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Learning from Developing Country Power Market Experiences

The Case of Peru

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Abstract

The Peruvian power market was established in 1992, amid serious supply constraints and financially distressed power utilities. Since its inception, the market has been adapted by competitive market reforms and adaptations due to government-driven public policy objectives. This paper analyzes the experience of Peru with power markets, including market design, implementation, and outcomes. A cost-based power pool with locational marginal prices was established overnight, with bilateral contracts among market participants and regulated capacity payments. After an initial period of rapid investment, sluggish capacity additions and a prolonged drought in 2003–04 motivated the successful introduction of competitive supply auctions in 2006, to ensure that needed capacity additions were made to meet demand growth. Competitive auctions for renewable capacity have also been successful, attracting investment at falling prices. However, the market has been adapted by the government, pushing technology-specific auctions to develop a balanced mix of gas and hydro power generation, with additional costs passed through to final customers. As a result, supply is less prone to hydrological conditions, but it is now subject to gas transport constraints; prices are depressed at US$9/megawatt hour; and the reserve margin increased to 81 percent in 2017. Overall, continuous adaptations to the Peruvian power market have delivered competitive outcomes, with concentration falling steadily and security of supply increasing over the past decade. However, the mixed approach of competitive forces and government-driven adaptations for public policy objectives calls into question the long-term efficiency of the market.

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Learning from Developing Country Power Market Experiences: The Case of Peru[1]

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Acronyms and Abbreviations

BOOT	Build, Own, Operate and Transfer
COES	Committee of Economic System Operation, Peruvian system operator
Discos	Distribution Company
MINEM	Ministry of Energy and Mines
OSINERGMIN	Regulator of the Peruvian power market
PPA	Power Purchase Agreement
REG	Renewable energy generation

1. Introduction

The World Bank is seeking to update its understanding on power sector reforms in developing countries, accounting for emerging challenges and new reform directions over the past decade. Implementation of power sector reforms in developing countries has been varied, especially when it comes to power markets, with widely different outcomes. This work forms a part of the World Bank's project "Rethinking Power Sector Reform", which was commissioned to analyze the recent experience of developing countries, including a series of case studies on wholesale power markets. These case studies, including the incumbent one for Peru, were developed based on both qualitative and quantitative inputs from experienced consultants of each studied country.

Peru is a relatively small market (with generation of about 49 TWh during 2017), with nodal pricing and central dispatch in a mandatory cost-based pool. Power Purchase Agreements (PPAs) are privately negotiated in the liberalized market and auctioned in the regulated market, typically without sovereign guarantees. Like in Panama and many other countries in Latin America, Peru relies on a combination of PPAs awarded through auctions and capacity payments to secure timely generation capacity expansion. Discos procure their expected demand through auctions 3 years in advance; and transmission expansion is secured through a centralized transmission planning process and establishment of concession contracts.

Table 1-1 Peru power sector summary.

Peru power sector summary	
Population (2016)	31 million
Electricity generation (2017)	49 TWh
Electricity demand CAGR (2005-2015)	6.7%
Major generation technologies[1]	Hydro: 50% Natural gas: 45%
Spot electricity price (2005-2017)[2]	39 USD/MWh

Source: Worldbank, Department of Energy.

[1] As share of 2015 energy generation.

[2] Average spot electricity prices from 2005 to 2017, expressed in 2015 currency.

The objective of this paper is to document and analyze the experience of Peru with power markets, regarding design, implementation and outcomes of the market. Ultimately, the analysis in this paper is expected to be useful for developing countries which are currently developing or considering the development of a power market. However, the paper does not aim at providing policy or market recommendations for improving the performance of the Peruvian power market. Furthermore, the scope of this paper is limited to assessing competitive power markets, with an emphasis on the generation and supply segment. Hence, retail competition, as well as the transmission and distribution segments, are not the primary focus of this paper. Moreover, the paper does not directly address several power sector reform issues, such as regulation, privatization, and political economy. These and other subjects are addressed elsewhere for each country, as part of the wider project.

This case study is structured as follows. Section 2 describes the basic pre-conditions for power markets, referring to both power system infrastructure and ownership (section 2.1), and to fuel supply (section 2.2). Section 3 describes the power market design. Section 4 describes the implementation of the power market, covering both the governance of the market (section 4.1) and the transitional process towards a power market (section 4.2). Section 5 assesses the performance of the power market from the perspective of prices and efficiency (section 5.1), investment and security of supply (section 5.2), and sustainability (section 5.3). Section 6 concludes this case study.

2. Preconditions for power markets

2.1. Power system

Base load units in Peru are combined cycle units fueled by natural gas. Peaking units are combustion turbines fueled by diesel oil and hence significantly more expensive. Hydroelectric generation meets the remaining load (all hydro plants are dispatched if available).

Spare capacity is very dispersed among generating plants and units depending on the days of the week and seasons. Usually, the most expensive (peaking units) and cold reserve plants are the ones to pick up any increase in demand or generator outages.

The center and the southern parts of the country have traditionally weak transmission links, creating congestion conditions. The southern part of the country has insufficient local generation to cope with large mining demands. Although these congestions have been alleviated by transmission expansions in 220 kV and 500 kV, the center-southern transmission link presented congestion about 60% of the year during 2017 (COES, 2017).

2.2. Fuel supply

Historically, Peru has relied mostly on hydropower, but after the entry into production in 2004 of natural gas from the Camisea gas fields, thermoelectric generation started to be an increasing part of power supply. Between 2004 and 2008, new natural gas-fired electric power capacity, primarily less investment-intensive but also less efficient open-cycle technology, expanded rapidly in Peru. The abundant supply of cheap natural gas facilitated this expansion.[3] Natural gas has become the primary fuel of Peru.

3. Market design

3.1. Generation scheduling and dispatch

Generation dispatch and network operations are carried out by the Committee of Economic System Operation (COES), which is organized/managed as an independent system operator (ISO). In addition to the system operation functions, COES supervises and performs the accounting of transactions in the "spot" market.

From the operational point of view, the short-term market, or spot market, is organized as a “mandatory pool” with participation of generators, where all the energy production is injected into the pool so that, in turn, the demand requirements are supplied from the pool, regardless of the specific generator that supplies it. That is, all generators inject their production into the pool and users physically withdraw from the pool what they need; attributing these withdrawals to the generator(s) the users have contracted their supply from.

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[3] In 2003, before the Camisea natural gas project came into operation, hydroelectric production accounted for 85% of total electricity generation. By 2015 gas-fired thermoelectric generation represented 50% of total electricity production.

Real-time generation dispatch follows a procedure based on the “merit order” of operating costs of generating units, regardless of existing bilateral contracts or supply auction results. This centralized procedure yields a system marginal cost which is the wholesale spot price of electricity (or, loosely speaking, the operating cost of the last unit in the merit order).

However, until 2017 the calculation of the marginal cost disregarded generating units classified as “emergency” or dispatched due to transmission congestions. Furthermore, the marginal costs were calculated disregarding constraints in the production and transportation of natural gas. This special arrangement was introduced by the Urgency Decree N° 049-2008 after serious constraints in the gas transport capacity from Camisea field. The arrangement, originally intended to operate until 2011, was extended to 2013 by the Urgency Decree N° 079-2010, and then further extended to 2016 by lay 30115. Finally, Law 30513 extended these market distortions until October 2017, when they finally ceased to operate.

Transactions between generators, distributors and large users in the wholesale market are made at the marginal/spot energy price. COES administers the wholesale market (the balance of “transactions” between the generators, large users and distribution companies), and supervises the obligations among the parties.

