in the public auction. Box 4 describes the payment process.

Finally, winning projects are granted priority of dispatch and access to transmission lines and distribution networks. This is important to ensure revenues. Power Purchase Agreement (PPA) contracts last 20 years.

Box 4

Payment process

The payment flow every month is as follows: the renewable project will receive payment for the energy delivered to the grid priced at the hourly short-run marginal cost of the system, plus firm capacity remunerated at the contracted price.

An ex-ante estimation is then made of the required subsidy[i] to comply with guaranteed annual income (auction-based tariff). This is done by OSINERGMIN for a given tariff year and published together with the annual bus bar tariffs. This subsidy is paid out of the excess charged to the users of the transmission network.

To conclude, there is also an annual ex-post adjustment to compensate generators for the differences between expected and actual payment received from the electricity market for the energy delivered. A penalty is imposed where there is a shortfall in energy produced. The final price to be paid is the price awarded minus any penalty.

i Known as "Prima" In Spanish and calculated as: subsidy = energy delivered (awarded tariff – marginal cost)

HIGHLIGHTS OF THE FIRST TWO RENEWABLE ENERGY AUCTIONS

FIRST AUCTION

In 2009, OSINERGMIN issued a notification for the first auction. This consisted of 1 314 GWh/year to be provided by the following technologies: biomass (813 GWh year), wind (320 GWh/year) and solar (181 GWh/year). In addition, auctions for small hydropower stations,[23] amounting to 500 MW, were also announced. Table 2 provides a summary of the results of this initial round by renewable energy technology.

In the initial round, projects finalised for contract covered 68% of the total energy required from wind, biomass and solar energy. In the case of renewable energy from small hydro, only 32% of the total tendered capacity was awarded.

The initial first call was declared partially unmet. A decision was made to move forward with a second call for the capacities not covered in this initial round. This call included biomass (419 GWh/year), solar (9 GWh/year), as well as 338 MW of energy from small hydro.

Through this second call a total of 19 companies with 27 projects presented their proposals, but only one small hydro project for 18 MW was awarded. The projects were disqualified since the prices offered were greater than maximum price caps set by the regulator.

Bid prices for awarded projects for at least two technologies, solar and wind, were much lower than the ceiling prices. Average prices for solar bids were USD 0.22 per kilowatt hour (/kWh) - 18% lower than the ceiling price of USD 0.27/kWh. Wind prices were at an average of USD 0.08/kWh - which represented a 28% discount on the ceiling of USD 0.11/kWh.

The auctions in Peru took place at a time when the prices of solar technology across the world had started declining. There was oversupply in the wind sector (REN21, 2012). Strong competition in the electricity sector and the position of the contracting utilities also provide a relatively sound explanation for the deep discounts on solar and wind. By contrast, the hydro projects were contracted at an average price of USD 0.06/kWh with a minor variance

23 Small hydro is defined as less than 20 MW

Table 2
Results of Peru's first renewable energy auction

	Biomass	Wind	Solar	Total
Energy required (GWh/year)	813	320	181	1 314
Energy awarded (GWh/year)	143	571	173	887
Percentage awarded	**18%**	**178%**	**96%**	**68%**
		Small Hydropower		
Power required (MW)		500		
Power awarded (MW)		162		
Percentage awarded		32%		

Source: OSINERGMIN, 2010

between different bids. Hydro is a well-known technology with many companies operating in the market at similar prices.

In the case of wind energy, an additional 251 GWh/year was awarded during this auction. Wind energy prices were very competitive and the quota for biomass was not covered. Thus wind energy bids offering a price below the biomass cap were contracted. This first auction attracted investments of nearly USD 1 billion. Total investments for nine projects in biomass, solar and wind amounted to USD 675 million while investments on 17 hydroelectric projects attracted investments of nearly USD 303 million.

Many interested parties from all over the world visited the data room of this auction, reflecting the interest in investing in Peru and more specifically its renewable energy market. In the case of wind energy, competition was strong with a much higher number of candidates bidding for capacity/energy than was actually available. All biomass projects were awarded to national companies. In the wind and solar auctions, international companies outbid the national companies. In the case of small hydro projects, all awards were won by national companies, two of which were joint ventures with foreign partners.

In February 2010, the process concluded with a total of 887 GWh/year awarded to two biomass projects, three wind projects and four solar PV projects. In addition, contracts were awarded to 17 hydroelectric projects amounting to 180 MW. Detailed results of this tender process are presented in annex 7.

This was the first renewable auction in Peru, thus as a learning process it was very important in that it kick-started the auction-based mechanism to promote renewables in Peru. The auction mechanism resulted in efficient prices, with outcomes 24% lower than cap prices and tariffs below international prices.

SECOND AUCTION

A second auction took place in August 2011 for 1 300 GWh/year for the following technologies: wind (429 GWh/year), solar (43 GWh/year), biomass (593 GWh/year) and waste-to-energy (235 GWh/year). Additionally, 681 GWh/year was auctioned for small hydropower.

Although the total auctioned energy requirement was of the same order of magnitude of that registered in the first auction, there were significant changes in the composition of energy required by

Table 3
Results of Peru's second renewable energy auction

	Biomass	Wind	Solar	Total
Energy required (GWh/year)	828	429	43	1 300
Energy awarded (GWh/year)	14	416	43	473
Percentage awarded	**2%**	**97%**	**100%**	**36%**
		Small Hydropower		
Power required (MW)		681		
Power awarded (MW)		680		
Percentage awarded		100%		

Source: OSINERGMIN, 2010

technology. The amount of wind power auctioned increased by 23% while the amount of small hydropower decreased by 78% compared to the first auction.

Three projects with a total of 473 GWh/year were awarded to the following technologies: biomass (14 GWh/year), solar PV (43 GWh/year) and wind (415 GWh/year). In addition, seven projects were awarded to hydro-electric power stations for a total of 680 GWh/year with commercial start-up planned for 31 December, 2014. However, the total energy contracted from these technologies (1 152 GWh/year), represented only 60% of the total energy available for auction. Table 3 summarises the key results of the second auction by technology. For more information refer to annex 7.

The second round of auctions has attracted investment of nearly USD 0.5 billion. Successful biomass, wind and solar contracts will result in investment of nearly USD 229 million. The seven successful small hydro projects are estimated to bring in investment of USD 227 million.

The outcome of the second auction can be considered satisfactory. It met the objective of promoting renewable generation and consolidating the auction-based renewable energy framework in Peru. Although a significant amount of energy was not supplied, offers submitted were competitive compared to the international tariff, but in some cases not competitive enough to win the Peru bids.

In the case of solar, the average tariff contracted was USD 0.12/kWh, very competitive compared to the international tariffs at that time. In the case of the Brazilian wind auctions carried out that same year, the price outcome was nearly USD 0.08/kWh, whereas in Peru the average wind energy tariff was contracted at USD 0.07/kWh. Unlike the first auction, this second auction did not automatically call for a new round of bids. This was not found to be very useful in the first auction and also led to market distortion.

Prices between the first auction in 2009/2010 and the second in 2011 fell by 11% for hydro, 14% for wind, 9% for biomass and 46% for solar PV. Peru has acquired solar PV in particular at the most competitive price compared to global trends.

It has also acquired wind generation for the very attractive price of USD 0.07/kWh in line with that obtained in the Brazilian wind auctions, the biggest in South America.

THIRD AUCTION

The third renewable auction awarded 16 small hydropower projects amounting 211 MW. These projects were contracted at an average price of USD 0.06/kWh to supply 1 278 GWh/year.

LESSONS LEARNT

Both auction processes were successful in the following respects:

- Consolidating the renewable energy regulatory framework in Peru and showing that the auction-based mechanism provides credible, transparent and efficient renewable energy procurement.

- Including Peru in the renewable energy map worldwide, attracting the interest of a wide and diverse number of potential investors.

- Attracting inward investment to the renewable energy sector in the region of USD 1.5 billion.

- Contracting significant quantities of renewable energy (more than 10% of the system peak demand in the first auction alone), clearly moving towards fulfilling the government's goal to introduce renewable generation in its electricity mix.

- Contracting electricity at competitive prices, reducing prices for all technologies - 11% for small hydro, 14% for wind, 9% for biomass and 46% for solar PV.

On the other hand, design improvements are necessary for future auctions to be successful. Two important considerations include:

- Definition of a clear long-term policy goal for renewables in order to ensure continuity and end the stop-and-go cycles. This would then provide a strong signal of intent and attract IPPs and equipment manufacturers to develop the local industrial base in Peru.

- Improve the process design so that it reduces the risk of aggressive bidding. An interesting practice followed in Indian solar auctions, is the increase in bid guarantee compared to the benchmark price as the bids become more aggressive, thus ensuring that bidders remain realistic.

By April 2013, 19 of the 27 renewable energy projects were connected to the grid. This includes all four solar projects (80 MW), the two biomass projects (27 MW) and 13 hydroelectric projects (98 MW).

However, eight projects from the first bid process are still under construction, including all three wind projects and five small hydro projects. All these projects have obtained an addenda to their contracts with the respective extension (see annex 8).

Peru has now called a third auction for renewable energy resources. A series of key findings on the design of the auction, bankability of PPAs, large lots, local content requirements, hybrid and technology neutral auctions are presented in the next section. This is to maximise the amount of renewable energy awarded in this and future auction processes.

WAY FORWARD AND FINDINGS FROM THE RRA

The discussions during the RRA process pointed to the need for a clear long-term policy goal for renewable energy in the Peru energy mix. Everyone agreed that the auction process had been quite successful. But a clear signal supported by a long-term vision and implementation plan is required if large international IPPs are to include Peru in their investment strategy. It is important to announce an implementation plan in advance that will enable potential investors to engage in project development activities[24] and provide an element of certainty and continuity.

Consultations must be held to formulate the National Renewable Energy Plan, as mandated by the Law for the Promotion of Investment in Renewable Energy Generation. This will help foster renewables in Peru on the basis of a long-term vision. Renewable energy targets, mandatory goals for renewable integration and long-term plans for renewable penetration in Peru are critical if serious investors are to build foundations in Peru. An implementation plan defining modalities would also prepare the ground for investment.

IMPROVING THE DESIGN

For the auctions to be successful, the design has to incorporate elements on the one hand that provide checks and balances in terms of incentives and penalties. On the other, they should not provide unnecessarily harsh or impractical penalties that discourage serious operators. Power generation finance in Peru occurs through project finance (where the project's revenues should be enough to ensure repayment of the debt with some debt service coverage ratios). It is essential not only that the auctioned product is properly designed, but that rational bidding, with risk-adjusted offers, is also observed in the auction.

In an attempt to maximise the probability of winning the auction, some bidders are often excessively aggressive in their offers. They do not price the contract in the proper way by considering the relevant risks. Aggressive bidding creates a mismatch between revenue and risks, which makes financing difficult. A document issued by MINEM or OSINERGMIN-GART containing some kind of guide for auction participants might help. It would clearly set out the risks and obligations of the contract and communicate to investors the relevance of correct pricing. It would also facilitate financial closure. As in India, auction clauses could be introduced that increase bid guarantees as the bids become more aggressive. This would act as a deterrent to over-adventurous bidding. In Peru, bidders are required to deposit a bid bond for USD 20 000/MW of capacity installed. This acts as a guarantee preventing delays (IRENA, 2013a).

Penalties for project abandonment or delay need to be defined in order to reinforce meeting project deadlines by successful bidders. To foster new generation, it is very important to have the proper mechanisms in an auction-based framework to anticipate potential problems and avoid failure. Peru correctly applies project completion guarantees. These penalties are financial, and they do not physically provide the energy failed projects would deliver. Security of supply can be threatened depending on the volume of voided projects and on how late notice is given by the investor. Hence, it is also important to introduce a provision in the general regulatory framework of auctions in Peru or in the auction tender

24 For example, one of the conditions for participating in the auctions is a resource assessment of at least one year.

documents. This allows the regulator to unilaterally terminate the contract over a relatively short time frame (for example, one year) if some very basic project development landmarks have not been reached. This mechanism would allow the system to swiftly rearrange a contract for the missing energy. For reference, annex 11 presents a high-level overview of the qualification prerequisites for generation auctions in Brazil.

The lengthy Environmental Impact Assessment approval process also created delays in project implementation. RRA participants pointed out that even when an environmental licence was obtained on time, companies have faced delays in project implementation. This arose from environmental licensing requirements for transmission lines that have to be constructed as part of the project. One alternative to mitigate this risk is to request the environmental licence of each candidate generation project in the auction as part of the qualification process.

Announcing the auction bidding process at least one year in advance should allow companies to plan their participation in renewable energy auctions more effectively. It should also allow them to undertake in depth the necessary resource assessments and due diligence. This will mean participants can take all the steps necessary to prepare their projects in advance and thus reduce potential technical and any financial delays once project implementation begins.

Working closely with local government could help to speed up the process. Companies implementing renewable energy projects in the field could potentially face lack of clarity on land tenure. Sometimes the real estate property ownership and the property boundaries are not clearly registered. In that case, the challenge for regional governments will be to draw up the real estate cadastre for their region. It might also be important for regional governments to consult with local stakeholders (local authorities, communities and civil society) in areas where renewable energy projects may be constructed. This will secure their understanding of the benefits of such initiatives and thus obtain their support.

MAKING THE PPA MORE BANKABLE

Renewable energy generation is in most cases a non-dispatchable resource with variable or seasonal production. The most recent global climate change scenarios show that renewable energy generation could be adversely affected. It might therefore be relevant to consider more flexible energy delivery terms. One suggestion is to consider power supply quotas under current PPA contracts based on the three-year average and not on a single year. For example, in the case of the Brazilian wind energy auctions, the product offered defines quotas based on production over four years with some annual deviation limits.

The number of years selected can be related to the storage capacity of the hydroelectric system, since it will be the primary resource balancing renewable production at a small cost to the consumer. Local banks capacity building for technology risk assessment was highlighted during the workshop. It has an impact on the ease of financing renewable energy projects.

Most renewable energy technologies are new to the market. It is therefore important to communicate best practice to local banks and financial institutions on how to assess renewable energy project performance parameters and technology risks.

This could potentially smooth finance flows to this sector. Clear communication of the product characteristics and relevant penalties, allowing banks to perform a proper risk analysis, is also of benefit to finance.

In cases of underproduction, variable renewable energy resources — mainly solar and wind — could compromise security of electricity supply. Limiting electricity sales of wind or solar projects to a percentile of certified production for each project is one way to reduce this effect. For example, Brazil limited wind power sales to half of certified project production in 2009-2012. As a result, projects claimed very high capacity factors from 45% to 60% that might not be reached. Since 2013, the 50% threshold for wind plants has been changed to 90% of certified production.

LARGE POWER AUCTION ROUNDS

Higher transaction costs arise from organising and promoting several auction rounds with the same process. One suggestion raised during the RRA discussions was to hold larger auctions. This could reduce transaction costs and create economies of scale, fostering development of local manufacturing. Discussions centred around the merit of larger auction rounds and relevant international experience.

