

Republic of Peru

Yuncan Hydro Power Plant Construction Project (PAUCARTAMBO II)

External Evaluator : Global Group 21 Japan, Inc.

Hajime Sonoda

1. Project Description



Location of the Project



Yuncan Hydro Power Plant
(Underground Powerhouse)

1.1 Background

Peru in the 1990's was leaving a period of economic confusion as the Fujimori Administration was implementing economic stabilisation policies along with structural adjustment policies. In 1993, the public investment programme was formulated, and the government was promoting prioritised public investment in the rehabilitation and development of socioeconomic infrastructure.

In the power sector in Peru, hydropower generation accounted for 56% of the installed capacity and 77% of the electric energy generated in 1995. Meanwhile, the electrification rate of 62% was still low and Peru's power consumption per capita of 689 kWh was half of the average for Latin America. Under these circumstances, the government designated the power sector as a priority sector for economic development and the Ministry of Energy and Mines (MEM) prepared a Referential Plan of Electricity up to 2005. This programme predicted that the power consumption would increase at an annual rate of 5.0 ~ 5.5% from 1995 to 2008. To meet such extra power demand, a plan for expansion of generation capacity was formulated and the subject project for the present evaluation was listed as one of 10 new hydro power plants to be constructed during the period from 2000 to 2008.

The early study for the Project began in the 1960's. After review of the feasibility study conducted from 1976 to 1978, the MEM conducted the detailed design in 1981 to 1982. Based on the above-mentioned plan, the Government of Peru made a formal request for a yen loan for the Project in 1995. This was followed by signing of the Loan Agreement in 1996 and the implementation of the Project from 1996 to 2005.

For reference, the Yaupi Power Plant (PAUCARTAMBO I) which has a generating capacity of 108 MW and which has been operating since 1956 is located some 10 km downstream of the project site.

1.2 Project Outline

To provide a timely response to the increasing power demand in Peru by means of constructing an underground hydro power plant with an installed generating capacity of 126 MW (42 MW x 3) with intake facilities, headrace tunnels and transmission lines at some 200 km northeast of Lima in the upstream of the existing power plant (PAUCARTAMBO I) along Paucartambo River in the Pasco Region, thereby assisting the development of production infrastructure in the region and contributing to the development and vitalisation of the local economy and local communities.

Approved Loan Amount / Disbursed Loan Amount	¥33,000 million / ¥30,669million
Exchange of Notes/ Loan Agreement	August 1996 / September 1996
Terms and Conditions	Interest Rate : 2.7% (Consulting service : 2.3%) Repayment Period (Grace Period) : 25 years (7 years) Procurement : General Untied
Borrower / Implementing Agency	Government of the Republic of Peru / EGECEEN (since December 2009, ACTIVOSMINEROS) under the Ministry of Energy and Mines ¹
Final Disbursement	March 2008
Main Contractors (contract amount of ¥1 billion or more)	ALSTOM BRASIL LTDA.(Brazil) • ALSTOM POWER HYDRO(France)(JV), ALSTOM HOLDINGS(France) • Toshiba (Japan) • ALSTOM POWER HYDRAULIQUE SUCURSAL DEL PERU(France)(JV)、VA TECH HYDRO S.A.(Swiss)、Chizaki Industry(Japan) • COSAPI S.A.(Peru) • SKANSKA AB(Sweden)(JV)
Consultant (contract amount of ¥100 million or more)	J-POWER (EPDC) (Japan)
Feasibility Study (F/S)	Feasibility studies and detailed engineering studies were conducted by the Ministry of Energy and Mines during 1970 – 80s.

¹ The Project was originally supposed to be implemented by an implementing unit created in the Ministry of Energy and Mines, but in reality it was implemented by EGECEEN which was assigned the implementation of the Project. All the facilities of the Project is owned by the State through EGECEEN, which was created as a public company specialized in generation and sales of electric energy and merged with ACTIVOSMINEROS in December 2009. ACTIVOSMINEROS is a public company under FONAFE (*Fondo Nacional de Financiamiento de la Actividad Empresarial del Estado*: National Fund for Financing of State Company Activity). It undertakes environmental conservation / rehabilitation projects at the state owned lands such as mines and currently supervises the usufruct contract of the Yuncan Hydro Power Plant.

2. Outline of the Evaluation Study

2.1 External Evaluator

Hajime Sonoda (Global Group 21 Japan)

2.2 Duration of Evaluation Study

The ex-post evaluation study of the Project was conducted over the following period.