As part of the urgency measures taken during 2008, generators dispatched due to transmission or gas constraints receive the difference between variable generation costs and the system marginal cost (calculated disregarding these constraints). These payments are charged to all participants in the wholesale market by bundling the charge in the transmission tolls. All these charges are applied to peak-load hours, so free customers who shift their energy consumption to off-peak hours pay lower bills due to a reduction of these additional charges (for example due to power transmission and gas pipeline constraints). These arrangements for out-of-market generation operated until October 2017.

3.2. Price formation

3.2.1. Spot price

There is only one energy price setting mechanism in the short-term/real-time power market, at which all generator transactions are valued. Gencos inject power to the grid at a set of injection nodes, and they also withdraw power from the grid at another set of withdrawal nodes, associated to the customers with whom the Gencos have signed bilateral supply contracts. Imbalances between total injections and withdrawals of each Gencos are settled in the pool at the nodal spot price cleared by the system operator COES.

The spot price or marginal cost is cleared by the system operator COES by means of a cost-based merit-order dispatch, in turn based on variable costs declared by Gencos for each power plant. It is worth noting that gas power plants with take-or-pay contracts (common for power plants running on gas from the Camisea field) can and often do declare zero variable costs to ensure full dispatch and therefore usage of the contracted gas supply.

3.2.2. Capacity price

The price of capacity included in bilateral contracts is established by OSINERGMIN (the regulator) through a pre-determined administrative procedure. The capacity payment is intended to cover the fixed costs of generators. The capacity price is calculated on a yearly basis by OSINERGMIN, and is equal to what the regulator considers to be the efficient expansion cost of generation to supply an increase in peak power demand. This expansion cost (expressed in US$ per MW), is equal to the annualized investment cost and annual fixed costs (of operation and maintenance) of a turbogas unit operated with diesel oil (OSINERGMIN, 2016, p. 147).

3.2.3. Retail prices

Depending on demand levels, eligible customers can freely negotiate prices and terms with Gencos, while others are subject to regulated prices (see section 3.3). Besides distribution charges (e.g. investment in distribution networks), the retail regulated price comprises a combination of market-based prices resulting from supply auctions (called firm prices), and regulated prices calculated yearly by OSINERGMIN (called bar prices). Market-based prices are the average prices obtained by distributors in the supply auctions they independently organize (see section 3.4). These market-based prices apply for the volumes of energy and power contracted in the auction. Additional consumption (i.e. above contracted volumes) is paid for by regulated customers at the regulated price. During August 2016, 89% of the generation price paid by regulated customers was determined by the results of auctions, while 11% corresponded to the regulated price.

The regulated “bar” prices are composed of generation level and transmission level charges. Generation level charges comprise both energy and capacity (the so-called basic prices of energy and capacity, respectively). While the capacity price is calculated as the expansion cost of generation to supply peak demand (as described previously), the regulated energy price is a weighted-average of expected future marginal costs. These future marginal costs are calculated by the regulator with a computer model. Therefore, regulated energy prices are said to be more stable than wholesale spot prices (OSINERGMIN, 2016, p. 147).

The transmission level prices comprise the payment for transmission infrastructure and management as well as additional generation charges. These additional charges cover the price premium for renewable generators; charges for cold reserves; charges for emergency supply and generation variable costs exceeding marginal incomes (i.e. valued at “idealized” marginal costs); and charges for the security gas duct; among others.

It is important to note that generation surcharges bundled with transmission tolls are charged to customers based on peak-power consumption if such metering is available. Hence, there is an incentive for large customers to lower their consumption during peak hours, thus lowering the transmission charge they pay. The difference is allocated to regulated customers.

The components of the regulated retail prices are summarized next:

- Distribution charges
- Firm prices: market-based prices resulting from supply auctions
- Bar prices
    - Generation level prices
        - Basic Energy Price: weighted average of expected future marginal costs, calculated by the regulator with a computer model
        - Basic Capacity Price: generation expansion cost to supply peak demand
    - Transmission level prices
        - Transmission tolls: payment for transmission infrastructure and management

- Additional charges
    - Renewable generation premiums
    - Cold reserves
    - Emergency supply
    - Generation with variable costs exceeding marginal incomes
    - Security gas ducts
    - Others

3.3. Demand participation in the wholesale market

From the demand side of the market, sector legislation recognizes two general categories of electricity users, regulated and "free", according to the level of maximum user demand. Users requiring up to 200 kW of maximum demand are considered Regulated Users. Users with a demand greater than 200 kW up to 2,500 kW can choose to be a Regulated User or a Free User. Finally, users with demands greater than 2,500 kW are considered Free Users who need to negotiate contracts for their electricity supply requirements and are not eligible to be a regulated user. Users with demand equal or greater than 10,000 kW are considered Large Users and can directly participate in the wholesale spot market. Distribution companies should participate in periodic competitive supply auctions to cover their regulated demand.

Table 3-1 Customer choice arrangements in the Peruvian power market.

Monthly consumption	Below 200 kW	Between 200 kW and 2,500 kW	Between 2,500 kW and 10,000 kW	Above 10,000 kW
Customer choice arrangement	No customer choice	Optional customer choice	Mandatory customer choice	Mandatory customer choice
Comments	Regulated prices are set by the regulator (OSINERGMIN)	Can opt for a regulated tariff	Required to negotiate directly with distributors or with generators	Can also participate in the wholesale market

Since 2018, new regulations of the spot market allow direct customer participation in the pool. Large customers can purchase up to 10% of their maximum demand over the last 12 months. Distributors can purchase up to 10% of the maximum demand of the liberalized customers they supply.

3.4. Contracts and bilateral trading

The short-term pool market is complemented by bilateral transactions in the medium and long-term supply contracts market, which are freely negotiated by generators with Free Users, distributors or other generators; including supply contracts through auctions for the regulated market. Through bilateral contracts, customers acquire the right to withdraw from the system pool the energy and power required, paying its supplier the price committed in the contract. Bilateral contracts between free customers and generators are complex non-standardized legal documents, with extensive articles and clauses, independently negotiated between the parties.

Supply auctions were introduced in Peru to ensure adequate investment in power generation plants. Distributors are required by Law Nº 28832, 2006, to supply the expected demand of their customers by entering medium and long-term contracts with generators (with new or existing power plants). Distributors are required to independently organize supply auctions at least three years ahead of delivery, with terms of 5 to 20 years, and at least 75% of demand must be supplied through contracts longer than 5 years. A "firm price" is obtained for both energy and capacity by taking the weighted sum per awarded volumes of prices offered by winning generators. The regulator must approve the auction design and indexation formulas, and establishes maximum prices for each auction (OSINERGMIN, 2016, p. 146).

3.5. Market settlement

After actual operations in the market have been completed, it is necessary to balance the sales and purchases of all participating generators. If a generator injects more than its customers have withdrawn (consumed), it will have a surplus in the pool and if the opposite happens, it will have a deficit. Deficit generators will pay surplus generators the involved energy quantities, evaluated at the spot/marginal energy price at each injection and withdrawal node.

Additional costs due to electricity transmission and gas transport constraints are levied directly to final customers, as well as additional costs due to gas-fired generation in the south of Peru introduced by the government to finance new gas pipelines from Camisea gas fields (see section 4.2). It is worth noting that the surcharge for financing the southern gas pipeline (Gasoducto Sur Peruano) ceased to exist in March 2017.

3.6. Summary of power market design

A broad overview of power market design in Peru is summarized in Table 3-2.

Table 3-2 Power market design overview, Peru.