Large power auctions seem to be more efficient at fostering increased competition and at attracting more bidders, including international ones. They could also contribute to the standarisation of the renewable energy auction process. For example, in Brazil regular auctions for energy supply are held centrally every year and are based on demand forecasts provided by distributors. The government does not interfere with demand forecasts and the auctioneer pools the different forecasts. This result is an auction which allows for economies of scale by contracting large projects, leading to lower project costs and thus tariff bids. After the auction, successful bidders sign bilateral energy contracts with each distribution company.

In general terms, auctioning large power rounds for renewable energy generation could lead to tariff reductions. This is because large power rounds would allow larger projects to be contracted, and these are more efficient per MW installed. In addition, large power auction rounds could catalyse investment in local component and equipment manufacturing.

While large power auction rounds could lower tariffs and have a positive impact on local manufacturing, they could also adversely affect the participation of Peruvian companies. This is due to the considerable amount of investment required. Making local partners a condition for participation by large international companies is one mechanism successfully employed in many countries. This may lead to large-scale deployment and promote participation of local investors, but it could be perceived as a barrier and keep away large players. A preferential tariff for companies with Peruvian partners is one variation of this approach. This has also already been used in other countries.

Large power rounds may require large-scale environmental impact assessments. This could have an impact on completion and commercial operations, given the present limited geo-referential information on land tenure. Large power round assessments should also take SEIN bar capacity and available grid capacity in both power lines into consideration. COES puts forward its plans on a biannual basis for transmission lines with a ten-year horizon, and this also needs to be taken into account.

POWER BLOCK SIZE

The size of the power blocks – which may of course differ according to technology – is another consideration for auctions. As the size of the power block increases, competition may decrease. If a large power block is auctioned with little competition, there is a high risk that demand may not get supplied.

Dissatisfaction with the fragmentation observed in Peru when an auction process is conducted over several rounds cannot be solely related to block definition. There is an art to holding an auction. The most important parameters for proper auction design are the reduction of barriers to entry for new players and a correct definition of the price cap.

Block size needs to be defined in a very careful way and consider not only Peru's renewable policy goals, but also the degree of competition that can be achieved for each block defined. No standard round-size has been found to attract international bidders. However, rounds should be large enough to draw the interest of bidders, and power blocks sized to foster competition. It is also important to evaluate carefully the trade-off between one large auction round or different auctions carried out in different years. The latter signals to the market a continuous programme to integrate renewables.

MINEM is to analyse to what extent the disclosure of the auctioned volume is necessary. Disclosure is current practice. While revealing auctioned demand communicates the size of the auction to investors, it removes auctioneer flexibility. It might also create perverse incentives for competitive behaviour (empiric auction theory shows that bidding under demand uncertainty leads to cheaper outcomes). If there is no requirement to publish demand, the auctioneer has more flexibility to define it once candidate supply is already known and registered in the auction.

The Brazilian experience is interesting in this respect. Brazil conducts two main types of energy auctions. Firstly, regular new energy auctions contract an amount declared by distribution companies to meet demand growth in the regulated market. Secondly, reserve energy auctions are used to contract supplementary energy to increase the system's reserve margin. Demand for reserve energy is entirely determined by the government following its own security of supply and energy policy criteria. The costs of these contracts are split among all consumers by means of a system charge. In either auction, the government has the right to intervene with policy decisions (some auctions have had candidate supply restricted to renewables). The demand to be auctioned is not disclosed before the auction. This gives a great deal of flexibility for the government to adjust, through the reserve energy auctions, the level of demand to ensure competition.

HYBRID GENERATION AUCTIONS

Hybridisation in Peru is defined as a renewable generator that combines different types of renewable resources (*i.e.* wind and hydro, wind and solar). It aims to manage production variability more effectively. This is achieved through a portfolio of non-dispatchable resources with complementary production patterns or through a portfolio of dispatchable and non-dispatchable resources.

In addition, renewable energy hybridisation may potentially raise the baseload power generation offered by renewable energy systems. This has a subsequent positive impact on grid management, while at the

Hydropower plant
Photo Courtesy: Shutterstock

same time increasing the service reliability and overall energy security. COES has stated that hybridisation is welcome to the extent that it can help increase the plant load factor. OSINERGMIN has at present a hybridisation procedure on electricity generation facilities using renewable energy sources.

There are concrete opportunities in Peru for hybridisation systems, according to resource assessments. The first is on the North coast and consists of wind-hydro systems that could complement each other effectively. This is because there is good wind potential during the dry season and vice versa. The possibilities of wind generation are limited during the months with high precipitation. The second potential area for hybrid systems is on southern coast. This offers the opportunity for solar-hydro systems.

Due to the variability of renewable energy production, hybrid systems could be appropriate for reducing the commercial impact of production variability. Electricity market players worldwide have created such systems, whenever there is a spot price risk due to imbalances in energy production.

Since wind power has developed quickly, the most relevant hybridisation experience comes from wind farms and pumped-storage hydro plants. Portfolios of wind and solar and even solar and gas have recently been analysed in Europe and the US.

In Latin America, Brazil provides the most relevant experience with a portfolio of renewables. There, energy trading companies form portfolios of small hydro, wind and (sugarcane-based) biomass production to devise commercial strategies for supplying a stable energy load and mitigating production risk. The natural synergy between these two production sources makes it possible to develop a portfolio that can mitigate hydrological and fuel shortage risks. It thus enables competitive, stable energy delivery. Portfolios of wind and small or large hydro, and even wind and thermal generation, have recently emerged in Brazil to enable less risky transactions in the free market.

Peru has significant resources that would enable efficient hybrid systems in general. This includes fossil fuels and mid-large hydro, which have not yet been considered by the norm for system hybridisation using renewable energy resources.[25] Two hybrid system portfolios are possible in Peru. Firstly, a portfolio of non-dispatchable resources with complementary production patterns such as wind and small hydro, or wind and solar. Secondly, a portfolio of non-dispatchable and dispatchable resources such as wind and hydro, solar and gas, etc.

One option is to allow fossil fuel generation – mainly natural gas – and other hydro plants into the hybridisation process. For example solar/wind/hydro and gas systems could form a portfolio of non-dispatchable and dispatchable resources that could ease the penetration of renewables. The southern coast of Peru offers one of the continent's premier areas for solar generation. This offers clear opportunities for gas — solar (both PV and Concentrated Solar Power) development, and for hybrid solar — natural gas electricity generation. For example, the Southern Gas pipeline project in the South of the country to Arequipa, Moquegua and Tacna is being developed in the medium-term. The subsequent construction of a petrochemical and thermocouple pole in this region will result in a substantial increase in natural gas demand. Demand for energy generation due to an expanding mining sector (Quellaveco, expansion of Cerro Verde and expansion of Southern Copper Corporation,

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among others) will increase. These two factors could prompt the need to investigate other sources of energy, especially renewables.

The hybridisation focus in Peru in an auction-based setting for long-term contracts is not typical. Most hybrid systems across the world have not been developed in the context of renewable energy auctions, but free market transactions and spot market bidding to mitigate spot price risk. Only Colombia has made similar proposals. This involves the investigation of a hybrid system formed by wind and hydropower in the Colombian Firm Energy Market, which is based on auctions using long-term reliability options. The proposals arising from this study, however, have still not been implemented (Cramton, *et al.,* 2010).

MINEM will need to further study and overcome challenges arising from the inclusion of hybrid systems in auctions. These consist of defining a proper product and the price cap of a given product for each hybrid system. Other challenges include penalty definition, guarantee and incentives schemes for hybrid systems (not for separate technologies). Finally MINEM will need to ensure that the lenders would be interested in such a financial portfolio and that the hybrid systems would not discourage finance.

LOCAL CONTENT REQUIREMENTS

Peru has a metalworking industry with the capacity and experience for the local manufacture of equipment components for renewable energy generation. The auction bidder could acquire a competitive advantage over competitors by using local manufacturers. The opportunities are clear. Strategic alliances could be made between renewable energy companies and local electrical and metalworking companies.

To improve the auctions, it would be worth considering for a period of time, a separate scoring criteria by incorporating Local Content Requirements (LCR). These would be ranked according to the manufacturing capacity and a national economic added value score up to a certain maximum limit. Alternatively, the state could offer to purchase the energy in the auction in 20-year PPA contracts. It would, contract a maximum tariff per technology under the condition that a certain percentage of manufacturing takes place locally, allowing reinvestment and job creation. This may include the local supply of wind turbine-towers, kits and batteries for PV panels. Other examples include electrical wires, medium voltage substations, boards with command and monitoring elements, insulators, instrumentation, capacitors and metal structures. The definition of the percentage number is important, since it can be done on a component-by-component basis or according to the total development cost of the plant.

Globally, LCR for renewable technologies has been used in different forms mainly in developing countries. China required LCR from renewable energy systems developers until 2010, but discontinued the requirement after negotiations with the US. Through the Brazilian National Development Bank (BNDES), Brazil offers subsidised loans to renewable developers only if they source 60% of their equipment and work locally. In the Organisation for Economic Cooperation and Development (OECD), the Canadian provinces of Quebec and Ontario stand out for their application of LCR. The World Trade Organisation (WTO) challenged the LCR in Canada because it discriminates against foreign suppliers. Additionally, LCR is not permitted under EU competition rules. South Africa was successful in attracting foreign companies to its renewable energy auctions because of the absence of LCR (IRENA, 2013a).

In the case of Peru, the government has the opportunity to carefully assess the objectives of developing a manufacturing industry for renewables. This needs to consider two main aspects:

i) the size of the potential market for renewable generation over a long time horizon.

ii) the existence of manufacturers in other countries.

It is important to provide signals on market potential and economies of scale in Peru. This communicates whether there is enough local demand to absorb equipment production or export potential. The National Renewable Energy Plan is one way to transmit these signals. The size of the potential market could point to the need to rely on exports to ensure a market for local manufacturers. If so, it is important to assess which manufacturers are already in the region.

It is also important to analyse whether Peru's current infrastructure (supply chain-logistics, transportation, ports, etc.) and human resources (HR) could absorb a growing renewables manufacturing industry.

LCR might also lead to the opposite effect to that intended. Restricted competition might allow local producers to extract monopoly rents. It might reduce both competitive pressures and the number of players in the sector. This can increase investment costs and often compromises the quality of equipment used in renewable generation plants. As a result of raised costs, fewer renewable projects may be developed, while compromised quality leads to fewer operating hours and lower generation efficiency. This effect is particularly strong in countries that introduce LCR without having already established a local manufacturing and service industry, or that lack a comparative advantage in manufacturing renewable technologies. In these countries, investors struggle to find local suppliers and are forced to delay project development.

Finally, it is worth mentioning that the world's biggest exporters of renewable technologies were first movers. They applied predictable support policies for renewable energy generation and strong research and development (R&D) support. They enjoyed long-lasting growth in domestic demand for green power and a stable investment environment.

Direct R&D programmes or support for dedicated innovative industrial clusters proved more powerful and more sustainable for facilitating knowledge and technology transfer to the domestic manufacturing sector. Most late entrants to this market could catch up with the competition, not by protecting non-competitive local producers of standard technologies, but by creating a stable and growing domestic market for renewable energy generation. They could then support R&D in innovative renewable technologies. This can create a new wave of front-runners, who become the global industry leaders. Strong domestic demand and targeted R&D support will automatically encourage local manufacturers, whether they are owned by foreign or domestic companies.

INTERNATIONAL EXPERIENCE OF TECHNOLOGY-NEUTRAL AUCTIONS

During Peru's two auctions, limits per renewable technology have been specified and contracts signed in each technology depending on tariffs offered. Following international experience, the next call could consider a technology-neutral approach. This would remove limits for each technology. The auction would be designed so that the competition is between bidders of all renewable technologies. Contracts are awarded starting with the power block with lowest tariff and moving to the next tariff level.

Renewable auctions can be bundled and structured in different ways, depending on the level of competition and specificity desired. Auctions can be designed to allow IPPs using different renewable energy technologies to participate together. Alternatively, participation may be restricted to IPPs providing energy from particular types of technologies or at particular sites (as is the case in Peru at present). The decision to go with technology-neutral, technology-specific or technology and site-specific auctions involves a trade-off between competition stimulation and policy objectives. These include, for instance, energy diversification, the promotion of selected technologies and the achievement of emission reduction targets.

All technologies could in principle be allowed to compete on a level playing field to intensify competition. That would imply that the auctions are not technology-specific. The underlying assumption behind this type of auction is that the market can price energy correctly in time and space. However, certain energy policy objectives and other practical considerations need to be made by policy makers who decide to guide the energy mix in a certain direction. This they do by selecting the type and relative participation of different technologies in the generation portfolio allowed to participate in energy auctions. It is sometimes difficult to open an energy auction up to all conventional sources.

This is the case, for example, for very large hydro generation plants prioritised by governments due to their strategic role in a specific country. The capital expenditure of these projects is significant, and requires very special arrangements for financing and guarantees. It also demands the formation of specific consortia to develop projects. Environmental and construction risks may be high, requiring careful and expensive due diligence in comparison to smaller plants. This has prompted the development of project-specific auctions. The objective in this case is to create the conditions to maximise competition among a set of bidders for a given project.

Energy policy decisions are multi-faceted and take into account cost, diversification, environmental objectives and energy security concerns. Promoting renewable technologies that are not yet economical (or not viewed as such) to compete with traditional energy sources requires specific government energy policy interventions.

Strictly speaking, an auction is a selection process and its award is based solely on a financial bid. If non-price objectives are legitimate and need to be considered, the most effective practice is to carry out auctions with restrictions on participation. This means pre-selecting a range of possible technologies that meet the non-price objectives, and restricting participation in the auction to those technologies. Auctions can still be an efficient allocation mechanism, even when applied to a more limited technology portfolio.

One of the advantages of auctions differentiated by technology is that, given the similar features of a given technology, bids can be compared on an equal basis. The disadvantage is the fragmentation of the procurement process, which could lead to reduced competition and increased costs for end-users. Technology-neutral auctions always aim to bring about the purchase of the cheapest technology. Their main disadvantage is that using purely price-based criteria do not adequately value externalities.

Energy policy should drive auction design, not vice versa. Auctions will not have the most efficient outcomes when underlying policies driving their design and implementation are absent and constrain the effectiveness of energy procurement at least cost.

This explains the importance of a National Renewable Energy Plan for Peru. If governments have a preference for particular technologies due to energy policy concerns, this should be made explicit and transparently reflected in the auction design. Policy objectives, such as increasing renewable energy to diversify the energy matrix, meeting peak and base-load requirements cost-effectively and developing a nascent local manufacturing industry, all can affect auction design.

South American experience of technology-neutral and technology-specific auctions is interesting. Given that long-term electricity auctions are nowadays the main driver for capacity expansion. Initially, the auctioning schemes represented a new capacity mechanism fostering investment in new generation plants by competitively assigning long-term contracts.