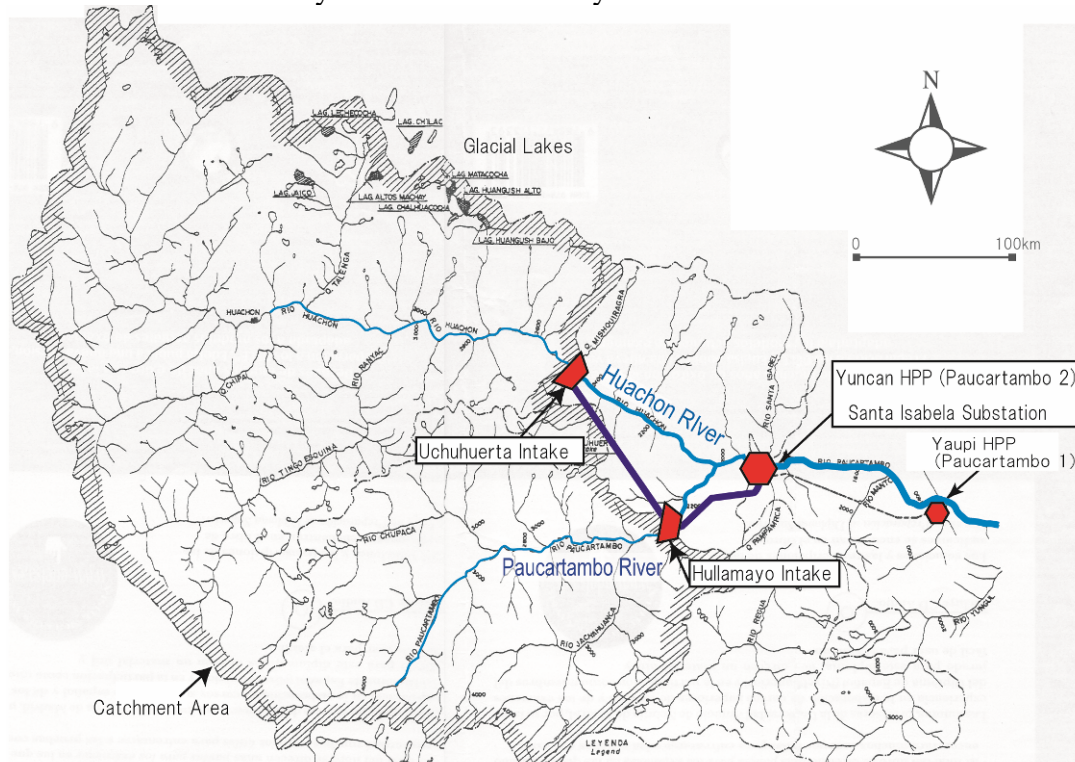
Study Period : September, 2009 to July, 2010

Field Survey : 14th November to 24th December, 2009
21st February to 16th March, 2010

2.3 Constraints during the Evaluation Study

During the course of the Study, vital information was collected through a series of interviews with the project implementing body and other stakeholder organizations, gathering of relevant documents, visits to the project site (power plant) and nearby area, interviews and workshops targeting local residents and a household survey. In areas where strained relations existed between the power plant management and opposing local residents, only interviews involving a small number of residents were conducted and neither a workshop nor the household survey were conducted to avoid unnecessarily inciting local residents.

Layout of the Yuncan Hydro Power Plant



3. Results of the Evaluation (Overall Rating: A)

3.1 Relevance (Rating: a)

3.1.1 Relevance with the Development Policies of Peru

As described in 1.1 - Background, the Project was included in the Referential Plan of Electricity based on the public investment policy of the Government of Peru and, as such, was highly compatible with the official development policy.

The primary objectives of the energy policies of the present government are (i) the rational utilisation of resources, (ii) reduction of external dependency, (iii) rationalization of energy prices that contribute to the strengthening of industrial competitiveness, and (iv) environmental conservation. As the power demand is expected to continually increase, the importance of the power sector in the overall economic development of Peru is expected to remain unchanged. However, there has been a shift in the priority of government investment since 1996 with policy emphasis on privatisation. To be more precise, the private sector has been increasing its investment in power generation, transmission and distribution (in urban areas) while government investment has been shifted its focus on rural electrification. The present government designates the promotion of rural electrification as a priority social policy, adopting a target of 90% electrification nationwide by 2011.

3.1.2 Relevance with the Development Needs of Peru

As described in 1.1 - Background, Peru's electrification rate and power consumption per capita in 1995 were low, making an increase of the power supply capacity an urgent task in the light of the anticipated continual increase of the power demand.