Power Market Element	Peru Design Choice
Overall Market Organization	Mandatory net pool based on costs with technical and economic parameters supplied by generators.
Demand Participation	All energy withdrawals from the grid are balanced in the pool. Since 2018, large customers and distributors can participate directly in the pool for up to 10% of maximum demand. Customers above 2.5 MW are liberalized (i.e. must negotiate power supply directly with generators), while customers between 200 kW and 2.5 MW can opt for the regulated or liberalized supply regime.
Coordination of Operations	Fully centralized, merit-order based dispatch and operations planning (week ahead). Re-dispatch is carried out in case of transmission congestion.
Congestion management	The core market design entails nodal spot prices considering transmission congestion and losses, but a spot price disregarding transmission congestion was used from 2009 to 2016, with congestion costs being levied directly to final customers during this period.
Contracts and Bilateral Markets	A bilateral market of financial contracts runs in parallel to the pool. Contracts to supply regulated customers are awarded by auctions organized independently by distributors.
Price Formation	System marginal cost is calculated by the system operator for each high-voltage bus every 15 minutes, considering transmission losses. Generators operating due to transmission congestions are excluded from this calculation (until October 2017).

	Financial contracts are priced in centralized auctions for regulated customers, and in bilateral negotiations for free customers.
Capacity Markets	Regulated capacity payments are provided to all generators, valued to the yearly cost of capacity expansion with diesel turbines.
Settlement	Pool transactions are calculated by the system operator and settled independently by market participants. Contracts are settled independently by market participants.
Non-Conventional Renewable Generation	Renewable generators have priority in the real-time dispatch over any other generation. Renewable generators receive the wholesale price and a premium price if the spot price is lower than the offered price in the renewable energy auctions. The price premium payments are recovered through a surcharge to electricity rates of all users.

4. Power market implementation

Having described key preconditions for the Peruvian power market, and the overall market design adopted by the country, this section describes the implementation of the envisioned power market design. First, governance of the power market is described in section 4.1. Then, the process of transition towards the power market is described in section 4.2. A summary of power market implementation and institutional indicators for Peru is presented in section 4.3.

4.1. Market governance

COES (the Committee for Economic Operation of the System) creation and functional objectives were part of the Electricity Concession Law of 1992 and Law N° 28832 of 2006. Its main functions are:

- to coordinate the short, medium- and long-term operation of the electrical system at a minimum cost, preserving the security of the system, the best use of energy resources;
- planning the development of the bulk transmission system; and
- managing the pool electricity market (e.g. calculate economic transactions between pool participants to balance hourly energy production and withdrawals in the power system).

Legally, COES is a private, not-for-profit entity with public law status. All agents with generation, transmission and distribution activities, or large demand users, in the power systems are members of COES.

The governing bodies of COES are the Assembly, the Board of Directors and the Executive Directorate. The Assembly is composed of the power system agents, grouped into four subcommittees: one of generators, one of distributors, one of transmitters and one of Free Users. The Board of Directors must act independently, impartially and technically. In practice, there have been no problems with the independence of the operator.

The Board of Directors is composed of five members, for a period of five years, four representing each of the subcommittees and one appointed by the Assembly, who will preside over it. The President and members of the Board of Directors shall have a minimum of 10 years of professional experience in the electricity sector. While they hold office, they are prohibited from carrying out activities for the Public Administration in any way; as well as to have labor, commercial or financial links with the agents, their related companies, or with the majority shareholders of the same. The only exception to the restrictions noted is the teaching activity.

Once members of the Board of Directors cease to hold office, they will be subject to the same prohibitions for a period of one year, during which period they will receive the same remuneration for the current period, unless they have committed serious misconduct. The members of the Board of Directors can only be removed by the Assembly in case of incapacity or serious misconduct, duly verified and substantiated.

The Board of Directors must periodically inform the agents, the Ministry (MINEM) and OSINERGMIN of the facts, acts, agreements and important decisions that may affect the operation of the system, the short-term market and/or transmission planning. This information must be published on the COES website along with the respective supporting documentation. The Executive Directorate is made up of the Operations Directorate and the Transmission Planning Directorate, whose functions are established by the regulation. The Executive Director is selected by the Board of Directors. It can only be removed by the latter in case of incapacity or serious fault, duly substantiated and proved, with the vote of at least four Directors.

The COES budget is covered by contributions from agents, which will be determined in proportion to the amounts recorded in the previous year, of:

(a) Power and energy injections of generators, valued at the Basic Peak Power Price and at the Short-Term Marginal Cost, respectively;
(b) the total revenues derived from the provision of the transmission service by transmitters; and
(c) the withdrawals of power and energy from distributors and Free Users, valued at the Basic Peak Power Price and at the Short-Term Marginal Cost, respectively.

4.1.1. Dispute resolution

The Peruvian arrangement for dispute resolution in the power market is organized in three tiers. A first administrative tier is within the system operator COES who analyzes disputes between two market agents and issues a statement on the conflict. A second tier of dispute managed by the regulator OSINERGMIN follows in case one of the parties does not accept the administrative resolution by COES. Within the regulator there are collegiate bodies which resolve the dispute in two instances, first a committee assigned specifically for each case, and then a second and common instance which is basically a dispute tribunal. Members of both the specific committee and the dispute tribunal are appointed by OSINERGMIN, although the dispute tribunal needs approval from the Prime Minister's office. Finally, a third tier involves any unsettled dispute in a court.

In practice, the dispute resolution system has worked appropriately with many disputes being solved in the specific collegiate body of the regulator or within the system operator COES. Of the remaining disputes which follow through to the dispute tribunal within the regulator, very few disputes escalate to country courts since it is a cumbersome process and the courts are unlikely to proceed unless evidence which was not available to the dispute tribunal is made available to the courts. Moreover, the courts have never ruled against the ruling of the dispute tribunal. Hence, in practice parties have not commonly brought cases up to the judicial system of Peru. Although bilateral contracts can specify an arbitration mechanism between the parties, such process often requires the collegiate body to rule on the matter before proceeding.

4.2. Transitional process

There was no transition; the electricity market was explicitly established in the Electricity Concession Law as part of the sectorial reform in 1992.

During the initial years after the reform of the electricity sector, investments in generation, transmission and distribution increased year after year reaching a peak in 1999, followed by a sharp decline until 2003. At that time, the authorities of the sector and the government were concerned about the reduction of investments and consequently a system with low generation reserve margin, vulnerable to power cuts. This was compounded by a prolonged drought period during 2003 and 2004. As a result, the Executive proposed to Congress a complementary electricity bill (akin to a second-generation reform) to address the problems. In July 2006, Congress passed Law Nº 28832 "to ensure the efficient development of electricity generation." This new law introduced important changes in the Electricity Concession Law (ECL), mainly in generation and transmission planning and regulation, the reorganization of the system operator (COES) and the administration and operation of the electricity market.

Law Nº 28832 established a system of energy auctions to ensure short to long term generation supply to distribution companies to meet the demand of the regulated market. The supply contracts between generation and distribution companies are awarded under competitive bidding procedures. Generation prices resulting from the auctions are incorporated in the methodology for setting regulated generation tariffs. During the period 2009-2015 there were 14 long-term distribution supply auctions under Law Nº 28832 and its regulations.[4]

In transmission, Law Nº 28832 addressed the problem of almost no investment by private initiative under the former ECL regulations,[5] which did not guarantee investment recovery. The new regulatory framework formalized a transmission planning process (undertaken by the system operator COES and approved by MINEM) and establishing concession contracts under BOOT (Build, Own, Operate and Transfer) competitive bidding procedures to develop the transmission projects included in the plan.

The third important change introduced in Law Nº 28832 concerned the composition and governance of COES. It addressed inclusion of distribution companies and large users as new members completing the full spectrum of all four main groups, namely generation, transmission, distribution and large consumers.[6]

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 main legal instrument was Legislative Decree (DL) Nº 1002 for the Promotion of Investment for Electricity Generation Using Renewable Energy (enacted in May 2008), setting a target of up to 5% of the national energy demand to be covered by renewable energy generation (REG) and establishing an auction system (organized by OSINERGMIN) for contracting this generation. Detailed regulations (DS Nº 050-2008-EM) were approved the same year which included the administrative procedures for announcing renewable energy auctions and granting concessions for the development of renewable power generation. It also set the requirements for submitting, evaluating and awarding bids, as well as marketing procedures and renewable energy generation tariffs.