These settle part of the generators' remuneration, thus hedging their risks. Following this regulatory trend, these mechanisms have recently started to be used for the promotion of renewable energy technologies too. To start with, these two contexts were considered separate. Conventional technologies (large hydro, fossil fuel thermal plants) competed in system-adequacy auctions. Renewable energy technologies competed in technology-specific auctions. The former were meant to involve large quantities of energy (or stable energy) at the market price, while the latter were to cover lower quantities at relatively high prices. However, the most recent renewables auctions in Brazil and Peru contracted renewable energy supply at very competitive prices, unimaginable only a few years ago. These schemes, separate until now, seem to be close to convergence. This is reinforced by the participation of wind energy projects in recent conventional Brazilian auctions (competing against gas, coal, small hydro and biomass).

In countries and regulations where these mechanisms seem to be merging, it is possible to observe how conventional and renewable technologies are still far from competing under equal conditions. The main differential lies in the way these technologies are assessed for their contribution to security of supply and how this is settled. For instance, this can work using a firm energy/capacity calculation methodology and non-compliance penalties for the provision of energy. This has an implication on the design of products for each technology. Experience shows that these problems get in the way of a level playing field and prevent full competition between technologies.

INTEGRATION OF RENEWABLE ENERGY INTO THE GRID

Electricity demand is not evenly distributed throughout Peru. COES has forecast that in 2016 greatest demand will come from the South, accounting for 57.6% of electricity and representing 8 015 GWh. The central region will come next with 31.9% (4 439 GWh) and northern Peru comes last with 10.5% (1461 GWh) (COES, 2012a).

By 2016, Peru will have to supply almost 60 000 GWh/year. New power generation plants need to be commissioned to meet this demand, including those using renewable energy resources. Hydropower is the dominant technology, supplying 52.3% of the electricity mix. Other renewables will contribute 1 285 GWh. Wind will account for 1.7%, solar 0.4% and biomass 0.1%.

The present transmission system structure has been optimised for the conventional generation plants. The SEIN northern zone does not suffer from congestion. Its average flux to the centre is less than 500 MW. For the next few years the development of new projects will not compromise this part of the grid. Although most conventional projects are located in the centre of SEIN, the lines operate undercapacity. However, fast growing demand in the southern region will probably cause a bottleneck.

The centre has surplus production capacity of low cost energy, while the northern and southern areas have deficit balances between local generation and demand. As a result of this situation, the central region supplies electricity to the southern and northern areas. There is at present a 500 kV single circuit line from the centre to the North of the country. A 500 kV double circuit line to the South of the country is under construction. The first and second inner circuit lines are expected to be completed in 2016.

New generation from renewable energy is an option for the North and South of Peru. However, technical challenges for integrating variable renewable power into the grid would need to be addressed for this to become a reality. Wind is the second largest renewable energy resource in the generation mix and more capacity is expected to come onstream in the next few months. It is therefore necessary to establish maximum wind power values and other non-dispatchable renewables that can be fed into the grid without compromising its stability.

By 2016 wind power is expected to contribute 232 MW of new capacity and will account for 1.7% of electricity generation in Peru. Most wind projects are planned to be commissioned in the North and South. It is therefore crucial to understand the impact of injecting wind power from non-synchronous generators into the SEIN.

In 2011, a study entitled 'Wind Power Generation in SEIN - Analysis of the Maximum Capacity to be Injected' was completed. It analysed the maximum wind power that can be injected at different grid connection points for 2013-2014. The conclusion was that a maximum of 497 MW can be connected in the selected nodes, given the present status of the grid and upgrade projects in progress. Annex 9 presents the main results of the study by bus (Ramirez, 2011).

Additional studies will help understand the performance of SEIN when including renewables. For example, MINEM is carrying out a study of the maximum on-grid renewable energy generation that can be connected to SEIN between May 2013-May 2017.

CHALLENGES

Transmission expansion has historically focused on the development of a high-capacity network allowing for the reliable supply of generation and load patterns at a minimum cost. At the same time, it needs to comply with technical criteria such as equipment overloads, admissible voltage magnitudes, stability and power quality. These practicalities refer to a transmission planning paradigm in which system expansion was characterised by comparatively low uncertainty as generation was developed mainly through large units. In the case of large hydro and thermal plants, the significance of connection costs usually faded when compared to total project investments. In the case of large hydroelectric plants, the time needed for erecting a transmission system was usually much shorter than the power plant construction time.

Renewable energy projects throw up a number of considerations not efficiently resolved through traditional transmission planning and cost allocation practices. Projects are remote, and this demands considerably costly transmission solutions. These costs may be significant in comparison with total project investment and can even be prohibitive to some investors.

PROACTIVE VERSUS REACTIVE PLANNING

This leads to a chicken-and-egg dilemma in the decision to build a project. Investors can only assess project feasibility once they know connection costs, but transmission is usually planned only after financial (or physical) commitment of the units. The significance of total connection costs in comparison to total expenditure may also mean higher cost of capital. This is because lenders may have the perception that the recovery of capital is uncertain. Furthermore, the comparatively greater numbers of smaller projects seeking connection can mean longer lead times for processing requests. This is because it stretches the capacity of the transmission planning workforce.

The existing market, commercial and regulatory frameworks have become a barrier to timely and cost-effective renewable generation connection. This is because they may not be flexible and rapid enough to allow for the connection of smaller, dispersed generators with short construction times. The problem of connecting renewable generating units to the bulk transmission system has often been approached by sequentially analysing and processing individual connection requests from physically and/or financially committed generators. This is known as the reactive planning approach.

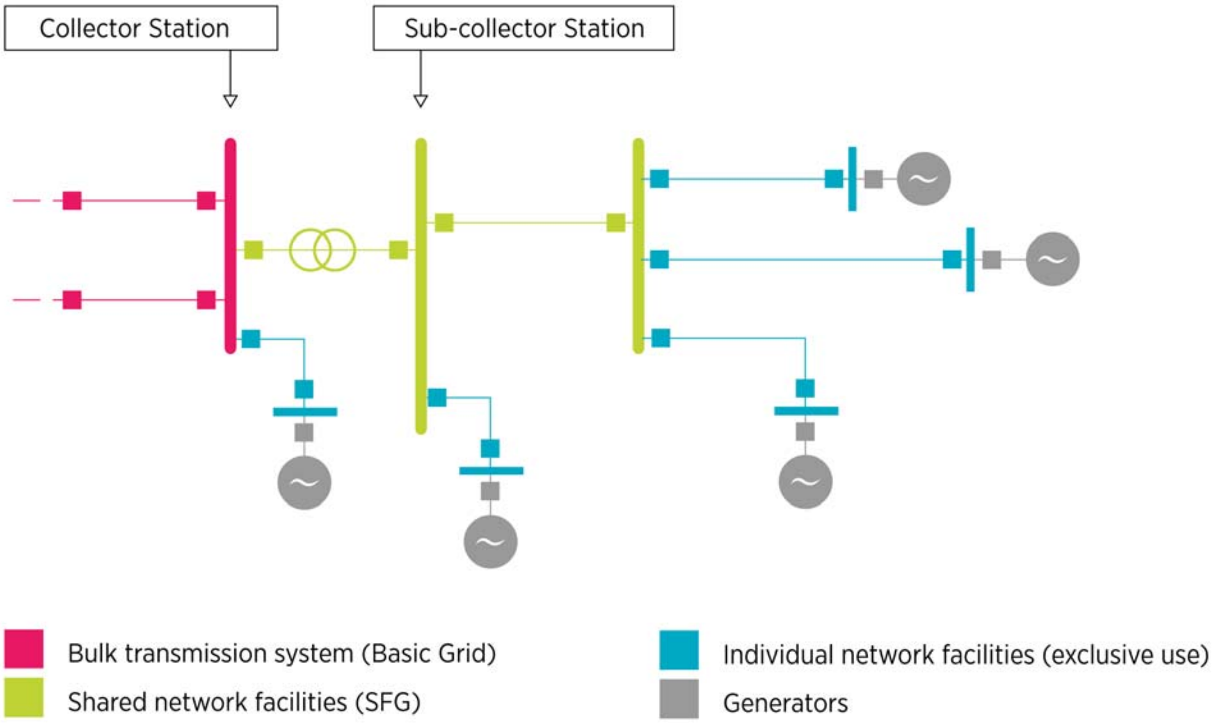
However, the integration of renewable energy to the grid has been seen as an important driver for new approaches. Many countries have been moving towards using a more proactive planning to network design practices. This is where transmission planning anticipates and facilitates renewables connection. A proactive approach to transmission planning for renewables connection might start by identifying proactive planning criteria under which potential investments will be evaluated. Traditional minimum cost and reliability criteria may not result in generation and transmission expansion through the integration of renewable generators. It may therefore be necessary to also explicitly consider criteria that specifically aim to support the integration of relatively small-scale, remote and variable renewable generators.

TRANSMISSION PLANNING

In Peru, the system operator, COES, plans the transmission capacity expansion every two years. This is done in accordance with system performance requirements. The resulting transmission plan must be approved by the Ministry of Energy. The plan has a ten-year horizon. Planning criteria are based on indicators (congestion hours and cost, supply cost, investment costs, cost of unsupplied energy) for possible generation, demand, and transmission expansion scenarios. The selected plan optimises transmission system operation by considering variations in the parameters using a risk-return approach. The costs of the resulting transmission plan upgrade are recovered as a tariff.

In long-term studies, COES considers the typical annual production pattern for renewable generation. In short and medium-term studies, COES also considers the limited reactive contributions characteristic of renewable generation. Using technical and economic studies, COES also

Figure 13
Shared connections to the high voltage grid



Source: www.PSRInc.com

determines the maximum wind generation capacity that may enter the system without adversely affecting its operation.

ZONING FOR BETTER PLANNING

Certain mechanisms help drive proactive transmission planning for renewables integration. The planning process can be triggered by introducing a cluster of potential projects. These could be based on location, development phase, estimated date for commissioning and/or other attributes. It is possible to conduct studies to plan and facilitate economies of scale by considering sharing transmission facilities. This will make transmission planning less reactive and more proactive to integrating renewables. It can lead to the identification of areas with a high renewables potential. It can also help estimate the possible impact of different levels of renewable generation from various sources on the transmission system.

Brazil has used renewable generation to drive new planning and cost allocation techniques. Transmission connection was made on a first-come first-served and case-by-case basis according to available grid capacity determined by the system planning company.

Now there is a higher share of renewables in the grid, transmission planning has, however, become more proactive. In 2008-2012, solutions were designed based on cooperative planning of integration networks to connect renewables. These networks became known as Shared Facilities for Generators (SFGs). These facilities are used exclusively by generators, but shared by different projects. Their aim was to anticipate renewable penetration, and they were based in areas with a large number of renewable projects under development. As illustrated in figure 13, this avoided the need for individual exclusive high voltage (HV) grid connections for each generator.

This approach worked well in the first few years but suffered from implementation problems. These were related to lack of certainty on renewable project development. This was especially true when the grid was extended for expected rather than actual projects awarded through the renewable energy auctions. Its application was therefore suspended in 2012 to allow for a review of its improvement.

The second approach, initiated by the Ministry of Energy in 2013, used studies of existing and planned transmission capacity. These were the source of a public list of the available capacity of several transmission zones before the renewable auction. Renewable generators have to compete in two auctions. The first is for transmission connection (lowest energy offers have grid connection priority). Then, the winning projects have to compete for the PPA.

In 2014, a final approach will use transmission planning techniques in Brazil to identify areas with high renewables potential. It will suggest the construction of transmission highways (or a bulk transmission system) to anticipate the development of renewable projects. Planning practices in Peru are considered adequate. Transmission plans take account of uncertainty about how demand and generation capacity will evolve.

However, further improvements based on the concept of proactive transmission planning for renewables integration described above could be investigated. Of particular interest is the proactive identification of possible areas with a high renewables potential. This would yield proposals for some ex-ante (binding) transmission reinforcement planning.[26] The main trade-off in any proactive scheme is, of course, related to economic risk allocation. The more proactive the transmission planning for grid connection (anticipating connection based on renewable potential), the lower the likely cost to generators and the higher to consumers, and vice versa. This should be carefully analysed. Moreover, proactive transmission planning will also influence auction design. It may become more site-specific than it is at the moment.

REGIONAL GOVERNMENTS

At the moment, the role of regional governments in energy policy is to formulate policies. They also implement and monitor energy plans in their region in accordance with national policies and sector plans. Additional mandates include investment promotion in their jurisdiction and monitoring and implementing rural electrification programmes within the National Rural Electrification Plan framework.

Regional governments grant authorisations and final concessions for renewable electricity projects in their region whose installed capacity is greater than 500 kW[27] and less than 10 MW.[28] They are also responsible for granting land concessions[29] and operation permits to bidders awarded renewable energy projects in their regions, under the national auctioning process. Regional governments are also in charge of land planning in their regions. They identify ecological and economic areas, and establish and classify extractive areas for power generation activities. Obtaining land titles is one of the challenges associated with implementing projects success-

26 This means establishing obligatory mandates in the construction of future transmission facilities.
27 Concessions are not required for systems under 500 kW (article 2 and 3 of Law Decree N^{O} 258)
28 Supreme Executive Order 056-2009-EM
29 The Special Programme for Land Titling ("PETT") was transferred from to regional governments by the Organismo de Formalización de la Propiedad Informal (Commission for the Formalization of Informal Properties) (COFOPRI).

ful through the auction process. Unlike the mining cadastre, land was not geographically referenced with a Unique Cadastre Code,[30] which aggravates the problem. It sometimes leads to land disputes and social conflict due to the lack of clarity in property rights for land to be used by successful bidders. It leads to subsequent delays in project start-up.

The governors of Arequipa and Puno, who participated in the RRA discussions, demonstrated their commitment to renewables deployment. This example, along with the regional government mandate, prompted a strong recommendation that regional governments and MINEM coordinate the planning process more closely for future renewable energy auctions. There seems to be a definite need to encourage regional authorities to prioritise land registration in areas with renewable energy potential to facilitate future auctions. Working together, MINEM and regional governments could define appropriate locations for the installation of solar and wind projects. They could eventually plan and promote regional industrial parks acting as load centres for renewable energy clusters. Coordination between these two entities would also lead to better definition of power blocks in renewable energy auctions.

While MINEM is responsible for the energy sector, the regional governments have a much broader development agenda. Regional industry and investment promotion is a critical element of that agenda, as well as providing energy access. Closer coordination and role clarity in facilitating renewable energy procurement can ease renewables business transactions in Peru.

30 Law for the establishment of the National Integrated Cadastre System (2008); Law No. 28294

V. Rural electrification

Peru has made remarkable efforts to improve its national electrification rate. This has increased from 55% in 1993 to 87.2% in 2012. Its rural electrification rate grew by over 50% from almost 30% in 2007 to 63% at the end of 2012. This provided electricity to 3.9 million people (MINEM, 2012a).