The current electrification rate and power consumption per capita in Peru are 80% (2007) and 1,010 kWh (2008) respectively. This level of power consumption per capita is still half of the Latin American average. There is much room for increase in terms of both the electrification rate and power consumption per capita, underlining the strong development needs in the power sector. The nationwide power demand in Peru increased at a high annual rate of 8.6% in the eight year period from 2000 to 2007 and the annual increase rate of 7.3% is expected to continue up to 2017. This situation of a continuous high power demand increase signifies a strong necessity for sustaining and the further development of the country's generating capacity.

3.1.3 Relevance with Japan's ODA Policy

The old ODA Charter of Japan adopted in 1992 stipulated that Japan would provide assistance for the development of infrastructure which is an important precondition for socioeconomic development. Around that time, Japan actively provided assistance to Peru in recognition of the positive reform efforts of the then Fujimori Administration since 1990 to ensure sustainable economic development and to eliminate poverty. In line with the diverse development needs in Peru, Japan decided to provide loans every year, in principle, from FY 1996 onwards with the qualitative as well as quantitative

enhancement of cooperation in mind. In FY 1999, the development of economic infrastructure was identified as a priority field for Japan's ODA for Peru and active cooperation for the power sector, etc. was called for, partly to respond to the local needs. Accordingly, the Project was compatible with Japan's ODA policies at the time of its appraisal.

Based on the above, the Project was sufficiently compatible with the development policies and development needs in Peru and also with the ODA policies of Japan. As such, relevance of the Project is high.

3.2 Efficiency (Rating: b)

3.2.1 Outputs

According to the plan put forward at the time of appraisal, the Project would consist of the following three components.

- ① Power plant component: This would include (i) the construction of an underground powerhouse (126 MW) along Paucartambo River, (ii) the Huallamayo intake facility on Paucartambo River, (iii) the Uchuhuerta intake facility on Huachón River and (iv) tunnels and headrace tunnels to link these intake facilities to the underground powerhouse. Both intake facilities would be provided with a reservoir for daily control of intake volume.
- ② Power transmission component: Some 130 km long transmission lines would be constructed to link the Yuncan HPP to the adjacent Santa Isabel Substation as well as the Oroya Nueva Substation and Carhuamayo Substation.
- ③ Others: Harnessing of two glacial lakes upstream². Procurement of maintenance equipment for waterways, discharge channels and roads would be procured. Consulting services for review of the detailed design and construction supervision.

The powerhouse component was completed almost as planned. The length of the tunnels and their construction method were modified through the process of reviewing the original detailed design, taking the actual geological and other conditions into consideration.

In the case of the transmission component, the introduction of expensive technologies of GIS (Gas Insulated Switchgear) to the Santa Isabel Substation was abandoned because government funding was restricted due to the fiscal difficulties experienced by the Government of Peru. Instead, conventional technologies were used. Furthermore, the construction of two new substations and part of one transmission line was removed from the scope of the Project and the work was conducted by a private transmission company (ISA PERU).

² Harnessing of the glacier lakes was expected to have the effect of some 4% increase of the electricity generated by the Project.

The glacial lakes were owned by a state mining company (CENTROMIN) under FONAFE³. In the process of its division and privatisation, a different organization from the project implementing body was assigned to manage these lakes. Subsequently, the work to harnessing these lakes under the Project was cancelled⁴.

Meanwhile, the procurement of maintenance equipment became unnecessary as ENERUR, a private company awarded the usufruct of the Project through the process of privatization, was already in possession of the necessary equipment.