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[4] In the interim period 2006-2009, a temporary auction regime was implemented in order to have a smooth transition to the new comprehensive power supply auctions regulations.

[5] The former transmission tariff system was based on a theoretical "New Replacement Value" that yielded different results every year and was not linked to actual transmission investment costs.

[6] The reform of 2006 had a rather slow start since a great part of the procedures mandated by the said law were not completed until 2008-2009.

The original Peruvian power market design has been adapted by the government to develop Camisea gas fields and artificially lower marginal costs. Indeed, in the face of constraints in gas transportation in 2008 and spiking marginal costs, the government adapted the market in 2009 (Urgency Decree 049-2009) by removing gas and electricity transmission constraints from the spot price formation process. Instead, additional costs due to transport constraints were transferred directly to final customers by bundling these extra costs with transmission tolls, thus artificially lowering marginal costs cleared in the Peruvian power pool. Moreover, additional charges bundled with transmission tolls are referred to peak-load hours, thus incentivizing customers to opt for freely contracting with Gencos to lower their electricity bills (see section 5.1). Such distortion operated until 2017.

The government also adapted the competitive power market by forcing the development of gas-fired generation in the south of the country. “Reserve” power plants were auctioned in the south of the country, with the objective of financing new gas pipelines from Camisea, particularly the southern gas pipeline (Gasoducto Sur Peruano). Additional costs required to finance these forced (i.e. out-of-market) gas-fired generation assets were passed-through to final customers by an additional charge bundled with transmission tolls at a national level. It is worth noting that the surcharge for financing the southern gas pipeline (Gasoducto Sur Peruano) ceased to exist in March 2017, following the enactment of Law Nº 30543.

Dipping domestic gas prices due to the development of the Camisea gas fields has deterred investments in new hydro generation assets. The market was therefore adapted by the government by establishing technology-specific take-or-pay hydro-power auctions with government guarantees, backed by state-owned ElectroPeru. An auction was held expecting high competition, but only a few hydro power plants were awarded (about 1500 MW) at relatively high prices (65-75 US$/MWh).

4.3. Summary and institutional indicators for the Peruvian power market

Peru has adopted an intermediate power market design (with respect to the text-book design), with relatively good governance (albeit with much room for improvement), according to the institutional indicators developed and calculated in this study (further details on each of the components of the indicators are available in Annex A). The low score on power market design reflects the cost-based market design, while the score on governance is related to very weak accountability and monitoring, in contrast with relatively strong decision-making autonomy and transparency in the market.

Table 4-1 Institutional indicators for Peru’s power market, per level

	Level	Peru score
1	**Wholesale Market Design**	**41%**
1.1	Market Architecture	25%
1.2	Market Rules	57%
2	**Market Governance**	**61%**
2.1	Decision Making Autonomy	78%
2.2	Transparency	88%
2.3	Accountability and Monitoring	17%

It is worth noting that the aforementioned institutional indicators do not capture specific aspects of the Peruvian case. Most notably, the market design indicator does not capture auctions for the supply of regulated customers nor for renewable power plants. Also, the indicator does not capture market adaptations. Furthermore, the score of 17% for accountability and monitoring is the result of primarily two normative aspects considered for calculating the indicators. First, the Peruvian power market lacks an independent monitoring entity, external and independent from the regulator, the system operator, and market participants.[7] However, this indicator does not assess the oversight and monitoring role of the regulator or other government agencies. Second, the Peruvian power market was established practically overnight, without a transition phase. However, the lack of a transition phase for the wholesale power market had no evident negative impact on the outcomes of reforms. Hence, the low indicator for accountability and monitoring does not necessarily imply poor performance (outcomes of the market are analyzed in section 5). Instead, this indicator provides a comparison between the power market and some aspects which are generally deemed to be positive for the development of power markets.

Table 4-2 summarizes the Peruvian approach to implementing the envisioned power market.

Table 4-2 Overview of power market implementation in Peru.

Power Market Implementation Element	Peru
Key market participants and actors	• Gencos, which generate power, engage in bilateral contracting with free customers, and participate in Discos supply auctions • Free customers, whether bulk customers or large customers in the distribution network • Discos • Transco
Governance of system and market operation	System operator (COES) is a private non-for-profit organization, independent from market participants (and owns no transmission assets) and is also the market administrator and transmission planning entity.
Investment responsibility and risk allocation	Gencos bear the risk of investment in the core market design, but the market has been adapted to incentivize gas generation in the south (with extra costs levied directly to final customers), and hydro power plants by take-or-pay auctions specific to hydro projects.
Barriers to investment and entry	• Risks in the wholesale market • Complicated and lengthy processes for permits and license
Open access in practice	Open access established by law, which also mandates separate contracting of network and energy services and forbids transmission and distribution companies from participating in power generation.
Market transparency	Transparent market, with procedures, market prices and quantities, and settlements, all made publicly available by the system operator.
Approach to market monitoring and oversight	No dedicated entity for market monitoring. Regulator oversees the market.
Provisions for market intervention and related events	There are no clear provisions for market intervention. The market has been nevertheless adapted due to government-driven public policy objectives.

[7] An independent monitoring entity, such as the one established in PJM, could conduct periodic assessments of market outcomes, and also propose market design adjustments to the regulator and to the system operator.

Power Market Implementation Element	Peru
Year the market was introduced	1992
Major reform adaptations and milestones	• 2006, Law Nº 28832 is enacted to force Discos to organize supply auctions to supply the expected future demand of their customers. • 2009, in the face of gas transport constraints the government establishes ideal dispatch (Urgency Decree 049). "Ideal" spot prices are therefore calculated disregarding electricity and gas transport constraints. Additional operation costs due to these constraints are levied to final customers by bundling extra charges with transmission tolls.

5. Power market performance

Performance of the Peruvian power market is assessed in this section, in terms of prices and competition (section 5.1), investment and security of supply (section 5.2), and sustainability (section 5.3).

5.1. Electricity prices

The most relevant wholesale power market in Peru is the bilateral contracts market, followed by the spot market. The Peruvian power market design requires all Discos and open access customers to have a contract with a Genco for the supply of their electricity requirements (both energy and capacity). Contracts are key for financing new generation assets. In addition to the contracts market, all real-time transactions between Gencos are settled in the cost-based power pool based on the system marginal price.

Wholesale electricity prices in Peru have fallen considerably over the past decade (see Figure 5-1 and Table 5-1). Wholesale spot prices have fallen by 88% in real terms over the past decade, from 76.6 US$/MWh in 2005 (yearly average, inflation adjusted to 2015) to 9.22 US$/MWh in 2017, reaching a maximum of 97.1 US$/MWh in 2008. As described in section 3.3, bulk customers connected to the transmission grid and large customers in distribution networks engage in bilateral contracting directly with Gencos to supply their power demand. The yearly average price for such free customers (i.e. the average price of liberalized contracts) has decreased by 25% in real terms over the past decade, from 62.7 US$/MWh in 2005 (inflation adjusted to 2015) to 46.9 US$/MWh in 2017. Free customers obtain lower electricity prices partly because shifting energy consumption out of peak-load hours reduces many additional transmission-level charges which are referred to peak-hours, such as charges for developing gas networks (see section 3).

In contrast to the wholesale and liberalized prices, the regulated energy component of retail tariffs for regulated customers (mostly households and small businesses) has increased by 5%, from 56.1 USD/MWh in 2005 (inflation adjusted to 2015) to 58.6 USD/MWh in 2015. Lower power prices for liberalized customers have resulted in customers opting for freely contracting with Gencos instead of remaining as regulated users.