The 2013-2022 National Rural Electrification Plan includes a goal to provide electricity access to 6.2 million people in the next decade. This plan provides strategic direction and sets medium- and long-term goals for rural electrification. One of its objectives is the promotion of renewable energy for productive uses. Another is to coordinate different private and public stakeholders to create favourable financing conditions for rural renewable energy projects.

In accordance with the provisions of the Rural Electrification Law and the 2013-2022 National Rural Electrification Plan, rural electrification activities will in the short term include renewable energy systems installation. They will also include grid expansion. Projects led by the national government (MINEM-DGER), regional governments and distribution concessionaires are part of the implementation plan.

NATIONAL RURAL ELECTRIFICATION PLAN

The Rural Electrification (Law No. 28749), states that DGER has the authority to draw up the National Rural Electrification Plan. Peru aims to achieve universal access to electricity by 2021.

Electricity access in rural Peru is challenging because of the mountainous terrain and scattered settlements. Low energy consumption and limited purchasing power per household add to the challenge. Investors are therefore not attracted to these projects unless the state provides the right financial incentives and other necessary requirements.

MINEM has placed an emphasis on grid extension, mini-grids with hydro, solar and wind, in that order of priority, to achieve universal access. The rural electrification strategy states that wherever grid extension is possible it should be chosen over off-grid solutions. However, many settlements are located in areas where grid extension is not feasible. Small and mini-hydro are preferred where communities have perennial sources.

MINEM-DGER has 437 rural electrification projects clustered into 35 groups. The total investment is estimated at USD 417.8 million[31] and will benefit 1.2 million people. Additionally, DGER is implementing 16 other special projects which will benefit 150 000 people, with approximately USD 140 million will be invested.

31 PEN 1 162 million. Exchange rate Pen/USD =2.78

Off grid rural renewable energy system, solar PV and wind
Photo Courtesy: MINEM Peru

Competitive funds for rural electrification projects are on offer. The project for increased rural electrification (FONER), finances rural electrification projects. FONER subsidises the investment cost of rural electrification projects to distribution companies qualified to provide electricity to rural communities (Andina, 2012). The first phase was known as FONER I (2006-2013) and had a total budget of USD 129.55 million. This initiative provided 110 000 new electricity connections (7 000 using renewable energy). Following its success, the second phase (FONER II) has been awarded a total budget of USD 82.7 million. There are 19 grid extension and 29 solar PV projects in the pipeline.

Two more programmes: Programa Nacional de Electrificación Fotovoltaica Domiciliaria (National Photovoltaic Household Electrification Programme) and Luz en Casa (Light at Home) are also in progress.

The National Photovoltaic Household Electrification Programme was launched by MINEM in 2013. Its aim was to install 500 000 stand-alone solar PV systems and to increase the national electrification rate to 95% by 2016. The first phase started in July 2013 with 1 601 solar PV systems distributed among 126 communities (MINEM, 2013). In September 2013, OSINERGMIN invited companies to participate in the tender for 500 000 solar PV systems (Pekic, 2013).

Companies are expected to make a bid for the design, installation, operation and maintenance of three different sized solar PV systems to households and public facilities, like schools and health centres. They range from 85 Wp to 1 kWp. The electricity provided by the systems should be enough to satisfy the needs of the end-user and depending on the design also offer a commercial service. Depending on the bids, a monthly fee will be set by OSINERGMIN based on the size of the system, investment required and commercial service provided, among other things. OSINERGMIN will form a trust fund in order to pay these companies. The capital will come from the monthly payment from rural off-grid users and a social compensation fund[32] (FOSE). It will also be based on the compensation mechanism outlined in the Law for Energy Security and Development of the Southern Petrochemical Pole of Peru (Law 29970).

The Acciona Microenergy Foundation has created a sustainable energy service company to lead its Light at Home programme. This provides underprivileged families with solar home systems and three compact fluorescent lamps (CFL). The management model is fee-for-service and so far it has installed more than 1 300 solar home systems.

By the end of 2013 an additional 1 700 solar home systems had been installed, reaching a milestone of 3 000 families (REVE - Revista Eólica y del Vehículo Eléctrico, 2013). The IDB provided a loan of USD 900 000 and a donation of USD 330 000 via the Multilateral Investment Fund for technical cooperation and capacity building activities. Acciona Microenergy Foundation provides USD 500 000 (Acciona, 2013).

The innovative financing and business model, as well as good project management, has resulted in project success. A large number of successful microfinance institutions are operating in Peru, although they have not yet made a foray into rural renewable electrification projects

32 Fondo Social de Compensación Eléctrica

(El Comercio, 2013b). This is partly because of their lack of knowledge of the technology, performance parameters and risks. Capacity of these entities needs to be built to understand the technology, value chain management, equipment standards and criticality of establishing a good after-sales service. This needs to be done in collaboration with local universities and technical institutions.

Finally, improved coordination with relevant stakeholders — regional governments, private sector and technical institutions — is needed. This accelerates the deployment of renewable energy technologies in rural areas. Programmes for promoting rural livelihoods and poverty alleviation provide natural leverage points for off-grid solutions. Identifying a successful livelihood programme in rural areas as a partner immediately provides the scale required, as off-grid programmes take time to build up.

RENEWABLES FOR DEVELOPMENT

Access to modern energy services can transform the quality of life. Renewable energy, combined with other factors such as human capacity, knowledge and markets, can foster productive uses of energy. This hopefully contributes to income generation and local value chain development and thereby to economic growth and poverty alleviation in rural areas (IRENA, 2012).

In 2011, Peru completed a very successful pilot project in Cusco, Junin and Lima. It supported almost 5 000 micro-enterprise engaged in income-generating activities, such as cereal milling, agro-processing and irrigation business by providing grid connections.

The total investment in the three communities was over USD 700 000. This contributed an additional demand of 1 863 MWh per year and improved the financial feasibility and sustainability of electricity infrastructure in rural areas (Finucane, Bogach and Garcia, 2011).

This pilot showed the importance of linking community ownership of a rural electrification programme to investment in employment promotion to enhance its economic feasibility. But lessons from the successful pilot are still to be embedded in the regulatory design and guidelines for implementing rural electrification programmes and operating electricity distribution companies (Finucane, Bogach and Garcia, 2011).

Off-grid solutions based on renewables such as solar and small hydro can provide the energy for development in remote areas. Successful and innovative programmes from Tanzania and Indonesia providing energy for productive uses with solar, small-hydro and hybrid systems can be studied and replicated.

Solar-powered systems are ideal for low power Productive Use of Energy (PUE) such as cellphone charging. In Tanzania local entrepreneurs may start a cellphone charging business by using a 12 Volt rechargeable battery. It charges from a solar panel, a dynamo connected to a bicycle or grid-based electricity. One important feature of the system is the battery charge controller, which provided a battery lifetime of two or three years (GSMA, 2011).

This type of system provides enough energy to charge up to ten cellphones per day. It also supplies LED lighting, allowing shopkeepers to work longer hours. The cost of the system is around USD 200, with estimated revenue of USD 40-50 per month (Gifford, 2013). Crowd funding produced the necessary funding for the second stage of the solar systems (Kickstarter, 2013).

For more power-intensive productive use, small hydro is a suitable option. For example, Energising Development (EnDev) in Indonesia implemented a pilot project in nine villages in Sumatra and Sulawesi. It assessed PUE in existing community-operated micro-hydropower (MHP) plants.

A total budget of USD 12 776 was distributed among 53 businesses with the objective of studying the impacts of PUE on potential revenue expansion. It also assessed whether single specialised large appliances are more cost-effective and less technically vulnerable than numerous small-scale appliances.

Following several months of evaluation, it was concluded that medium-cost appliances for productive use have a higher chance of success. The rice huller was the most expensive appliance in the whole pilot project and it failed to satisfy expectations. Profitability of the businesses was the highest with group-owned as opposed to individual or community-owned businesses. PUE is very compatible with mini-hydro plants, and in most cases the operating times could accommodate productive activities without modifying operating hours. For the MHP operator, an additional PUE tariff generally does not require additional effort and helps increase its income (Shultz and Suryani, 2013).

Pilot projects like these will raise awareness in the community and among relevant stakeholders of the benefits of including productive uses in electrification programmes. Hopefully, it will accelerate the rural electrification rate.

TECHNICAL STANDARDS AND QUALITY ASSURANCE

To ensure renewable energy systems last long enough and perform appropriately, components and installations have to comply with national technical regulations. Peru is already using national technical standards to ensure component and equipment quality, both imported and local. The following specific national standards are relevant:

- PV systems up to 500 Wp: technical specifications and energy rating method of a PV system.[33]
- Lead-acid electric batteries: requirements and test methods.
- Biofuels: physical-chemical characteristics and test methods for biodiesel 321.125:2008 321.126:2011 NTP specifications for ethanol blends with petrol engine use.

The National Institute for the Defence of Competition and Protection of Intellectual Property (INDECOPI),[34] Peru's national standardisation body, has developed solar PV systems standards. However, there are still opportunities to further develop similar standards for other renewable energy technologies, like wind, biomass and geothermal. It is recommended that in the near future INDECOPI maps the existing gaps in technical standards for all renewable energy technologies and should also adopt the required national standards that are based as far as possible on international standards.

33 NTP 399.403.2006
34 Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectua

The IRENA recent report 'International Standardisation in the Field of Renewable Energy' may provide valuable information on existing international standards as well as how to adopt them at national level (IRENA, 2013b).

The first step is to identify a list of equipment and services, which need standardisation. A second step determines the national technical standards already in existence. The third step is to define the chronological prioritisation of existing national technical standards to be revised and updated and new national technical standards to be adopted. As a fourth step, international reference standards should be identified as a basis for developing national standards.

Technical committees responsible for developing national standards for renewable energy should include representatives from various stakeholders in the renewable energy market. These include industry associations, equipment suppliers, manufacturers, users, project developers, power generation companies and relevant state agencies.

Box 5

Financing renewable energy projects in Peru

In recent years investors have shown an interest in renewable energy projects in Peru. Nevertheless, there are opportunities to further support an increased financial institutional participation in the sector.

Some project developers have in recent times experienced delays on renewable energy project financial closure. During the RRA discussions it was clear that bank project appraisal units had a limited understanding of technology performance and risks. This led to a reluctance in project financing. It has also meant renewable energy projects are subject to increased collaterals and higher costs of finance and coverage ratios.

Commercial banks have successfully participated in funding projects in Peru's two renewable energy auctions. The Banco Bilbao Vizcaya Argentaria (BBVA) has national experience of funding renewable energy projects. It is financially supported by IFC through a green credit line that was used for two small 5.9 MW and 9.6 MW hydropower plants (IFC, 2011).

COFIDE has access to a credit line of USD 100 million from JICA designated to finance energy renovation infrastructure (Peru 21, 2012). It also has a credit line of EUR 50 million with KfW for renewable energy and energy efficiency (COFIDE, 2012). The European Commission financed over USD 8 million under the Euro Solar programme. In addition, the Peruvian government provided additional funds of almost USD 2 million under this project. Euro Solar aims to provide 130 rural communities in Peru with access to electricity and the internet. Likewise, IDB implemented a USD 230 million programme to help Peru develop a sustainable energy programme to increase renewable energy and energy efficiency uptake (IDB, 2012). IFC has proven experience of funding renewable energy activities in Peru, for example, funding a market evaluation of Peruvian renewable energy finance, the 168 MW hydropower plant Cheves and a bioethanol project developed by Maple (IFC, 2011).

Recent renewables auctions allowed local financial institutions to engage with renewable energy projects and improve their appraisal of renewable energy projects with variable power. It is expected that domestic banks will be actively engaged in future auctions, based on their increased understanding of how these new technologies are performing. Specialised training for local banks in cooperation with technical institutions could be arranged. This would provide them with a better understanding of the technology, using case studies of actual projects on the ground.

An understanding of technology, revenue streams, regulatory framework, electricity markets and auction processes would reduce bank perception of the renewables risk. It would increase lending to renewables projects. Feedback from banks could contribute to design PPAs for renewable energy projects, ensuring its bankability.

Jatropha for biodiesel production
Photo Courtesy: Shutterstock

VI. Bioenergy

MOTIVATIONS FOR BIOFUELS DEVELOPMENT

Domestic demand for liquid fuels has been growing over time, particularly as a result of increased demand from public transport. Figure 14 shows the national consumption of liquid fuels derived from oil, expressed in thousands of barrels of oil equivalent (KBOE) per day. Diesel shows the greatest consumption in 2006-2010. Since 2011, the Regulation for Biofuel Commercialisation has set a mandatory blend of 7.8% ethanol in gasoline and 2% to 5% biodiesel B100 in diesel.

Biofuels could be a renewable energy alternative to fossil fuels in the transport sector. In Peru, biofuels could have subsequent positive impacts by diversifying the energy matrix, developing rural and marginal areas, and creating value chains and jobs in agriculture, industry and research.

Peru has crops with potential for producing first and second generation biofuels. Sugarcane and sorghum are the crops with greatest potential for ethanol production. For biodiesel production the crops are palmoil, jatropha, castor oil and canola (SNV-IIAP, 2007).

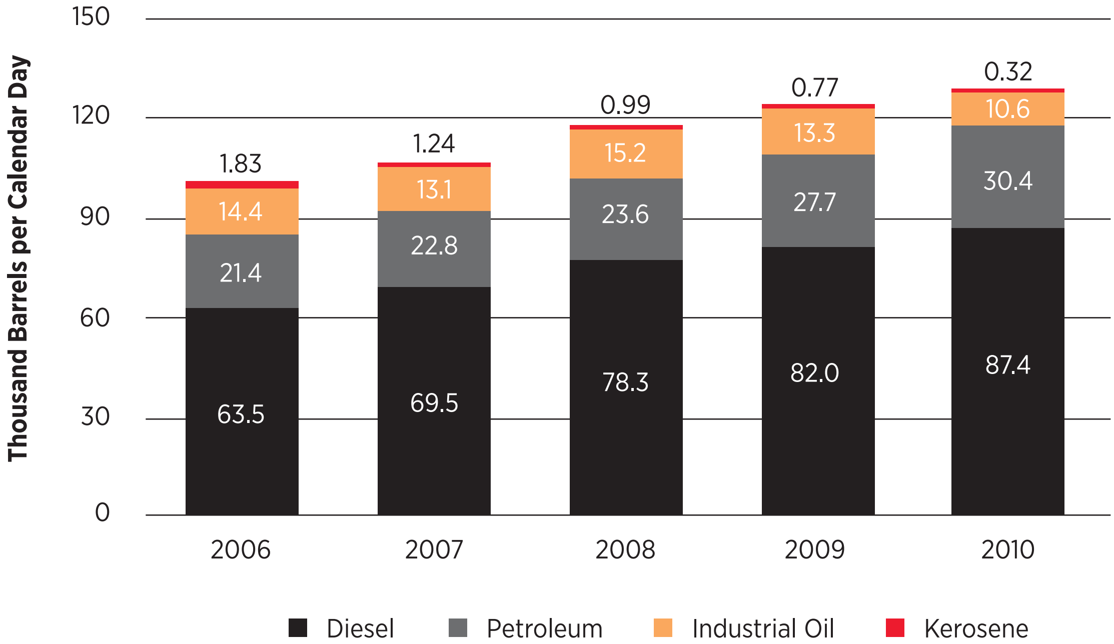
BIOFUELS REGULATORY FRAMEWORK

In 2002, the National Environmental Council[35] (CONAM) approved the creation of a technical committee for the biofuels promotion in Peru.[36] This group proposed the Law for the Promotion of the Biofuels Market,[37] which was approved in 2003 by the permanent commission of Congress. This law defines a regulatory framework for the promotion of biofuels in a free market while encouraging the development of the agricultural sector and the reduction of environmental pollution. It also establishes the basis for the creating the Programme for the Promotion of the Use of Biofuels (PROBIOCOM) under the jurisdiction of the Agency for Promotion of Private Investment (Proinversión).