Table-1 Comparison of Planned and Actual Project Outputs

<p><Power Plant Component></p> <ul style="list-style-type: none"> • Uchuhuerta Intake <ul style="list-style-type: none"> Intake dam Intake (max 20m³/sec.) Settling basin Tunnel No.1 (non pressure, 12.3km) Tunnel No.2 (pressure, 569.5m) • Huallamayo Intake <ul style="list-style-type: none"> Intake dam (hight 50m, capacity 1.8 million m³) Intake (max. 30 m³/sec.) Tunnel No.3 (pressure, 283.8m) Tunnel No. 4 (pressure, 7,036m) Surge tank Penstock line (784m) • Underground Powerhouse <ul style="list-style-type: none"> Tail Race Tunnel (976m) Outlets Turbine (43.3MW x 3 units) Generator (47MW x 3 units) Transformer (15.7MW x 10 units) <p><Power Transmission Component></p> <ul style="list-style-type: none"> • Transmission line (130km) • Substations <ul style="list-style-type: none"> Santa Isabel substation (construction) Oroya Nueva substation (expansion) Carhuamayo substation (expansion) <p><Others></p> <ul style="list-style-type: none"> • Harnessing of glacial lakes ; 2 lakes • Procurement of maintenance equipment for water canal, and access road • Consulting services 	<p><Power Plant Component></p> <ul style="list-style-type: none"> • Uchuhuerta Intake : as planned <ul style="list-style-type: none"> Intake dam : As planned Intake (max 20m³/sec.) : as planned Settling basin : as planned Tunnel No.1 (non pressure, 11.2km) : slightly shorter Tunnel No.2 (pressure, 1.6 km) : longer than planned • Huallamayo Intake : as planned <ul style="list-style-type: none"> Intake dam : (hight 60m, capacity 1.86million m³) : Slightly smaller in capacity Intake (max. 30 m³/sec.) : as planned Tunnel No.3 (pressure, 247.0m) : slightly shorter Tunnel No. 4 (pressure, 7,010m) : slightly shorter Surge tank : as planned Penstock line (709m) : shorter • Underground Powerhouse <ul style="list-style-type: none"> Tail Race Tunnel (869m) : slightly shorter Outlets : as planned Turbine (44.5MW x 3 units) : slightly larger Generator (48.2MW x 3 units) : slightly larger Transformer (48.2MW x 3 units) : slightly smaller <p><Power Transmission Component></p> <p>Part of the planned scope was excluded due to financial constraints and implemented by other funding. Transmission line was reduce to 50km; 80km was implemented by private sector.</p> <p>Santa Isabel substation (construction) : GIS→Conventional technology</p> <p>Oroya Nueva substation (expansion) : Out of scope (implemented by private sector)</p> <p>Carhuamayo substation (expansion) Out of scope (implemented by private sector)</p> <p><Others></p> <ul style="list-style-type: none"> • Harnessing of glacial lakes : cancelled • Procurement of maintenance equipment for water canal, and access road : cancelled • Consulting services : as planned
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³ Refer the footnote 1.

⁴ The organization assigned to manage these glacial lakes was ELECTROANDES, a specialist company responsible for the operation and maintenance of power plants in the mine areas in Central Peru and sale of generated electricity.



Uchuhuerta Reservoir and Intake



Hullamayo Reservoir and Intake



Santa Isabel Substation and Office Building

3.2.2 Project Inputs

3.2.2.1 Project Period

The original plan was to implement the Project in 82 months from February, 1996 to November, 2002. In reality, the Project was implemented in 108 months from September, 1996 to August, 2005. The overall project period was 132% of the

originally planned period and completion was delayed by two years and two months compared to the original plan. The main reasons for this delay are explained below.

- The procedures by the Ministry of Economy and Finance and MEM to approve the transfer of the concession of implementation EGECEM and to transfer the necessary funds took a long time to complete, delaying the commencement of the preparatory work and civil engineering work by one and a half years and one year respectively.
- Difficulties of the tunnelling work caused by seepage and collapse delayed the completion of the work.
- The commencement of the civil engineering work was delayed due to insufficient funding for the domestic currency portion and the restriction on the use of external fund caused by the tight government finance from 2000 to 2003. Moreover, delayed payment led to the suspension of the work, considerably prolonging the overall work period⁵. The work was ultimately completed as funding for the domestic currency portion was secured through a usufruct contract with a private company regarding the operation of the facilities to be constructed under the Project⁶.
- The work was temporarily suspended by the strike action of local residents demanding assistance for the development of local social infrastructure, as the short-term employment would end with the completion of the construction work⁷.

⁵ As for the transmission line work, the original contractor could not fulfill the contract due to its financial problem etc., making it necessary to find a new contractor. As a result, completion of the work was delayed till February, 2006 after commissioning of the power plant. However, no practical problems were experienced as another transmission line was temporarily used until the completion of the new transmission line of ELECTRO ANDES.

⁶ Because of funding difficulties faced by the Government of Peru, a possibility of discontinuation of the Project was examined in 2000. The Government of Peru made a proposal to continue the Project, as a part of privatization, by means of awarding an usufruct contract to a private company regarding the operation of the facilities to be constructed under the Project in return for the payment of an up-front fee by the said company. The materialisation of this proposal took several years because of (i) the incomplete state of the Project, (ii) the application of the social contribution system adopted by the Project being the first such application in Peru and (iii) initial opposition by local residents and local governments to privatisation. Finally, the usufruct contract for the operation of the project-related facilities was awarded to ENERSUR, a private power generating company with a power generating capacity of 1,030 MW in Peru (national share of 20%) in February, 2004. ENERSUR pays US\$ 205 million to EGECEM over a period of 17 years as a fee for the usufruct for 30 years and has a legal authority to sell electricity generated by the power plant even though the ultimate ownership of the facilities remains with the State through EGECEM, now ACTIVOS MINEROS. Because of a number of risks, there was only one bidder. Although the bid amount of US\$ 205 million is approximately half of the total investment amount, it exceeded the planned minimum price by the government. As the new power plant can expect to operate for at least 50 years with some additional investment, fund recovery operation can continue even after the contract period.