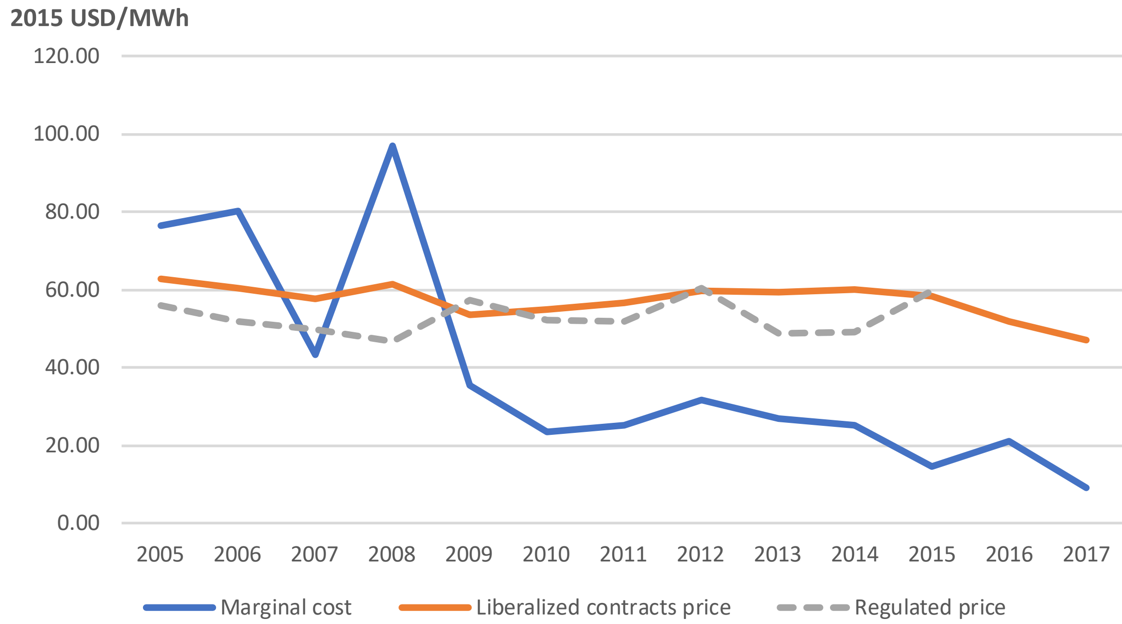

Figure 5-1 Evolution of wholesale and retail electricity prices in Peru (inflation adjusted to 2015 US$/MWh).

Source: Worldbank

Table 5-1 Yearly evolution of retail and wholesale prices (in 2015 USD/MWh).

Year	Average Wholesale Pool Prices[1] (2015 US$/MWh)	Average Liberalized Prices[2] (2015 US$/MWh)	Regulated Price[3] (2015 US$/MWh)
2005	76.6	67.2	56.1
2006	80.1	63.3	52.0
2007	43.4	62.0	49.7
2008	97.1	59.1	46.6
2009	35.6	60.8	57.4
2010	23.3	59.2	52.2
2011	25.1	59.2	51.7
2012	31.9	59.2	60.5
2013	27.0	55.4	48.9
2014	25.3	54.8	49.1
2015	14.7	54.5	58.6
2016	21.15	51.90	N/D
2017	9.22	46.93	N/D
2005-17	**-88%**	**-25%**	**5%**

[1]Average of wholesale energy prices in the power pool.
[2]Average of energy prices for liberalized customers.
[3]Average of energy prices for regulated customers. Data not available for years 2016-17.

Source: Worldbank

Monthly wholesale spot prices in Peru are volatile due to hydrological conditions and transmission congestions (see Figure 5-2). Volatility of monthly prices surged from 2001 to 2008, with the spot price reaching a monthly average of 235 USD/MWh in July of 2008, coinciding with low hydro generation.

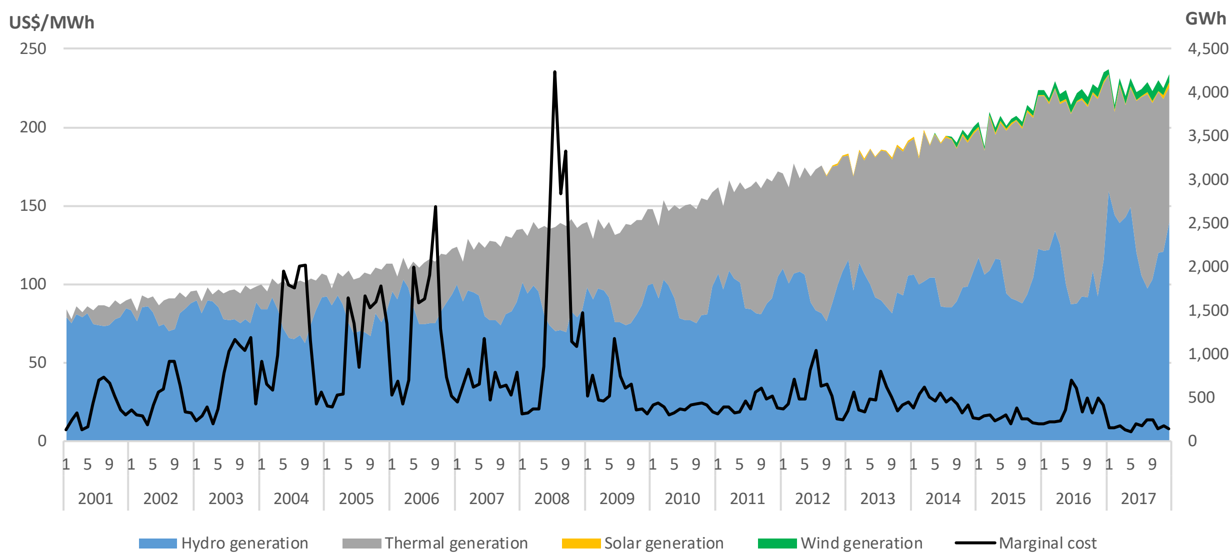

Figure 5-2 Evolution of monthly electricity prices and technology-wise generation in Peru, from 2001 to 2017.

Source: COES

As previously explained in section 3, from 2008 to 2017 the Peruvian power market was altered by disregarding transmission congestions in the calculation of marginal costs in the pool, thus lowering wholesale spot electricity prices. However, additional charges due to transmission congestions are levied upon retail customers. Furthermore, transmission losses have grown in the last decade up to 5.5% annual average (with respect to gross generation) in 2015, from 2% in 2005.

Market concentration has fallen steadily over the past decade in Peru, from 2,783 in 2005 to 1,509 in 2015 (see the Herfindahl-Hirschman Index evolution in Figure 5-3). Although competition has increased in the Peruvian power market, 68% of the market remains concentrated in four major actors as of 2017 (including government-owned power utilities) (OSINERGMIN, 2018).

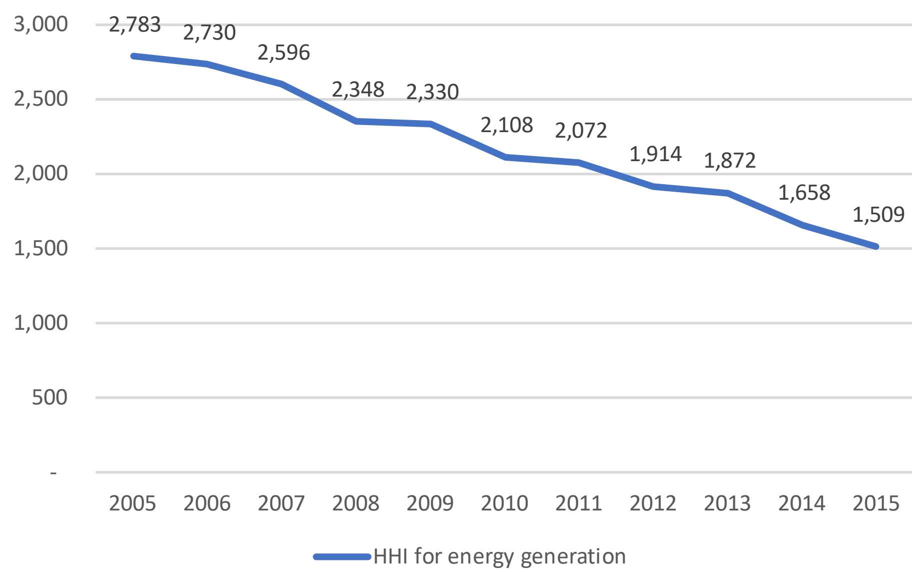

Figure 5-3 Evolution of the Herfindahl-Hirschman Index (HHI) for the Peruvian power market, in terms of energy output per company.