35 Consejo Nacional del Ambiente
36 Via decree 024-01-CD/CONAM
37 Law Nº 28054 followed by D.S. Nº 013-2005-EM in 2005, and the RE-0014-2007-EF in 2007

Figure 14

Trends in annual domestic demand for liquid fuels in 2010



Source: OSINERGMIN, 2011

A subsequent standard, the Regulation for Biofuels Commercialisation,[38] set out the requirements for marketing and distributing biofuels. It also set out requirements for technical and quality standards, the scope of application and the roles of the entities involved in the process. This standard also set mandatory requirements for ethanol blend percentages in petroleum and biodiesel in B100 diesel. From 2011 onwards, this blending mandate has been established at 7.8% ethanol in petroleum and 5% biodiesel in diesel (diesel B5).[39] Table 4 provides detailed information on the blending requirements for biodiesel.

BIOFUELS STAKEHOLDERS

The biofuels market comprises different stakeholders that can be divided in two groups. Firstly there are those in charge of the regulatory framework and its application. The others are responsible for biofuels production and commercialisation. The role of the main players in the Peru regulatory framework is established in the Regulation for Biofuel Commercialisation[40] as follows:

- Ministry of Agriculture[41] identifies and promotes the development of areas available and suitable for agriculture and biofuel production.
- Ministry of Production[42] grants permits for installing and running biofuel plants.
- Ministry of Energy and Mines—Dirección General de Hidrocarburos (DGH) provides records and authorisations for marketing biofuels.
- OSINERGMIN is responsible for supervising and monitoring compliance with the regulation on biofuels marketing, transportation and quality.

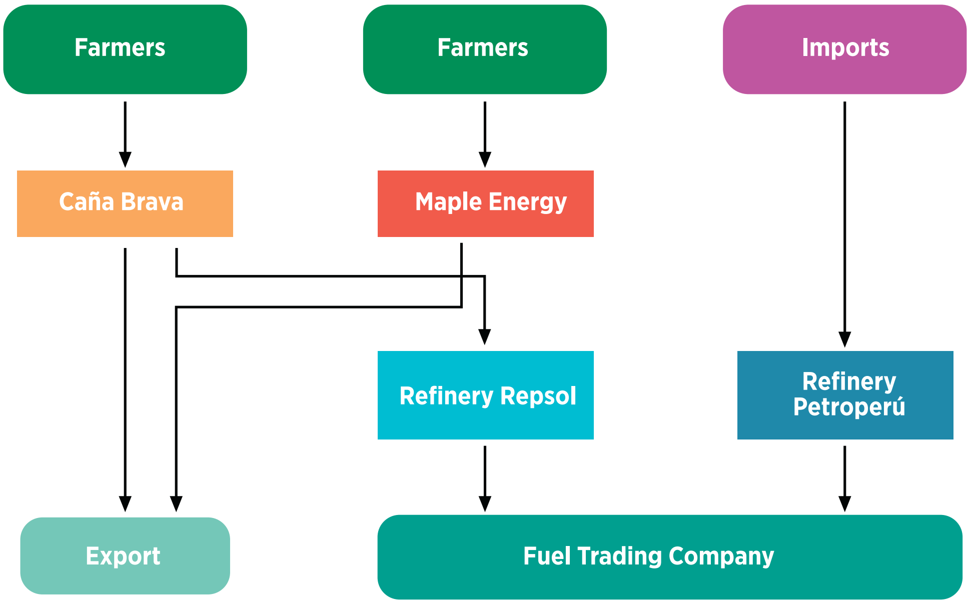
38 Through the D.S. Nº021-2007-EM amended by the D.S. Nº 0064-2008-EM, D.S. Nº 0091-2009-EM, D.S. Nº 0061-2010-EM, and D.S. Nº 0024-2011-EM.
39 From 2009 to the end of 2010 the mandatory blend for biodiesel was 2% for diesel B2.
40 Nº021-2007-EM
41 Ministerio de Agricultura
42 Ministerio de la Producción

Table 4
Diesel blending under the Regulation for Biofuel Commercialisation

Volume biodiesel*	% Volume diesel	Denomination	Applicability
2	98	Diesel B2	1 Jan 2009 - 31 Dec 2010
5	95	Diesel B5	from 1 Jan 2011

***(B100)**
Source: OSINERGMIN, 2010

Figure 15
Ethanol production chain in Peru



The second group of stakeholders is involved in biofuels production and commercialisation in Peru. Key stakeholders within this group are domestic producers of ethanol (Caña Brava[43] and Maple Energy[44]), biodiesel B100 producers (Grupo Palmas,[45] Pure Biofuels and Bio Agro Heaven), several fuel trading companies[46] and two oil refinery companies (Petroperú and Repsol's Refineria de la Pampilla). The latter two are both involved in the blending process. It is expected that second generation biofuels production projects will come forward in the next few years, producing ethanol and biodiesel B100 from agro-industrial products.

43 Caña Brava started operations in 2009 with three subsidiaries: 1) Agrícola del Chira, responsible for planting and harvesting sugar cane; 2) Sucroalcolera del Chira, responsible for ethanol milling and industrial production; and 3) Bioenergia del Chira, responsible for electricity generation through bagasse.
44 Maple Energy started operations in 2012 and currently has two subsidiaries; Maple Etanol S.R.L and Maple Biocombustibles S.R.L.; Maple Energy harvests and processes sugar cane to produce ethanol. Production is marketed locally and also exported.
45 Grupo Palmas is located in the San Martin region. It converts palm oil into biodiesel in a plant with production capacity of 50 000 million tonnes of biodiesel B100 per year. In 2012, its production was 15 137 million tonnes per year.
46 In the Lima region, Pure Biofuels and Bio Agro Heaven import crude oil and refine it to produce mostly biodiesel B5 and occasionally biodiesel B100, which is then offered on the market.

BIOFUELS BUSINESS MODELS

Peru has been promoting a biofuel market based on a model of free competition and free access to economic activity. This is in accordance with a legal framework established by the Law for the Promotion of the Biofuels Market and the Regulation for Biofuel Commercialisation.

To satisfy current blending mandates for ethanol (7.8%) and biodiesel (5%), refining companies procured these inputs from national and international markets. Price and availability of the products are important parameters while procuring biofuels.

Repsol Refinery purchases some of its ethanol inputs domestically and imports the remaining balance, while Petroperu imports 100% of its ethanol inputs. Cana Brava, for its part, sells some its production to Repsol Refinery and exports the rest. Maple Energy sells 100% of its ethanol production to markets abroad.[47] Figure 15 displays the present ethanol business model in Peru.

In the case of biodiesel, two different products are on the market, B100 (100% biodiesel) and B5 (5% biodiesel B100 and 95% diesel). As in the case of ethanol production, most raw materials used in the biodiesel blending are imported. Repsol Refinery buys 100% of the B100 biodiesel used in its process while Petroperu only replaces imports of biodiesel B100 in situations where the imported biodiesel purchases are delayed. Petroperu claims that the quality of the biodiesel produced domestically does not meet the required standards, thus giving a preference to imports. Grupo Palmas produces B5, which is then sold to the trading company Primax. Bio Agro Heaven and Pure Biofuels, two companies based in Lima, import crude oil and produce B5. It is then sold to fuel trading companies as well as to private companies.

Petroperu and Repsol Refinery run international tenders for biodiesel purchase. Grupo Palmas transports at a high cost, its biodiesel from the Amazon jungle to the Lima region because of the inadequate existing infrastructure. Figure 16 displays the present biodiesel business model in Peru.

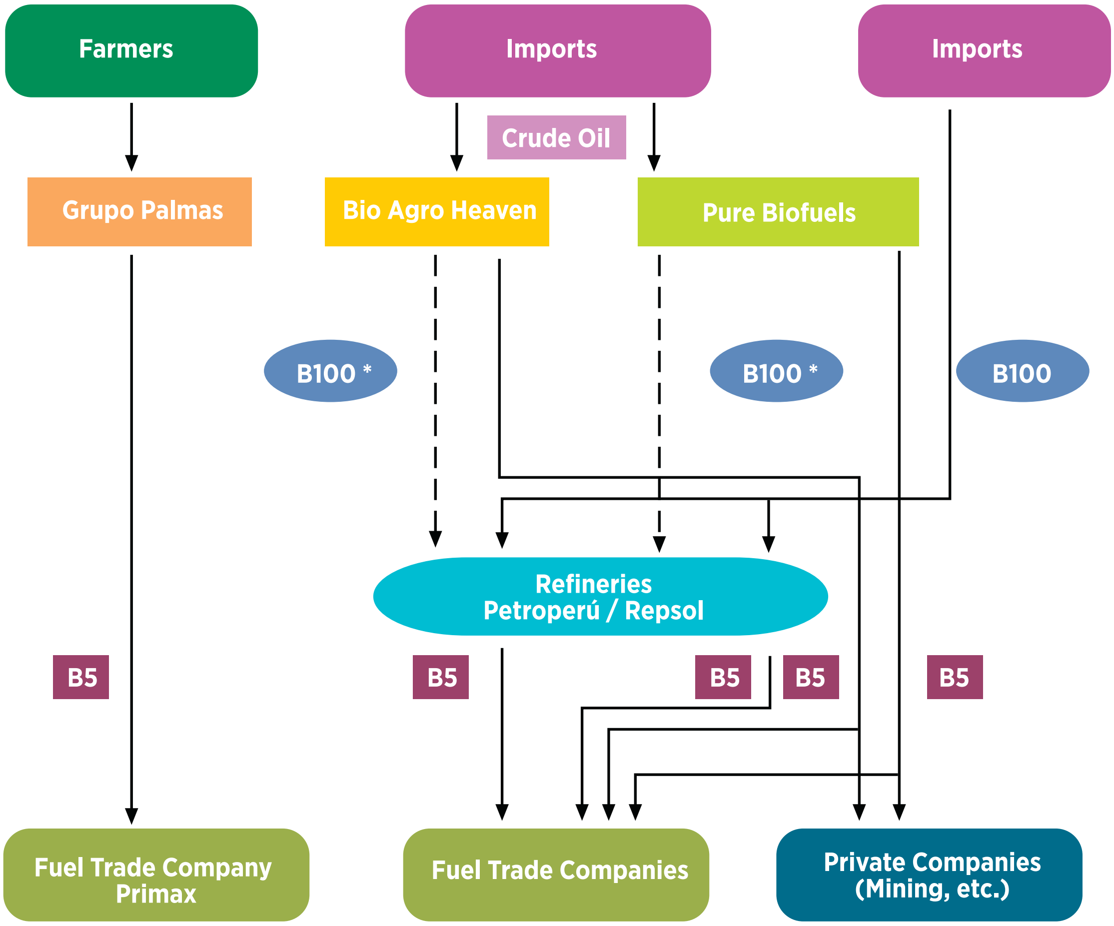
CHALLENGES TO BIOFUELS DEVELOPMENT

Peru has made major efforts to set up standards and regulations promoting biofuel. Nevertheless, there are still challenges to overcome, especially in relation to the development of the local biofuel markets and the promotion of local production. One of the main challenges is the need to increase local biofuels production. The objective of the Regulation for Biofuel Commercialisation is to promote biofuel under market conditions. This leads to price competition between biofuels produced in Peru and potential imports. Biofuels produced domestically are generally priced higher.

To substitute biofuel imports, an increase in local biofuel production will be required.[48] Table 5 shows the average prices of biofuel in the national and international markets. Table 6 shows biofuel production volumes and import, and export volumes for 2012. It can be determined from this information that domestic biodiesel production in 2012

47 Several ethanol certifications are recognised in Peru, so that some companies prefer to sell their production abroad, where they may gain an additional premium from these certifications.
48 Some countries, like Colombia, have promulgated norms that promote the production of biofuels. Diario Oficial Colombia, 'Ley 939 del 2004', www.secretariasenado.gov.co/senado/based oc/ley/2004/ley_0939_2004.html, 31 December 2007

Figure 16
Biodiesel production chain in Peru



B100* only occasionally

Table 5
Average biofuel prices, 2012

Biofuel	National market(i) USD/mt	Import price(ii) USD/mt	Export price(ii) USD/mt	International market USD/mt
Ethanol	800	650-800	1 010	725
Biodiesel (B100)	1 500	1 280	-------	1 500(iii)

Source: (i) Biofuels Committee-SNI, Sucroalcolera del Chira and Grupo Palmas; (ii) Lima Chamber of Commerce, SUNAT biofuels customs information for import and export 2012; (iii) UFOP biodiesel report 2011/2012

Table 6
Biofuels production, import and export volumes- 2012

Biofuel	Market for national production mt/p.a	Imports mt/p.a	Exports mt/p.a
Ethanol	78 607[(i)]	67 149[(i)]	126 438[(iv)]
Biodiesel (B100)	18 136[(iii)]	223 613[(ii)]	

Source: (i) National Industry Society, Biofuels Committee; (ii) Lima Chamber of Commerce, SUNAT biofuels customs information for import and export 2012; (iii) MINEM, Grupo Palmas; (iv) Lima Chamber of Commerce

was substantially lower than that required to sustain market demand.

To increase biofuels production, it may be necessary to do other things such as registering land tenure or forming producer associations, which could integrate biofuels into productive chains. Regional governments could engage in these activities, particularly land registration. This could be an opportunity to move forward with a cadastre.

More effective coordination between different stakeholders may also be important. There might be an opportunity to create an autonomous entity at ministerial level to coordinate and provide regulatory supervision of the activities of the different stakeholders in the biofuels value chain. This entity could facilitate greater coordination between MINEM, the Ministry of Agriculture (MINAG), OSINERGMIN and biofuels producers.