⁷ In response to the strike, EGECEM constructed schools, health post and water supply facilities in areas around the new power plant.

3.2.2.2 Project Cost

The planned project cost at the time of appraisal was approximately ¥44.0 billion (Yen loan : ¥33.0 billion) and the actual cost ended up at approximately ¥42.8 billion (Yen loan : ¥30.7 billion) which was within the original budget. The cost of the civil work increased by 31% compared to the original plan due to the increased cost of the tunnelling work and the prolongment of the construction work period caused by temporary suspensions and delays. In contrast, the overall procurement cost of the electrical and mechanical equipment dropped by 40% compared to the original plan due to competition. The actual spending for the transmission lines and substations ended up at 49% of the original plan as some of these facilities were removed from the scope of the Project or their specifications were altered. In contrast, the cost of the consulting service increased due to the prolongment of the project period.

The efficiency of the Project is evaluated as medium (ranking: b) as the actual project period was much longer than originally planned period even though the project cost was within the original budget.

Table 2 Planned and Actual Project Cost

(Unit: ¥ million)

	Planned at the Time of Appraisal			Actual		
	Foreign Currency Portion	Local Currency Portion	Total	Foreign Currency Portion	Local Currency Portion	Total
Civil Works	3,871	11,090	14,961	0	19,530	19,530
Electrical & Mechanical Equipment	9,135	2,643	11,778	3,824	1,904	5,728
General Administration	0	565	565	0	3,098	3,098
Land Acquisition	0	785	785	0	135	135
Customs Duties and Taxes	0	6,646	6,646	0	8,909	8,909
Consulting Service	1,897	709	2,606	3,443	0	3,443
Physical Contingency	1,490	2,244	3,734	32	0	32
Interest During Construction	2,922	0	2,922	1,936	0	1,936
Total	19,315	24,682	43,997	9,234	33,577	42,811

Foreign Exchange Rates: (at the time of appraisal) US\$ 1 = S/. 2.25 = ¥100.00
(at the time of evaluation) US\$1 = S/. 2.85 = ¥116.46

3.3 Effectiveness (Rating: a)

3.3.1 Quantitative Effects

3.3.1.1 Results from Operation and Effects Indicators

The Yuncan HPP regulates its level of electricity generation in accordance with commands given by the COES⁸ based in Lima and supplies electricity to the trunk

⁸ The COES (*Comité de Operación Económica del Sistema Eléctrico Interconectado Nacional*) is a private body which issues instructions on the amount of electric energy to be generated and other

transmission grid covering entire Peru (SEIN: accounting for 97% of the nationwide supply of electricity)⁹.

The operation of the Yuncan HPP has been fairly smooth with few unplanned outages. The availability ratio from 2006 to 2009 (i.e. the ratio of hours when the plant in a state capable of generating electricity) was as high as 97.5%. The effective output based on the generating test in 2005 was 136.7 MW which exceeded the planned output. The maximum output recorded so far was 137.8 MW (2009).

The average annual electric energy generated by the Yuncan HPP in the period from 2006 to 2009 was 800.3 GWh which is equivalent to 88.0% of the originally planned figure at the time of appraisal (910.1 GWh) or 88.9% of the planned figure at the time of the detailed design (901.2 GWh). The main reason for failure to achieve the planned level of generation was the instruction by the COES to restrict the electric energy generated by the Yuncan HPP. This is because an increase of the generating capacity of a nearby thermal power plant due to rehabilitation created a situation where the critical transmission capacity limit was reached at parts of the existing transmission grid. This problem should be solved by the end of 2010 as an on-going project by a private company in coordination with the MEM will expand the capacity of the transmission line involved. The decline of the electric energy generated was partly caused by the suspended operation of one of the two intake facilities due to its occupation by local residents from November, 2008 to January, 2009¹⁰. The actual utilisation rate of the natural river runoff of some 50% is lower than the planned 70%¹¹.



Transmission line
by the Project

matters to the SEIN and connected power plants in order to achieve economical and stable power supply.

⁹ The trunk transmission grid, i.e. National Electrical Interconnected Grid (SEIN: Sistema Eléctrico Interconectado Nacional), covers 98% of the electricity market in Peru. It was born in 2001 through the connection of the central north transmission grid (market share: 80%) to the southern transmission grid (market share: 17%). At the time of appraisal, the Project was expected to supply electricity to the central north transmission grid.