Source: Worldbank

5.2. Investment and security of supply

Over the past decade, installed generation capacity in Peru has grown from 4,790 MW in 2005 to 12,508 MW in 2017 (8.3% per annum), while peak demand has grown from 3,305 MW in 2005 to 6,596 MW in 2017 (5.9% per annum, see Figure 5-4). The reserve margin has therefore grown from 35% in 2005 to 81% in 2017. The reserve margin has steadily increased since 2011 due to the sustained growth in installed capacity, which outpaced the growth in peak demand.

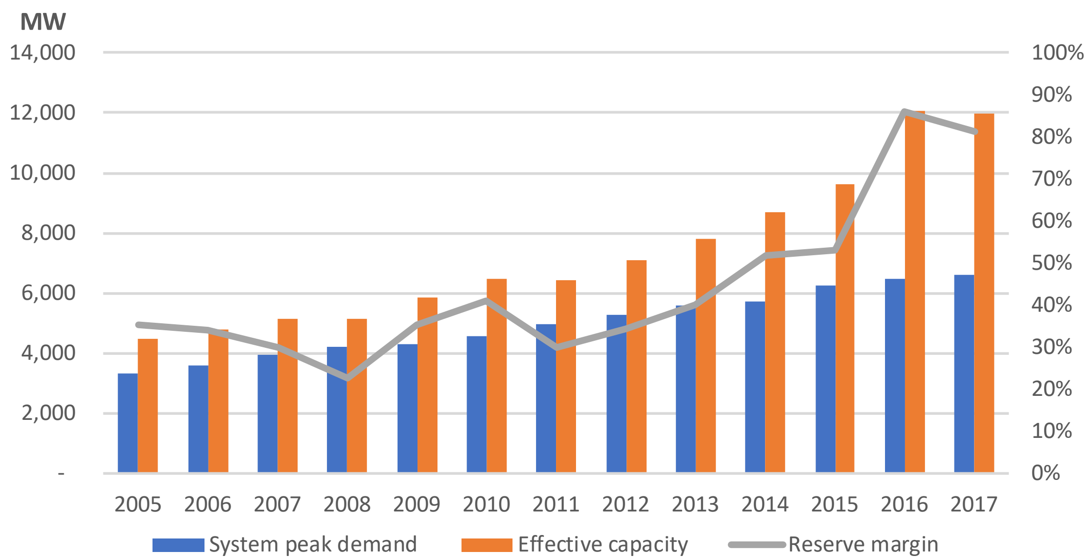

Figure 5-4 System adequacy in Peru: peak demand, installed capacity and reserve margin.

Source: COES

Generation capacity additions have been driven primarily by gas-fired power plants, which have increased by 3.7 GW, from 661 MW in 2005 to 4,384 MW in 2017 (see Figure 5-5). Over the same period, capacity additions have also been significant in hydro-powered (1.9 GW increase) and oil-fired plants (1.7 GW increase).

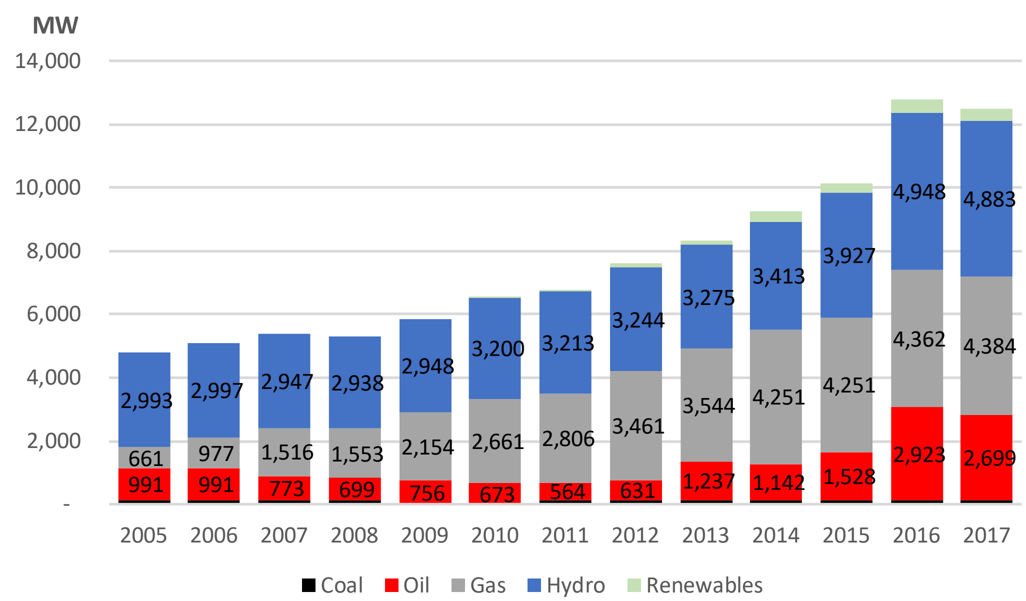

Figure 5-5 Evolution of technology-wise operational generation capacity in Peru.

Source: COES

Peru has historically lacked adequate power transmission capacity and has recently suffered from constraints on gas transport (see also section 4.2). Electricity transmission remained very weak until mandatory transmission planning and competitive bidding for new transmission projects was introduced. Supply restrictions and price spikes occurred during 2008 due to constraints on gas transport capacity from Camisea towards new generators.

Investments in power generation grew from US$ 235 million(m) in 2005 to US$ 1,829m in 2015 (22.8% per annum in real terms, inflation adjusted to 2015). A significant hike in generation investment occurred during 2011, when investment more than doubled from US$ 607m to US$ 1,307m. Generation investment remained at relatively high levels between 2010 and 2015, reaching about 70% of total investments in power infrastructure.

Investments in transmission infrastructure grew from US$ 35m in 2005 to US$ 341m in 2015 (29.6% per annum in real terms, inflation adjusted to 2015). Transmission investments quadrupled during 2009 to US$ 281m and reached a maximum of US$ 485m during 2012. Transmission investments grew from 5% of total investments in power infrastructure in 2005 to 13% in 2015.

5.3. Sustainability

The Peruvian power market has increased its reliance on fossil-fuels by substituting hydro-based power generation with gas-fired power generation supplied by domestic gas production, primarily from Camisea gas fields (see Figure 5-6 and section 2.2). Indeed, hydro supplied about 90% of the Peruvian electricity needs in the early 2000s. Since then, gas-fired generation increased its share of electricity supply from 17% in 2005 to 45% in 2015, while hydro generation lowered its share of electricity supply from 74% to 50% over the same period. Thermal generation (gas, coal and oil) accounted for 41% of power generation in 2017.