Annex 10 shows the typical water consumption of main crop types used to produce biofuels. Crops used for biodiesel production such as soybean or jatropha are the most water-intensive crops, consuming 400-600 m^3 of water per gigajoule (GJ). By contrast, crops for ethanol production such as sugar beet, sugar cane and sorghum require on average 100-400 m^3/GJ (Gerbens-Leenesa, Hoekstraa and van der Meerb, 2009). Securing a complete and enforceable regulatory framework for the rational use of water may result in an efficient allocation of resources, given the cost of working in the Peruvian jungle. It could also result in the sustainable development of biofuels projects.[49] In addition, it would be helpful to assess water resource availability before approving a project and concession land for biofuel crops. Finally, water usage could be improved by implementing irrigation systems, reservoirs, water damming and channelling.

Biofuels producers would also benefit from improved infrastructure such as roads, bridges and ports, particularly in the Amazon. This would facilitate their access to markets, cutting costs and transport time. This could be particularly important for bioethanol producers in the North of Peru and in the Amazonian region. Transportation from those areas to the consumption centres is a challenge.

Peru has favourable regulatory conditions for biofuels development. However, as highlighted earlier, research and train-

49 The Law on Water Resources (No. 29338) regulates the use and responsible management of surface water and groundwater. It states that the use of water resources is conditioned to availability, and recognises three classes of water use: primary use, population use and productive use. Meeting the primary needs of the individual takes priority over any other use. The last priority is for productive use, which includes agricultural, energy and industrial use, among others.

ing, among other factors, may be required to take advantage of these conditions. MINEM, (MINAG, regional governments, the Council for Science Technology and Innovation[50] (CONCYTEC) and universities all need to collaborate in setting up training, university curricula and research institutes. This will help develop a biofuels market. A capacity-building initiative, concentrated in regions with high biomass potential, could focus on agricultural production topics related to native crops and on the biodiesel refining process. It could also focus on the technical and financial assessment of biofuels projects.

The Brazilian experience is made up of an interesting mix. This consists of an early 1970s public policy on technology development aimed at reducing international oil price vulnerability combined with a late 1980s opportunity to foster a multi-market ethanol industry. This has had a positive result for the whole country. Box 5 summarises the key aspects of Brazil biofuels programmes.

Box 6

Key aspects of Brazil's biofuels programmes

The Brazilian experience of biofuels is an interesting mix of public policy and market opportunities and has had a positive result for the whole country. Ethanol development has taken Brazil decades of subsidies and policy intervention. These went through several changes and reviews. In the end, they led to an increase in ethanol production and a transformation of the sugar cane industry. Originally a family business, it became one of the strongest Brazilian agribusiness sectors.

Brazil has significant resource availability of both feedstocks (sugar cane and soy beans) and has taken advantage of economies of scale to increase their productivity. Brazil's push towards biofuels had a significant public policy component, which incentivised financing, created tax breaks and established mandatory blends to define a captive market. This has created the conditions for these industries to develop, including production and transportation networks. With respect to the design of specific policies, there are two important aspects that should be taken into account:

- It is important not to only consider resource availability, good agricultural practices and mechanisation, but also the logistics and transportation network. For example, as biodiesel production is geographically decentralised, its distribution may become a burden for the transportation network, due to the low density of its feedstock. As mentioned above, the National Petroleum Agency (ANP) auctions in Brazil consider a logistics factor (FAL – Factor de Ajuste Logístico) to place a value on the best locations.
- Fuel technical specification and blending practices: In the early days of Brazilian ethanol usage the percentage of ethanol in the ethanol-petroleum mixture varied widely and had no policy control. This lack of standardisation had a negative impact on engine efficiency and as a result consumers and the automotive industry became increasingly dissatisfied. Additionally, there were many complaints about engine problems due to biodiesel blending. These factors may have discredited the biofuels programme. Nowadays ANP has rigid control over ethanol specification/blending, and biodiesel specification is well-established in ANP biodiesel auctions. Thus the observation by Petroperu claiming the quality of biodiesel produced domestically does not meet the required standards, gives cause for concern and Petroperu have mitigated this by giving preference to imports.

Harnessing the plentiful supply of wind along Peru's coastline to power local communities and businesses
Courtesy of Ashden Awards

VII. Recommendations

Actions 1-3: Renewable energy auctions

Peru has taken significant steps to develop successful renewable energy auctions and it is one of the leading countries in the world with regard to this activity. However, there are opportunities to further improve planning and preparatory activities. Auction process design needs to be improved to resolve some outstanding problems.

Action 1: Undertake more effective long-term renewable energy auction planning

Resource- service pair(s)	On-grid/off-grid/solar/wind/biomass/hydro
Description	Define clear long-term policy goals for renewable energy auctions to articulate an enduring vision. This provides a strong signal of intent, attracts serious global IPPs and encourages equipment manufacturers to develop the local industrial base in Peru. Announce renewable energy auctions, at least one year in advance, so as to provide bidders sufficient time to perform resource assessments and undertake required due diligence, preparing the ground to secure finance and obtain, in–principle, clearance on potential project sites from regional governments. Encourage regional authorities to prioritise the identification and provision of land with clear land titles/lease options in areas with renewable energy potential. This would reduce project delays once a project has been awarded. Communicate best practice on how to better assess technology performance and risks associated with it. This includes PPA clauses to guide and facilitate renewable energy project appraisal with local banks and financial institutions. Regular consultations with financial institutions to improve renewable energy projects through PPA bankability. Consider the requirement, at least in-principle, of environmental clearance for each potential generation project in the auction, as part of the qualification process.

Relevant organisations	MINEM, OSINERGMIN, regional governments, financial institutions, universities.
Timing	End 2015
Key outcomes	Attracts more investment to the renewable energy sector. Promotes local content within the framework of overall economic efficiency. Mitigates the risk of failure in project implementation. Strengthened financial institution appraisal capabilities for renewable energy projects.

Action 2: Fine-tune renewable energy auction design and procedures to close gaps

Resource- service pair(s)	On-grid/off-grid/solar/wind/biomass/hydro
Description	Improve process design to secure participation of experienced developers and also mitigate risk of aggressive bidding. Develop a mechanism to closely monitor project implementation and also allow for contract termination at an early stage if ground-level implementation continuously lags behind and does not meet required milestones. Introduce PPA clauses to allow contracted power quota calculation to three years instead of the current practice of only one year. This would introduce more flexibility in the system and also reduce the inherent risk from a variable resource.
Relevant organisations	MINEM, OSINERGMIN, regional governments
Timing	End 2015
Key outcomes	Bidders awarded contracts have flexibility in power supply standards, in keeping with the nature of the resource, while meeting grid specifications. Companies are able to secure better financing conditions resulting from a more bankable PPA. Risks of projects not being commissioned due to delays are reduced in a timely manner.

Action 3: Reduce administrative costs of auctions and maximise their benefit

Resource- service pair(s)	On-grid/off-grid/solar/wind/biomass/hydro
Description	Size of rounds: large power auction rounds for renewable energy could lead to tariff reductions and promote local manufacturing. There is as yet no standard round size. Rounds should be large enough to draw the interest of bidders and small enough to foster competition. Large rounds will require a mechanism to reduce the potential adverse impact on domestic companies. Local Content Requirements (LCR) could lead to green jobs, but conditions should be set only after assessing existing manufacturing capabilities and the overall economic efficiency of the renewable energy auction process. A clear roadmap for gradually introducing local content into future auctions over a period of time, should be prepared so that manufacturing investments match policy aspirations. Hybrid systems: Peru's significant resources could make efficient hybrid systems possible. Auctions could be designed to allow investors to bid for a portfolio of non-dispatchable and dispatchable resources that could ease renewables penetration. Technology-neutral auctions: launch an in-depth examination of the possibility of further lowering tariffs by introducing technology-neutral auctions.
Relevant organisations	MINEM, OSINERGMIN, regional governments
Timing	End 2014
Key outcomes	Rounds are large enough to get the interest of bidders at the global level and small enough to foster competition, while securing local participation. Green jobs are promoted , as well as securing overall economic efficiency. Peru exploits a combination of its own energy resources.

Action 4: Increase intake of renewables into the grid

Resource-service pair(s)	On-grid/solar/wind/biomass/hydro
Description	Segment-specific upgrade of grid infrastructure to allow increased renewable energy uptake. Address renewable energy integration by proactively identifying areas with high renewables potential and by conducting studies to estimate possible impacts of different levels of renewable generation from various sources on the transmission system.
Relevant organisations	COES, MINEM, regional governments, Peruvian Renewable Energy Association (APER)
Timing	End 2015
Key outcomes	Increased capability of the grid to integrate renewable power from variable sources.

Action 5: Boost rural renewable energy

Resource- service pair(s)	Off-grid/solar/small hydro
Description	Achieve greater coordination between national and regional governments, private sector, as well as the alignment of the new energy infrastructure with social and economic objectives. Support and promote the productive use of energy so as to make system operations sustainable and further promote rural development. Complement existing renewable energy standards (*i.e.,* solar PV) with those that could be developed for other technologies. Capacity-building activities for installation, operation and maintenance of rural renewable energy systems for productive energy use.
Relevant organisations	MINEM-DGER, regional governments, private sector, Asociación Peruana de Energías Renovables (APER) (Peruvian Renewable Energy Association), universities and technical centres, and non-governmental organisations (NGOs)

Timing	End 2015
Key outcomes	Increases electricity access in Peru using technically and financially sustainable renewable energy systems. Includes productive use of renewable energy as a specific objective in rural electrification programmes in order to foster rural development.

Action 6: Continue developing biofuel

Resource-service pair(s)	Transport biofuels
Description	Provide enabling policy framework that facilitates business models for biodiesel and ethanol and promotes biofuel market development. Introduce university courses and provide research institutes with R&D funds, to provide the sector with trained personnel and entrepreneurs. A capacity-building initiative could be launched with academic institutions in regions of high biomass potential, focusing on agricultural production topics related to native crops, and the ethanol and biodiesel refining process. This could also include building capacity for the technical and financial assessment of biofuels projects. Develop quality standard for biofuels in Peru (applicable to both locally-produced and imported biofuels).
Relevant organisations	MINEM–DGH, MINAG, Ministry of Transport, National Society of Industries(SNI), Biofuels Committee, universities, CONCYTEC
Timing	December 2015
Key outcomes	Sustainable business biodiesel and bioethanol models developed in Peru.

Action 7: Periodically update solar and wind resource assessments

Resource- service pair(s)	On-grid/off-grid
Description	Update solar, renewable energy resource maps. Publicly announce methodology to be used for the assessments; undertake periodic updates of renewable energy maps.
Relevant organisations	MINEM IRENA could assist in providing expert advice on methodological issues, if required.
Timing	Ongoing
Key outcomes	Facilitates decision-making process and leads to accelerated renewable energy deployment in Peru. Continuous resource atlas updates and regular consultations with potential investors and users will improve data quality and availability, facilitating policy and investment decisions.

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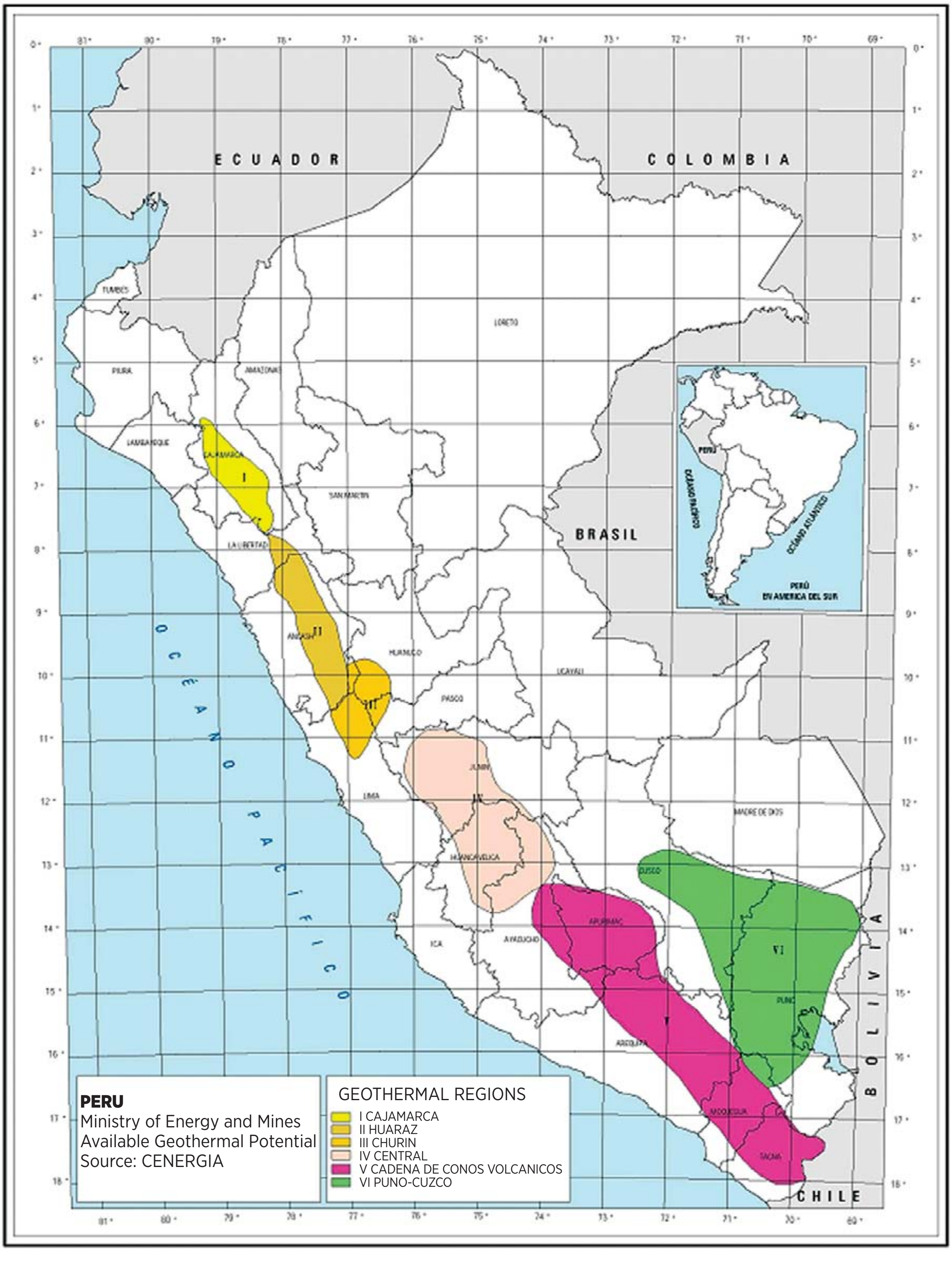
Annex 1: Renewable energy resource maps