¹⁰ This incident is explained in detail in 3.4 - Impacts.

¹¹ The observation results for around the power plant indicate that the annual rainfall in 2006 through 2009 was within the normal range.

Table 3 Planned and Actual Figures for Indicators for Operation and Effects of the Yuncan Hydro Power Plant (Source : EGECEEN)

	Target at Time of - Appraisal - Detailed Design	2005 (-23 rd Aug.)	2006	2007	2008	2009
Availability Ratio	-	-	96.9%	98.6%	97.6%	96.7%
Maximum Output	126 MW 130.6 MW	132.3 MW	136.9 MW	136.6 MW	137.2 MW	137.8 MW
Electric Energy Generated	910.1 GWh 901.2 GWh	222.9 GWh	837.4 GWh	764.0 GWh	782.1 GWh	821.7 GWh

Source : EGECEEN

3.3.1.2 Results of Calculations of Internal Rate of Return (IRR)

At the time of appraisal, the financial internal rate of return (FIRR) of the Project was calculated to be 9.1% but the assumptions and process of this calculation are unknown to the evaluator. For this ex-post evaluation, the FIRR of the Project was recalculated based on the following assumptions. The resulting FIRR was 9.3%. No comparison with the earlier calculation results, i.e. 9.1%, is made here because of the possibility of the use of different calculation methods.

Project life : 50 years

Benefits : Income from electricity sales; the electric energy generated in 2010 is based on the average figure from 2006 to 2009 and the figures for 2011 onwards will be those had been planned in advance; the electricity sales price is the average price from 2006 to 2009.

Costs : Power plant construction cost and cost for operation and maintenance

While the Economic Internal Rate of Return (EIRR) had not been calculated at the time of appraisal, EIRR of the Project was estimated as 18.4% considering as benefit the opportunity cost saved by the Project, which is the cost for construction and power generation by a thermal power plant of similar size completed in the same period.

3.3.2 Qualitative Effects

The electricity generated by the Yuncan HPP is primarily used to cater for the base load¹². As the Yuncan HPP is located near the lead / zinc mines and the Lima Metropolitan Area, both of which are major power consumption areas, it can efficiently supply power with little transmission loss.

The water used for power generation by the Yuncan HPP is again used for power generation by the Yaupi HPP in the downstream along with water not used by the Yuncan HPP. Even though the Project has not directly contributed to an increase of the electric energy generated by the Yaupi HPP, the Yaupi HPP is now capable of quickly responding to power generation commands due to the fact that the river runoff in the downstream is controlled to a good extent by the Yuncan HPP.

¹² Demand for power fluctuates according to the time in a day and minimizes in early morning. Base load is the minimum demand for power that exists throughout a day.

Based on the above results, the effectiveness of the Project is evaluated as high as the anticipated effects have been mostly achieved as planned.

3.4 Impacts

3.4.1 Intended Impacts

The Project was expected to contribute to steady power supply nationwide through its connection to the trunk transmission grid (SEIN) in Peru as well as to the vitalisation of the economy and regional development through the development of the country's production infrastructure.

Some US\$ 2,900 million was invested for power generation in Peru from 1995 to 2008 and the generating capacity connected to SEIN increased by 1,962 MW. The Project, with an investment amount of US\$ 380 million and a generating capacity of 137 MW, contributed to this increase. As of 2008, the hydro power plant constructed under the Project accounts for 2.3% of the total generating capacity connected to the SEIN and 2.6% of the total power supply to the grid. Changes of the power supply situation during the period concerned are shown in Table 4.

Table 4 Changes of the Power Supply Situation in Peru

	1995	2008
Total power supply to SEIN	12,426 GWh	30,830 GWh
Effective generating capacity connected to the SEIN	2,861 MW	5,371 MW
Surplus generating capacity connected to the SEIN	809 MW	1,172 MW
National household electrification rate	64.9%	79.5%
Power consumption per capita per year	584 kWh	1,010 kWh

Note: Increase in effective generating capacity during 1995 – 2008 includes the increase realized by the investment by those who are not form the private sector. The surplus generating capacity is the difference between the effective generating capacity and the maximum power demand.

Source: Evolución de Indicadores del Mercado Eléctrico 1995 - 2008 (Ministry of Energy and Mines)

Since 1995, the effective generating capacity connected to the SEIN has continually been above the maximum power demand, providing a sufficient surplus generating capacity. As such, no planned outages have taken place. According to the MEM and COES, stable power supply will continue for the foreseeable future if the power generating projects currently in progress and at the planning stage are implemented as scheduled. The COES has stated that the frequency and voltage profiles have been improved due to (i) the addition of new generating capacity, including that by the

Project, (ii) rehabilitation of power plants of which the operation was frequently stopped because of deterioration and (iii) improvement of the transmission grid¹³.