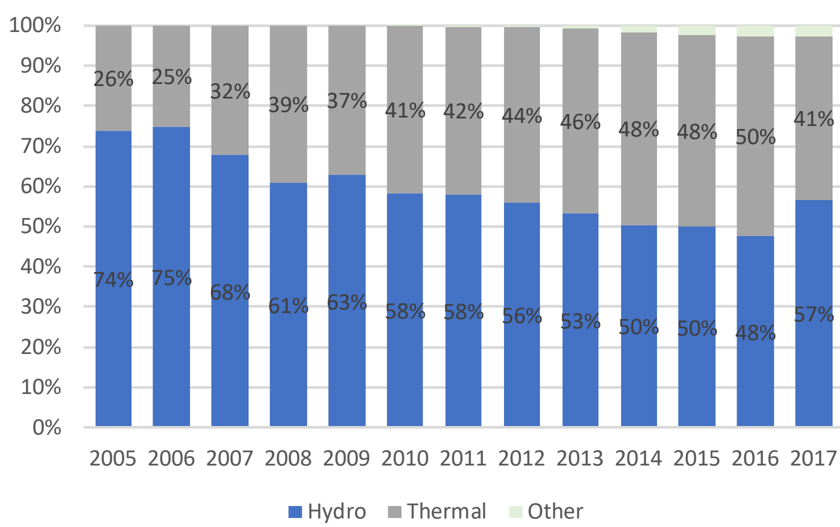

Figure 5-6 Evolution of technology-wise share of power generation in Peru.

Source: COES

Renewable generation has had modest but increasing contributions to power supply in Peru and is expected to continue growing in the future. Wind, solar and biomass power plants jointly contributed 2.8% of total net generation in Peru in 2017. Installed renewable generation capacity (other than hydro) increased up to 408 MW in 2017, with 243 MW of wind power, 96 MW of solar power and 69 MW of biomass power (see Figure 5-7). The share of renewable generation in Peru is expected to increase further, following the commissioning of new renewable generation facilities.

These and other expected renewable capacity additions have been driven by renewable auctions, which have resulted in total capacity additions by winning bidders of 537 MW of hydro power plants, 394 MW of wind power plants and 227 MW of solar power plants (see Table 5-2). Note that capacity additions awarded through auctions are yet to be fully materialized.

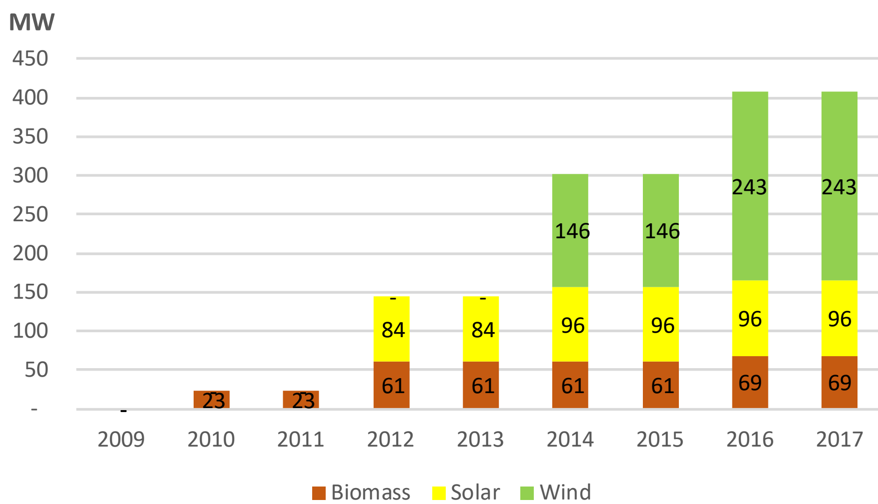

Figure 5-7 Evolution of renewable generation capacity in Peru (other than hydro).

Source: COES

Table 5-2 Capacity additions (MW) per technology in renewable auctions in Peru.

Auction	Solar	Wind	Hydro	Biomass
2009/10	27	142	180	14
2011	16	90	102	2
2013			211	
2015/16	184	162	80	4
Total	**227**	**394**	**573**	**20**

Source: Worldbank

Renewable energy (REG) auctions have successfully lowered energy prices for these projects in Peru (see Figure 5-8). The first REG auction was carried out in 2010 in two rounds, in February and August. In March 2011, before the second REG auction, the government approved upgraded regulations through DS Nº 012-2011-EM. Between 2011 and 2014, the second and third REG auctions were carried out. Finally, at the beginning of 2016 the latest, the fourth REG auction, was successfully completed. The last (fourth) auction showed record lower prices for solar and wind projects, in the order of US$ 48 per MWh and 37.7 US$/MWh, respectively. During the 6-years period of REG auctions, there have been project bid price reductions of 78% in solar power and of 53% in wind power. By the end of the fourth auction, a total of 66 projects have won bids (5 Biomass, 7 Wind, 7 Solar and 47 small hydroelectric); with a total installed capacity of 1,214 MW and 6,087 GWh of contracted energy.

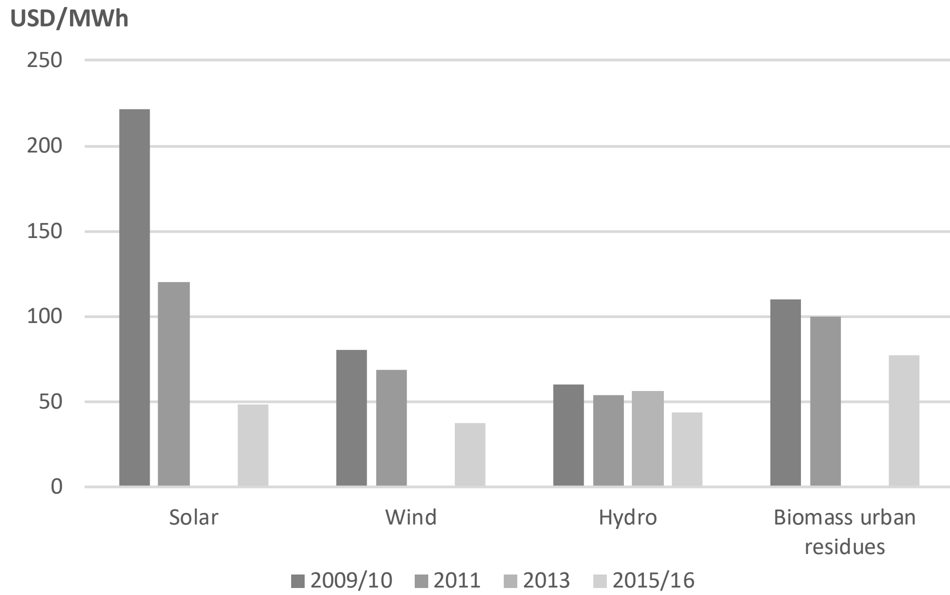

Figure 5-8 Evolution of average price of awarded renewable power projects in Peru.

Source: Worldbank

5.4. Summary

Table 5-3 summarizes the performance assessment of the Peruvian power market.

Table 5-3 Overview of power market outcomes in Peru.

Power Market Outcome Element	Peru outcome
Most relevant markets	1. Bilateral contract transactions. 2. Spot transactions between Gencos in the pool.
Evolution of prices and competition	• Wholesale spot prices have fallen by 88% in real terms over the past decade, from 77 US$/MWh in 2005 (yearly average, inflation adjusted to 2015) to 9 US$/MWh in 2017. • The average price of liberalized contracts has decreased by 25% in real terms over the past decade, from 63 US$/MWh in 2005 (inflation adjusted to 2015) to 57 US$/MWh in 2017. • Market concentration has fallen steadily over the past decade in Peru, from 2,783 in 2005 to 1,509 in 2017 (Herfindahl-Hirschman Index).