Geothermal atlas of Peru



Source: MINEM

Hydropower atlas of Peru

Source: MINEM

Annex 2: Major renewable energy stakeholders in Peru

ON-GRID MARKET

Name of organisation	Address and telephone	Website
MINEM-DGE	Av, Las Artes Sur 260 - San Borja-Lima 41.	www.minem.gob.pe
OSINERGMIN-GART	Av. Canadá 1460 San Borja - Lima 41.	www.osinergmin.gob.pe
Peruvian Renewable Energy Association	Av. Del Pinar 152-Piso 3-Oficina 302.	N/A
National Mining, Petroleum and Energy Society – SNMPE	Francisco Graña 671 Magdalena del Mar.	www.snmpe.org.pe
PD: Tacna Solar S.A.C	Av. V. A. Belaúnde 147- Torre Real 3- Piso 12- San Isidro- Lima 27.	www.solarpack.es
PD: GCZ Ingenieros S.A.C	Av. Del Pinar 152-Ofic. 508- Chacarilla-Surco- Lima 33- Perú	www.gczingenieros.com
PD: HMV Ingenieros del Perú S.R.L	Av. Del Pinar 152-Ofic. 705- Chacarilla-Surco- Lima 33- Perú.	www.h-mv.com
COES	Calle Manuel Roaud y Paz Soldan 364. San Isidro, Lima – PERÚ.	www.coes.org.pe
National Assembly of Regional Governments	Calle Coronel Inclán 750 Ofic. 602-Miraflores – Lima 18 – Perú.	www.angr.org.pe
Regional Government of Arequipa	Av. Unión 200-Urb. César Vallejo-Paucarpata-Arequipa;	www.regionarequipa.gob.pe

OFF-GRID MARKET – ELECTRIC AND HEATING/ COOLING APPLICATIONS

MINEM-DGER	Av, Las Artes Sur 260-San Borja-Lima 41.	www.minem.gob.pe dger.minem.gob.pe/
Regional Government of Puno	Jr. Deustua 356 - Puno	www.regionpuno.gob.pe
Practical Solutions (ITDG)	Av. Jorge Chávez 275-Miraflores	
ADINELSA	Av. Prolongación Pedro Miotta Nº 421 San Juan de Miraflores – Lima	www.adinelsa.com.pe
Renewable Energy Centre (CER) National Engineering University (UNI)	Av. Tupac Amaru 210-Rímac (Pab Central 2do piso B1-260)	www.cer.uni.edu.pe
Rural Sector Support Group Pontifical Catholic University of Peru (PUCP)	Av. Universitaria 1801-San Miguel.	gruporural.pucp.edu.pe
JICA	Av. Canaval y Moreyra 380 piso 21 Edif. Siglo XXI	www.jica.go.jp/peru/espanol

TRANSPORT
BIOFUELS MARKET

Name of organisation	Address and telephone	Website
MINAM (Climate Change Directorate)	Av. Javier Prado Oeste 1440 San Isidro-Lima 27- Perú.	www.minam.gob.pe
MINEM- DGH	Av, Las Artes Sur 260-San Borja-Lima 41.	www.minem.gob.pe
MINAG	Jr. Yauyos 258- 3er Piso- Lima 1.	www.minag.gob.pe
National Agrarian University (UNALM)	Av. La Molina S/N La Molina.	www.lamolina.edu.pe
National Society of Industries - (SNI) Biofuels Committee	Los Laureles 365 San Isidro- Lima 27.	www.sni.org.pe
Grupo Palmas	Av. Nicolás Arriola 740 - Urb. Santa Catalina-Lima 13- Perú.	www.palmas.com.pe
Caña Brava	Calle Francisco Graña 120 - Santa Catalina-Lima 13- Perú.	www.cañabrava.com.pe

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RENEWABLE ENERGY
FUNDING PARTNERS

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IFC - World Bank Group	Av. Miguel Dasso 104-5to Piso-San Isidro-Lima	www.ifc.org/lac
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Annex 3: Challenges and barriers identified in the RRA workshop

Barriers and challenges to on-grid renewable energy

Barriers and challenges	Small hydro	Wind	Biomass	Biogas	Solar PV	Geothermal	Solar CSP
Investment costs	Highly variable investment costs depending on technology and type of power station	Investment costs depend on resource	Investment costs depend on resource abundance	Investment costs depend on resource abundance	Significant technology cost reductions will be experienced in future	Costs must include exploration and exploitation of wells	Investment costs depend on resource abundance
Operation & maintenance costs	Low	Moderate HR training	Moderate HR training	Moderate HR training	Moderate	Moderate HR training	Moderate HR training
Transport and construction infrastructure		Logistics deployment should be overcome (roads, ports and cranes)	HR training and local experience in this type of installation is limited				
Environmental	Rigorous environmental evaluation to reduce damage and avoid affecting other sectors like agriculture	Some people consider its operation as visual pollution; probable damage to birds in surrounding areas	Potential greenhouse gas emissions	Potential greenhouse gas emissions	Availability of vast areas, greater impact caused by power station construction	Depending on technology considered, toxic fluids are produced	Vast areas are required, greater impact caused by power station construction
Financial	Bankers' lack of knowledge of renewable energy market and profitability; Credit officers' lack of knowledge about renewable energy project evaluation and regulations; banking may have external technical support to assess renewable energy investment projects; technical assistance component to credit lines						

Barriers and challenges	Small hydro	Wind	Biomass	Biogas	Solar PV	Geothermal	Solar CSP
Social		Potential visual and noise pollution in surrounding areas					
Operational		Lack of use of double fed induction generator (DFIG), static frequency converter(SFC), squirrel cage induction generator (SCIG) technologies to avoid instability in grid frequency due to generation fluctuation caused by wind variability			Moderate fluctuation of generated power		
Project maturity		Measures of at least one year are required				Longer maturity periods	Longer maturity periods
Administrative		Delays caused by central and regional governments during project management					

Annex 4: Challenges and barriers identified in the RRA workshop

Barriers and challenges to on-grid renewable energy

Barriers and challenges	Small hydro	Wind	Biomass	Biogas	Solar PV	Geothermal	Solar CSP
Existing electrical infrastructure - SEIN	Difficult grid access; transmission losses and high length radial network distribution; limited transmission lines	Possible dispatch restrictions due to limited transmission lines and weak radial power system					
Subsidised natural gas to electricity generators		Reduces generation competitiveness			Reduces generation competitiveness		
Ownership titles by regional governments (PETT)		Lack of register and ownership titles for land acquisition	Lack of register and ownership titles for land acquisition; delays	Lack of register and ownership titles for land acquisition; delays	Lack of register and ownership titles for land acquisition		Lack of register and ownership titles for land acquisition; delays
Normative		Limitations of maximum power connectivity nodes	Lack of biofuels incentives; failure to comply with toxicity index		Reduces network connectivity	Geothermal law not well-known	Lack of promotion and regulation
Lack of smart grid and Automatic Generation Control		Reduces network connectivity opportunities					

Biofuels

RENEWABLE ENERGY APPLICATION	BIOFUELS (SUMMARY OF DISCUSSION TABLE ON BIOFUELS –2012 WORKSHOP)				
RRA element	**Business model**	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, O&M**
Current situation (includes good practice areas)	Requires a deliberate state policy to promote biofuels	Requires - connection between entities involved in biofuels	Requires an autonomous governing body coordinating various aspects of regulation and biofuels market	Scarce resources and lack of technology; little or no infrastructure	Little or no state financial and/or private financial institution support
Challenges/problems to be solved	Create conditions that favour biofuels business	No consistent policies, only guidelines	Regulators (OSINERGMIN, INDECOPI) do not comply with their duties adequately	Generate HR and material needed for the development of the activity	Generate funding sources to facilitate the development of bioenergy projects
Capacity-building needs	No technical or university courses for biofuels	Educational policies leading to capacity building for biofuels	Creation of autonomous national biofuels authority with capacity and means	Promote the creation of institutes preparing professionals and technicians and developing technologies for biofuels	Facilitate training of professionals able to assess biofuels projects
Concrete actions	Promote a workshop with interested parties to discuss and issue a document to relevant authorities	-----	-----	-----	Promote a workshop with bankers on biofuels project evaluation

Off-grid renewable energy

BARRIERS AND CHALLENGES TO OFF-GRID RENEWABLE ENERGY

Barriers and challenges	SPP (small hydro)	Wind	Biomass	Biogas	Solar PV
Technology	Main technical difficulties due to inadequate resource estimation	Requires wind speed; conditions lacking in many places	Very little local experience using this kind of technology, thus reducing options for rural areas	Limited experience in electricity project generation using biogas in rural areas	Reduced power and energy; lack of local technical support
Investment costs	Moderate investment costs			Moderate investment costs	High investment costs in the short and long term
Operation and maintenance costs	Skilled operating and maintenance personnel are required		Due to the difficulty of standardising raw material required, results are uncertain		HR training
Transport - construction infrastructure	High costs of transport due to project location in remote areas				
Environmental	Rigorous environmental evaluation required in order to reduce damage and avoid affecting other sectors, such as agriculture		Training required in biomass waste management for energy use	Training required in animal and vegetable waste management for energy use	Battery recycling and disposal programmes required to avoid environmental contamination

Social	Conflicts can arise around water use	Moderate opposition to its use		Population problems in managing waste and operating power plant	Frequent theft of solar systems and/or components
Project maturity	Exhaustive evaluation of hydro resource required as part of development process	Exhaustive evaluation of wind resource required as part of development process	Complex project logistics		Exhaustive evaluation of solar resource required as part of development process
Administrative	These types of project require local management capacity due to unique ground and field conditions				
Existing electrical infrastructure –isolated system	Limited amount of transmission and distribution networks in isolated areas				
Normative			Reduced promotion of these renewable energies as rural isolated systems		

Annex 5: Key results from the RRA study

RENEWABLE ENERGY APPLICATION	WIND POWER				
	Business model	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, operation and maintenance**
Current situation (includes good practice areas)	Demand that motivates business has not been identified Only two wind turbine manufacturing companies	No evidence of policy or strategy	Some institutions conducting individual research In general, government entities know very little about wind technologies	National geography and topography determine regions with greater wind potential – typically along the coast GIZ conducted a study of wind in Puno in 1988 showing speeds of 3-4 m/s (this was before GTZ study)	In the absence of major wind projects, these issues become secondary
Challenges/ problems to be solved	Uncertainty re: exact wind power potential Little knowledge of this type of energy	People may be in favour of this type of energy		Wind atlas not useful for designing specific projects; it is necessary to carry out in situ measurements for potential applications	
Capacity-building needs	Generation of information to assist in business area			There is technological capacity to exploit wind power by manufacturing wind turbines	
Action to be taken	Conduct additional wind speed studies Include wind power in education programmes at all levels Training programmes at regional government decision-making levels	Recommend DGER generates new policies and strategies		Wide technology dissemination to attract interest on demand side	Government is receiving an increased number of local business proposals

RENEWABLE ENERGY APPLICATION — **OFF-GRID SOLAR PV**

RRA element	Business model	Policies and strategies	Institutions, regulations and market structure	Resources, technologies and infrastructure	Funding, construction, operation and maintenance
Current situation (includes good practice areas)	Present business model is designed to meet national renewable energy requirements There is experience of private company control	Oriented to renewable energy	Adequate regulation and formal framework	Solar resource potential is known	Minimum private participation and no PV business opportunities promotion; insufficient PV technology support within electricity distribution enterprises
Challenges/problems to be solved	Technical and adminsitratvie capcities in state agencies involved in Renewable Energy may need to be upgraded	Policies that generate integrated cross-sector action Policies and strategies to promote small interconnected PV systems	Lack of communication and partnership among governments and national universities Regulatory framework for small interconnected installations needed	Insufficient (regional) production to generate development proposals Formulation of rural development projects	Local business sustainability organisations support PV In rural business organisation with PV energy and installation sustainability
Capacity-building needs	Energy use for production purposes		In technical specification certification		
Action to be taken	Speed up current renewable energy projects Monitor present business model for future improvement	Create executive inter-agency for off-grid renewables Expand scope of PV tariff schedule at both ends of power range	Full implementation of existing regulation Specify environmental impact scenario of PV installations	Encourage national universities to generate marketable production projects	Extensive promotion of opportunities involving state entities Articulate a mechanism or electricity distribution intercom scenario with PV projects in sustainable management

RENEWABLE ENERGY APPLICATION	SOLAR THERMAL				
RRA element	**Business model**	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, operation and maintenance**
Current situation (includes good practice areas)	Business model is private sector driven; state not participating	Energy policy document to contains solar thermal system goals	There are five NTPs applicable to solar water heating systems: - solar water heating system collector efficiency - performance - efficient design - efficient installation - limits and labelling -certification labs needed	There are different technologies for solar water heating	Lack of knowledge of ACS business potential so entrepreneurs indifferent towards technological options and new developments
Challenges/problems to be solved	Slow technology penetration in large domestic sector	Identify potential uses of solar water heating	Lack of knowledge of technology choice and its scope	Strengthen and improve skills and training	Widespread lack of knowledge throughout training and educational institutions
Capacity-building needs	Entrepreneurship with AC Solar	Design and project management			
Action to be taken	Promotion of profitable solar water heating use in medical and industrial sectors; higher education institutions to communicate knowledge	Specifies goals written in the policy document	Establish appropriate mechanisms so that existing NTPs become compulsory	Suggest to all higher education institutions that this subject be included comprehensively in their syllabus	Wide communication of technological development opportunity and hence profitable businesses

RENEWABLE ENERGY APPLICATION	BIOMASS				
RRA element	**Business model**	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, operation and maintenance**
Current situation (includes good practice areas)	Programme to promote cooking stove upgrade; this is not a business plan at present.	Centralised government strategy (NINA Project), private initiatives and cooperation agencies	SENCICO certifies improved cooking stoves	Absence of comprehensive organisation with effective national outreach in different regions	Action associated with programmes promoted by government and NGOs
Challenges/problems to be solved	Limited scope of programmes undertaken	Lack of commitment of local and municipal governments		Organisational structure supports technology penetration	Limited scope of programmes undertaken
Capacity-building needs				Technological capacity building	Technical capacity building in HR
Action to be taken	Training and organisation at a municipal level				

RENEWABLE ENERGY APPLICATION	TRANSPORT BIOFUELS				
RRA element	**Business model**	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, operation and maintenance**
Current situation (includes good practice areas)	Lack of an explicit state policy to promote biofuels	Lack of coordination of entities involved in biofuels	Lack of an autonomous governing body that coordinates various aspects of regulation and biofuels market	Scarce resources and lack of technology; little infrastructure	Little or no state financial and/or private financial institution support
Challenges/problems to be solved	Create conditions that make biofuels business profitable and sustainable	No consistent policies, only guidelines issued	Regulators (OSINERGMIN, INDECOPI) do not comply with their regulations adequately	Generate HR and material needed for biofuels development	Generate funding sources to facilitate biofuels project development
Capacity-building needs	No specialised technical or university courses on biofuels	Start educational courses leading to capacity building for biofuels industry	Promote creation of an autonomous organisation to deal with biofuels	Promote creation of institutes educating professionals and technician and developing biofuels technologies	Facilitate training of professionals able to assess and evaluate biofuels projects
Action to be taken	Promote a workshop with interested parties to discuss and create a roadmap for relevant authorities				Promote a biofuels project evaluation workshop for Financiers