The growth of the Peruvian economy accelerated in the second half of the 2000's and the annual growth rate in 2008 was as high as 9.8%. According to a World Bank document¹⁴, the investment environment in Peru is ranked 7th among 32 Central and South American countries. The main constraints for investors are the recruitment of workers and obtaining of construction permits/approvals. The power supply is good as the average number of outages per month is only 0.9 times which is one-third of the average number (2.68 times) in Latin America. This stable power supply situation in Peru is a contributory factor for economic growth through the promotion of investment. The Project is considered to have been contributing to this situation.

3.4.2 Other Positive and Negative Impacts

3.4.2.1 Relocation of and Compensation for Local Residents

The planned sites for the Santa Isabel Substation and reservoir under the Project, lands owned by EGECEM, were farmland with a number of private houses. The consent of some 70 households to evacuate their land and to relocate was obtained in January, 1996 prior to the commencement of the Project. At the substation site, 53 households were eligible for compensation and among which 25 households were relocated to a nearby settlement. At this settlement, the relocation of other 11 households was necessary as a result of land adjustment. The infrastructure at the settlement was improved with the construction of churches, a school, a health post and water supply and sewerage system. Vocational training was provided for 120 people. Work is currently in progress to grant land ownership to the relocated residents through the Municipality of Paucartambo.



Resettlement Site (Santa Anita)



Health Post Constructed at the Resettlement Site

¹³ In the period from 1995 to 2008, some US\$ 3,900 million was invested in improvement of the transmission and distribution grids, contributing to the reduction of the transmission and distribution loss (23.4% in 1995 to 10.1% in 2008) and improvement of the electrification rate and level of power consumption.

¹⁴ Doing Business in Peru, 2010 (World Bank)

A questionnaire survey with relocated residents found that many of them were satisfied with the swift completion of the relocation procedure, granting of land ownership and infrastructure development at the new settlement but were not necessarily satisfied with the level of compensation and changes of the living environments¹⁵.

3.4.2.2. Impacts on Socioeconomic Development in the Surrounding Area

A social survey conducted in the surrounding area of the power plant in Huachon District and Paucartambo District found that the following project-related activities produced favourable socioeconomic impacts¹⁶.



School Constructed by the Project

- Short-term employment for the construction work (some 1,500 people) and long-term employment for operation of the power plant (some 70 people)
- Civilian use of the access road (some 30 km long) constructed for the Project and construction camps
- Rural electrification utilising the transmission line installed for the implementation of the Project
- Improvement of the social infrastructure conducted as part of the Project to support the local community (public hall, school, health post, water supply system and others)
- Improvement of the social infrastructure (public hall, health post, telecommunication system and others) conducted as a contribution by the power plant in the post-project period and an agricultural production support project¹⁷

¹⁵ A questionnaire survey and group interviews were conducted with 25 households out of the 36 relocated households. As the site for the Santa Isabel Substation was originally owned by EGEN, local residents inhabiting the site did not have land ownership. The level of compensation was calculated for each household based on the value of the house and the number of trees owned. Some of the relocated residents are not satisfied with the new living environment, that is a cluster of smaller lots and more crowded than before, without fruit trees and home gardens that they used to have.

¹⁶ A questionnaire survey was conducted with 25 relocated households and 75 other households in the Huachon District and a workshop to which local residents were invited was held in six places. In the Paucartambo District where there was a strained relationship between some residents and ENERSUR only several local residents were interviewed individually to avoid any unnecessary provocation of these residents.

¹⁷ There are two typical types of social contribution by the Project. One is based on the usufruct contract with ENERSUR and the other is independently made by ENERSUR. An example of the former was the establishment by law of a NPO called the Yuncan Social Fund Association in March, 2008 to follow the social contribution activities conducted by two successive trust funds in the period from 2004 to 2008 (total contribution equivalent to US\$ 11.5 million). This NPO received the balance from the second trust fund of US\$1.0 million and is due to receive US\$ 10.8 million from ENERSUR by

At the settlement to which some residents were relocated and other nearby settlements, there has been a rush to rebuild houses using the compensation and income from project-related employment. As a result, the number of houses using durable building materials has increased, considerably changing the local landscape. Population inflow to these settlements after the commencement of the Project led to the opening of many shops and restaurants. After the completion of the Project, many shops closed down and the Project failed to produce a sustainable economic impact in this regard.