Power Market Outcome Element	Peru outcome
	• Renewable energy auctions have successfully lowered energy prices, by 78% for solar power and 53% for wind power (albeit amidst falling investment costs in these technologies).
Stressful events for power markets	• 2004-2005, droughts limit availability of hydro-powered generation, later motivating law 28836. • 2008, supply restrictions occurred due to constraints on gas transport capacity from Camisea gas fields towards new generators.
Evolution of investment and supply reliability	• The reserve margin in Peru has soared from 35% in 2005 to 81% in 2017, driven by generating capacity additions (growing at 8% per annum, with important investment in gas-fired power plants) which outpaced peak demand growth. • Investments in power generation grew from US$ 235 million in 2005 to US$ 1,829 million in 2015 (growing 23% per annum in real terms, inflation adjusted to 2015).
Evolution of sustainability	• Peru has increased its reliance on fossil-fuels for power generation by substituting hydro with gas-fired power generation (supplied in turn by domestic gas production). Hydro generation fell from about 90% of net generation in the early 2000's to 57% in 2017, while gas-fired generation contributed 45% of net generation in 2015 and thermal generation contributed 41% in 2017.

6. Conclusions on the Peruvian experience with power market reforms

Security of supply. The Peruvian government has improved security of power supply by diversifying power generation away from hydro and towards gas-fired generation. The government has pushed for the development of gas-fired generation, which increased from 17% of total generation in 2005 to 45% in 2015, while hydro generation provided 50% of the country's needs in 2015, down from about 90% in the early 2000s. Although the diversification of the energy mix mitigates the risks of low hydro availability, it also introduced risks in gas-fired generation due to constraints on the gas transport infrastructure. Moreover, these risks have been transferred directly to customers, for example by additional charges for financing the south gas pipeline.

Competition. The Peruvian power market is composed mainly by financial bilateral contracts and a spot cost-based power pool. Market concentration has fallen steadily due to increased competition, although 68% of the market remains concentrated in four players (including government-owned utilities). Increased competition, rapid capacity additions and sluggish demand growth over recent years have contributed to depressed wholesale and contract prices. The average price of liberalized contracts decreased by 25% in real terms over the past decade to 57 US$/MWh in 2017.

Besides market-driven forces, market adaptations have artificially lowered wholesale spot prices over the past decade. Indeed, in 2009, the power market was adapted by removing electricity and gas transmission constraints from the spot price formation process. The government further incentivized the development of domestic gas supply by forcing gas-fired power plants and financing a new gas pipeline to the south of the country. Additional costs of constraints and the forced investment in gas-fired power plants were passed-through directly to final customers, as additional charges bundled within transmission tolls. It is worth noting that the surcharge for financing the southern gas pipeline (Gasoducto Sur Peruano) ceased to exist in March 2017.

Moreover, Gencos with gas-fired power plants often declare zero fuel costs to ensure full dispatch and avoid operating losses, given the take-or-pay contracts for the supply of natural gas from the Camisea field. Coupled with new investments driven, for example, by competitive supply auctions for Discos, wholesale prices have fallen by 88% in real terms since 2005, down to 9 US$/MWh in 2017.

Because of zero fuel cost declared by gas-fired power plants and adaptations of the competitive power market, spot electricity prices may not be adequately reflecting the marginal value of electricity. This possible distortion in spot prices could be problematic both for signaling new generation investments in the future, and for competitively pricing electricity in the contracts market. Nonetheless, the government objective of developing gas-fired generation has been met.

Sustainability. Peru has moved from generating about 90% of its electricity with hydro generation in the early 2000s, towards relying more on gas, which accounted for 45% of total generation in 2015. Carbon emissions from the Peruvian power sector have therefore increased over the past decade. The country has pushed for investment in renewable energies by means of competitive auctions, achieving modest but increasing levels of renewable generation. These renewable energy auctions have successfully lowered energy prices in Peru, by 78% for solar power and 53% for wind power (albeit amid falling investment costs in these technologies). Wind, solar and biomass power plants jointly contributed 2.4% of total net generation in Peru in 2015. Installed renewable generation capacity (other than hydro) increased up to 303 MW in 2015.

7. References

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8. Annex A: Institutional indicators for the Peruvian power market

Based on information gathered and provided by the local consultant for this project, institutional indicators were developed and calculated in this study. Questions are aggregated in two levels (see Table 8-1). Level 2 indicators aggregate responses to individual questions by dividing the number of positive answers by the total number of questions. Level 1 indicators are the simple average of level 2 indicators.

Detailed results for Peru's power market institutional indicators are provided in Table 8-2 and Table 8-3.

Table 8-1 Structure of power market institutional indicators

Level 1	**Level 2**
Wholesale Market Design	Market Architecture
	Market Rules
Market Governance	Decision making Autonomy
	Transparency
	Accountability and Monitoring

Table 8-2 Detail of wholesale market design indicators for Peru. Source: own

Level	Peru score
Wholesale Market Design	**41%**
Market Architecture	**25%**
Is there a real-time or balancing market currently operational?	1
Is there a market for reserves currently operational?	0
Is there a market for ancillary services (other than balancing and reserves) currently operational?	0
Is there a market for transmission rights currently operational?	0
Is there a market for CO2 emissions permits currently operational?	0
Has retail competition been introduced?	0
Are there hedging instruments available to different market participants in order to manage risks?	1
Is there a demand response and load control program in place?	0
Market Rules	**57%**
Is there open access to distribution networks?	1
Do wholesale energy market prices have nodal spatial resolution?	1
Are there take-or-pay PPAs or other arrangements that distort reliable and efficient dispatch (e.g. compulsory dispatch of particular generators)?	1
Are reserves co-optimized with energy during the scheduling and dispatch process?	0
Is separate contracting for energy and network services allowed with transmission revenues separated from energy and other revenues?	0
Can the regulator review the details of bilateral contracts (which are often confidential)?	0
Are there mechanisms to enforce payments throughout the electric supply chain?	1

Table 8-3 Detail of wholesale market governance indicators for Peru. Source: own

Level	India score
Market Governance	**61%**
Decision Making Autonomy	**78%**
Is there an Independent System Operator (ISO), or Independent Transmission System Operator (ITSO)?	1
Does the system operator hold ultimate authority on real-time system operation (i.e. above market operator instructions or generator self-schedules)?	1
Does the board of the market (or system) operator allow one class vetoes (e.g. allowing a class of market participants to veto rule changes sought by other classes, thus producing deadlocks and impede changes to the system operator and its procedures)?	0
Is regulatory backstop allowed, whereby the regulator (or minister) can review, revoke or modify decisions taken by the board of the market (or system) operator?	1
Is the market (or system) operator legally independent from market participants and government?	0
Can the market (or system) operator decisions be appealed?	1
Are there regulatory requirements for the board members of the market (or system) operator to be independent from market participants and the government to prevent conflicts of interest?	1
Is there a formally established mechanism for dispute resolution among market participants?	1
Does the board of the market (or system) operator have real decision-making authority?	1
Transparency	**88%**
Are operation procedures publicly available?	1
Is bid data publicly available?	0
Are market prices publicly available?	1
Are dispatch quantities and schedules publicly available?	1
Is settlement information publicly available?	1
Are the grid code and all the operating procedures (including market clearing processes) publicly available to all interested parties?	1
Are there well-defined boundaries on acceptable market outcomes?	1
Is the form of regulatory intervention clarified in advance?	1
Accountability and Monitoring	**17%**
Is there an external overseeing or monitoring entity?	0
Can the external monitoring entity access information from system and market operation, including commercially sensitive and confidential information?	NAV
Does the external monitoring entity report to the board of directors of the operator?	0
Does the external monitoring entity report to the regulator?	0
Does the system operator report regularly to the regulator, and policy makers?	1
Was sufficient time (> 3 years) allowed for fully phasing in the operation of the wholesale power market?	NAV
During the transition to a wholesale power market were any measures taken to reduce market power in the generation segment?	0
Was any transition mechanism put in place to ensure a minimum degree revenue certainty for generators and acceptable degree of price risks for retailers?	0