RENEWABLE ENERGY APPLICATION	FINANCE				
RRA element	**Business model**	**Policies and strategies**	**Institutions, regulations and market structure**	**Resources, technologies and infrastructure**	**Funding, construction, operation and maintenance**
Current situation (includes good practice areas) Challenges/problems to be solved Capacity-building needs	Lack of ability to evaluate projects for the financial system; very few bankable projects submitted to date	Lack of capacity of relevant institutions to assess renewable energy projects; funding for new opportunities lost	Lack of clarity in project management for compliance with renewable energy project requirements *e.g.,* environmental evaluations, environmental Impact assessments, leading to financial proposal rejections	Inventory system for licensing or cross-sector concessions are emerging, causing delays in renewable energy project implementation	Lack of knowledge of innovative finance that can improve renewable energy projects
Action to be taken	Develop user guide that provides investing promoters with necessary requirements for making loan applications	Build capacities to utilise renewable energy business model or chain *e.g.,* technology transfer through universities and R&D think tanks	Build capacities to enforce compliance with renewable energy projects	Create integrated information system for areas of interest	Finance hire-purchase option model to provide better terms for credit to promoters; suggested model adopted by CAF in other countries

Annex 6: Renewable energy auction process

Item	Activity	Deadline
1	Call for auction	day 1
2	Registration of participants	day 2 to day 41
3	Sale of auction documents	day 2 to day 41
4	Suggestions and queries to the terms	day 6 to day 23
5	Analysis of suggestions and queries	day 26 to day 30
6	Publication of suggestions and answers to queries.	day 30
7	Publication of consolidated terms on the website	day 37
8	Publication of schedule for bid submissions	day 72
9	Submission of bids	day 79
10	Evaluation of bids	day 82 to day 86
11	Notice of bidder qualification and comments to participants	day 90
12	Submission of rectifications	day 100
13	Publication of Bidder Certificate	day 104
14	Challenge to rejection of bids	day 106
15	Resolution including challenges and publication of final act of bidders, if necessary	day 113
16	Public Act for opening offers and award to bidder	day 118
17	Publication of auction results on OSINERGMIN website	day 119
18	Closing date	day 126

Annex 7: Renewable energy auction process

Projects awarded for biomass, wind and solar (first auction)

Technology	Project	Price offered (cts USD/ kwh)	Price ceiling (cts USD/kwh)	Power to be installed (MW)	Plant factor (%)	Energy awarded (GWh/year)	Estimated investment (USDm)	Date for commercial start-up
Biomass	**Paramonga1***	5.20	12.00	23.0	57.0	115.0	31.0	31/03/2010
Biomass	**Huaycoloro**	11.00	12.00	4.4	73.0	28.0	10.5	01/07/2011
Wind	**Marcona**	6.56	11.00	32.0	53.0	148.0	43.6	01/12/2012
Wind	**Talara****	8.70	11.00	30.0	46.0	120.0	71.1	29/06/2012
Wind	**Cupisnique*****	8.50	11.00	80.0	43.0	302.0	198.9	29/06/2012
Solar	**Panamericana^**	21.50	26.9	20.0	28.9	51.0	87.7	30/06/2012
Solar	**Majes Solar^^**	22.25	26.9	20.0	21.5	38.0	73.6	30/06/2012
Solar	**20T Solar^^^**	22.30	26.9	20.0	21.4	37.0	73.6	30/06/2012
Solar	**Tacna Solar 20T**	22.50	26.9	20.0	26,9	47.0	85.1	30/06/2012

*Paramonga 1 Cogeneration Power Plant | **Talara Power Station | ***Cupisnique Wind Power Station
^Panamericana Solar | ^^Majes Solar 20 T | ^^^20T Solar Distribution

Source: OSINERGMIN, 2010

Projects awarded for small hydropower (first auction)

Project	Price offered (cts USD/ kwh)	Price ceiling (cts USD/kwh)	Power to be installed (MW)	Plant factor (%)	Energy awarded (GWh/year)	Estimated investment (USDm)	Date for commercial start-up
Santa Cruz II	5.5	7.4	6.50	66	33.0	13.2	01/07/2010
Santa Cruz I	5.5	7.4	6.00	65	29.5	12.2	29/05/2009
Nuevo Imperial	5.6	7.4	3.97	81.4	25.0	7.5	01/05/2010
Yanapampa	5.6	7.4	4.13	77.4	28.0	9.0	01/12/2012
Huasauasi II	5.7	7.4	8.00	70.5	42.5	14.5	01/04/2012
Huasauasi I	5.8	7.4	7.86	70	42.5	17.4	01/10/2012
Chancay	5.9	7.4	19.20	85	143.0	36.9	31/12/2012
Poechos 2	5.9	7.4	10.00	75	50.0	20.3	27/05/2009
Concador	5.9	7.4	3.80	88.9	28.1	8.2	01/12/2010
La joya	6.0	7.4	9.60	65	54.7	19.4	01/10/2009
Angel I	6.0	7.4	19.95	75	131.0	23.1	31/12/2012
Angel II	6.0	7.4	19.95	75	131.0	21.5	31/12/2012
Angel III	6.0	7.4	19.95	75	131.0	25.1	31/12/2012
Pumacana	6.0	7.4	1.80	71.3	9.0	2.8	01/07/2011
Shima	6.4	7.4	5.00	75	32.9	N/A	30/09/2012
Carhuaquero IV	7.0	7.4	10.00	76	66.5	20.3	22/05/2008
Caña Brava	7.0	7.4	6.00	41	21.5	12.2	19/02/2009
Empresa (**)	6.4	7.4	18.00	67	85.0	39.6	31/12/2012

**Empresa Electrica Rio Doble Hydropower plant assigned after second call

Source: OSINERGMIN, 2010

Annex 7: Renewable energy auction process

Projects awarded for biomass, wind and solar (second auction)

Technology	Project	Price offered (cts USD/ kwh)	Power to be installed (MW)	Plant factor (%)	Energy awarded (GWh/year)	Estimated investment (USDm)	Date for commercial start-up
Biomass	La Gringa V	9.9	2.0	8.0	14.0	5.6	31/07/2014
Wind	Tres Hermanas*	6.9	90.0	52.0	415.0	180.0	13/12/2014
Solar	Moquegua FV	11.99	16.0	30.5	43.0	43.0	31/12/2014

*Tres Hermanas Wind Farm
Source: OSINERGMIN,2010

Projects awarded for small hydropower (second auction)

Bidder	Project	Price offered (cts USD/ kwh)	Power ouput (MW)	Plant factor (%)	Annual Energy (GWh/year)	Date for commercial start-up
Aldana Contratistas*	Canchayllo	4.74	3.73	77	25.16	31/12/2014
Arsac Contratistas**	Huatziroki I	4.76	11.08	75	72.27	31/12/2014
Peruanas Renovables^	Manta	5.29	19.78	74	127.50	31/05/2013
Renovables de los Andes	RenovAndes H1	5.39	19.99	90	150.00	31/12/2014
Andes Corporating Gerenation	8 de Agosto	5.39	19.00	90	140.00	30/12/2014
Andes Corporating Gerenation	El Carmen	5.59	8.40	76	45.00	30/12/2014
Empresa de Generacíon Junín^^	Runatullu III	5.65	20.00	80	120.00	15/12/2014

Aldana Contratistas Generales | ** Arsac Contratistas Generales | ^ Peruanas Renovables en Energías Renovables

^^Empresa de Generacíon Electrica Junín

Source: OSINERGMIN,2010

Annex 8: Power plants on stream 2013-2016

EC	Type	Project	Capacity MW
Jan-2013	Hydro	Yanapampa - ELÉCTRICA YANAPAMPA.	4.1
Mar-2013	Hydro	Huanza - EMPRESA DE GENERACION HUANZA	90.6
Apr-2013	Hydro	Las Pizarras - EMPRESA ELÉCTRICA RIO DOBLE	18.0
Apr-2013	Cold Reserve	Talara- Dual Plant with Gas Natural - EEPSA	183.0
Jun-2013	Combined Cycle	Fenix - TG1+ TG2 + TV– FENIX	534.0
Oct-2013	Cold Reserve	TURBO GAS DUAL Natural Gas - SUR (Ilo) - ENERSUR	460.0
Oct-2013	Thermal	Santo Domingo de los Olleros - TG1- TERMOCHILCA	197.6
Nov-2013	Wind	Wind Park Cupisnique	80.0
Nov-2013	Wind	Wind Park Talara	30.0
Dec-2013	Hydro	Manta - PERUANA DE INVERSIONES EN ENERGÍAS RENOVABLES	19.8
Jan-2014	Wind	Wind Park Marcona	32.0
Jan-2014	Hydro	Tingo - COMPAÑÍA	8.8
Jun-2014	Cold Reserve	TURBO GAS DUAL D2/ Natural Gas - NORTE (Planta de Eten)	219.0
Jul-2014	Hydro	San Marcos - HIDRANDINA	11.9
Jul-2014	Hydro	Pelagatos - HIDROELECTRICA PELAGATOS S.AC.	20.0
Jul-2014	Hydro	Santa Teresa - LUZ DEL SUR	98.1
Aug-2014	Biomass	La Gringa V - CONSORCIO ENERGÍA LIMPIA	2.0
Oct-2014	Hydro	Langui II - CENTRAL HIDROELÉCTRICA DE LANGUI S.A.	2.9
Nov-2014	Hydro	Quitaracsa - ENERSUR	112.0
Dec-2014	Hydro	Muchcapata - ANDES GENERATING CORPORATION S.A.C.	8.1
Dec-2014	Hydro	Machupicchu II-Etapa – EGEMSA	99.9
Jan-2015	Hydro	Carpapata III - Cemento Andino	12.8
Jan-2015	Hydro	Cheves - SN POWER	168.0
Jan-2015	Hydro	Runatullo III - EMPRESA DE GENERACIÓN ELÉCTRICA JUNIN	20.0
Jan-2015	Hydro	Runatullo II - EMPRESA DE GENERACIÓN ELÉCTRICA JUNIN	17.6
Jan-2015	Hydro	8 de Agosto - ANDES GENERATING CORPORATION	19.0
Jan-2015	Hydro	El Carmen - ANDES GENERATING CORPORATION	8.4
Jan-2015	Wind	Tres Hermanas - CONSORCIO TRES HERMANAS	90.0
Jan-2015	Solar	Moquegua PV - SOLARPARCK CORPORATION TECNOLÓGICA	16.0
Jan-2015	Hydro	Canchayllo - ALDANA CONTRATISTAS GENERALES	3.7
Jan-2015	Hydro	Huatziroki I - ARSAC CONTRATISTAS GENERALES	11.1
Jan-2015	Hydro	RenovAndes H1 - RENOVABLES DE LOS ANDES	20.0
Jan-2015	Hydro	Rucuy - EMPRESA DE GENERACIÓN ELÉCTRICA RIO BAÑOS S.A.C.	20.0
Jan-2015	Hydro	Vilcanota 2 - RENEWABLE ENERGY PERÚ S.A.C.	19.0
Mar-2015	Cold Reserve	PlantPuerto Maldonado	18.0
Mar-2015	Cold Reserve	Plant Pucallpa	40.0
Jul-2015	Hydro	Angel III - GENERADORA DE ENERGÍA DEL PERÚ	20.0
Jul-2015	Hydro	Chaglla - EMPRESA DE GENERACION DE HUALLAGA	456.0
Jul-2015	Hydro	Cola 1 - HIDROELECTRICA COLA	10.4
Jul-2015	Hydro	Tulumayo IV - EGEJUNIN TULUMAYO IV	40.0
Jul-2015	Hydro	Tulumayo V - EGEJUNIN TULUMAYO V	65.0
Jul-2015	Hydro	Macon - EGEJUNIN MACON	10.0

EC	Type	Project	Capacity MW
Jul-2015	Hydro	Chancay - SINERSA	19.2
Oct-2015	Hydro	Zaña - ELECTRO ZAÑA	13.2
Jan-2016	Hydro	Cerro del Águila - CERRO DEL AGUILA	525.0
Jan-2016	Hydro	Nueva Esperanza - ANDES GENERATING CORPORATION	8.0
Feb-2016		La Virgen - PERUANA DE ENERGÍA	64.0
Mar-2016	Hydro	Chancay 2 - EMPRESA DE GENERACIÓN ELÉCTRICA RIO BAÑOS S.A.C.	40.0
Oct-2016	Hydro	Potrero - EMPRESA ELÉCTRICA AGUA AZUL	19.9
Oct-2016		Pucará - EMPRESA DE GENERACIÓN MACUSANI	149.8
Oct-2016	Thermal	Quillabamba - (4 TGs - 50 MW) - Natural Gas - ELECTROPERÚ	200.0

Annex 9: Maximum power injected into SEIN 2013-2014

Region	Candidate business		Power [MW]	
	Name	Units [KV]	P admitted	Region total
North of SE Trujillo	LA NIÑA	220	41	**67**
	CHICLAYO	220	67	
	GUADALUPE	220	73	
	TRUJILLO	220	114	
	TUMBES	220	6	
	PIRUA	220	45	
	TALARA	220	32	
Between SSE Huacho and Chimbote	PARAMONGA	220	119	**57**
	HUIACHO	220	84	
	CHIMBOTE	220	135	
South	REPARTICION	138	45	**204**
	MOLLENDO	66	18	
	TACNA	220	15	
	MOQUEGUA	220	127	
South Middle	MARICONA	220	88	**168**
	ICA	220	81	
Total additional wind power [MW]				**497**

Annex 10: Major crop water consumption

Crop	Water/energy (m^3/GJ)	End-use
Sugar beet, sugar cane, maize	50	Biofuel
Canola (rape seed), jatropha	400	Biofuel
Sugar beet, potato	60-100	Ethanol
Sugar cane	110	Ethanol
Sorghum	400	Ethanol
Soybean, canola (rape seed)	400	Biodiesel
Jatropha	600	Biodiesel

Source: Gerbens-Leenesa, Hoekstraa and van der Meerb (2009)

Annex 11: Qualifications for auctioned generation in Brazil

Fiscal and labour requirements	Financial and economical requirements of bidder	Technical requirements (all sources)	Technical requirements (thermal and wind)	Technical requirements (hydro)	Construction performance guarantees and penalties
Fiscal clearance certificate	Clearance certificate of bankruptcy	Power grid access document	Proof of right to use the location where the project is to be installed	Basic project	Bid bond equivalent to 1% of the project's estimated investment
Social security clearance certificate	Liquidity (ratio between asset and liabilities) greater than 0.1	Environmental License – Prior License		Hydrological availability reserve	Performance bond equivalent to 5% of the project's estimated investment
Clearance certificate for federal taxes	Equity greater than 10% of the overall investment	Environmental impact studies and reports			There are several specific penalties for delays
Clearance certificate for state taxes					Contract termination and performance bond execution in the case of delay greater than 365 and 540 days for projects contracted in auctions for delivery 3 and 5 years ahead.

IRENA

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