Both the water supply and sewerage service coverage and electrification rate in local settlements have much improved since the Project and the improvement of infrastructure by the Project has partly contributed to this. Some settlements now have a mobile telephone system under a social contribution project of ENERSUR.

The Project has proved to have benefited the local economy in which agriculture is the main player. Schools, health posts and public halls, all of which were constructed in connection with the Project, are also benefiting local communities. Moreover, the access road constructed for the Project that connects the two intakes has facilitated the development of farmland on the hillside and also made it easier to transport agricultural products. As a social contribution by the power plant, a large quantity of chemical fertiliser was distributed in 2008 and 2009, followed by the commencement of several projects to support agricultural production. However, no concrete results of such contribution to the agricultural sector have yet been observed.

3.4.2.3 Relationship Between the Yuncan Hydro Power Plant and Local Residents

Residents of the Paucartambo District who were dissatisfied with the slow progress of the social contribution projects of the power plant strongly demanded direct physical support (procurement and distribution of fertiliser) which was prohibited by law and violently occupied the intake facility of the power plant in August, 2009¹⁸. The government agreed to provide such support as an exceptional case to ensure continued power generating operation but in consequence ENERSUR suspended all other social

2022 based on the usufruct contract. In addition to this contribution, ENERSUR has spent some US\$ 4 million from 2005 to 2010 for its own social contribution projects.

¹⁸ According to the findings of the survey conducted in the surrounding area of the power plant and the opinions of ENERSUR, EGECEEN and MEM, the social contribution projects conducted in two districts using the second trust fund involved too many parties in the decision-making process. Moreover, these projects were required to follow a strict project supervision procedure similar to that applied to the execution of public investment projects. As a result, progress was very slow and many projects failed to produce sufficient results. Many others did not reach the implementation stage even though the preparatory study and planning stages were cleared. Such situation led to dissatisfaction and mistrust on the part of residents. In the Paucartambo District, one of the facilities was violently occupied in August, 2009 against the background of influence by a local politician and the nationwide social and political situation at the time. However, if genuine dialogue between ENERSUR and local residents is held in the months ahead, there is little possibility of a similar incident occurring. In the Huachon District, although a facility was peacefully occupied in October, 2008, a good relationship has been maintained in subsequent years, as local residents have given their consent to the contents of the social contribution activities proposed by ENERSUR.

contribution projects in the Paucartambo District thereafter. As of March, 2010, the strained relationship with local residents is still continuing.

Meanwhile, amidst the conflict with local residents, ENERSUR is maintaining its contact with representatives of residents and is examining a variety of social contribution activities, taking the demands of residents into consideration. ENERSUR plans to reopen full-scale dialogue with local residents regarding wide-ranging social contribution projects, including the introduction of a mobile telephone system and health post, the two projects for which the local demand is strong, and agricultural improvement. An activity starting in April, 2010 to promote school education will be used as an opportunity for this new initiative.

In contrast, more than 80% of the residents of the Huachon District where the relationship with the power plant is favourable have positively evaluated the construction of the power plant. Such positive evaluation is presumably the result of the improved infrastructure (construction of schools, health posts, water supply system and mobile telephone system), increased employment and commercial activities and assistance for agriculture with a number of social contribution projects under the Project.

3.4.2.4 Impacts on the Natural Environment around the Project Site

The environmental impact assessment conducted in 1982 confirmed that the Project would not affect the supply of clean water, living environment and local ecosystem and the Project was approved by the Department of the Environment. Subsequently in 1998, EGECEEN conducted a supplementary study in line with the new environmental protection regulations, which concluded in favour of the approval of the Project. Based on the recommendations of the said study, EGECEEN implemented environmental conservation measures during construction, and after the completion of the Project, ENERSUR is implementing an environmental monitoring program.

The environmental monitoring is conducted mainly on quantity and quality of river flow and the stability of the slopes at water reservoir and access roads. Though it had been pointed out that measures were needed to mitigate the collapses of slope due to soil erosion at a part of access road, as far as observed at the site inspection, their magnitudes are to be on the normally expected scale along the newly constructed access road and therefore judged not to be a serious problem. There is information that the trees along this access road were illegally cut at one time by unemployed local youths. Other than that no serious impacts on environment are reported.

The social survey conducted in the surrounding area of the power plant found that the majority of local residents believed that the types and quantities of the fish caught in the local river declined after the Project. As an environmental conservation measure, EGECEEN twice released in total 105 thousands fish seedlings. However, this did not achieve sufficient results as local residents failed to abide by the official guidance on controlled fishing activities.

An estimate by ENERSUR suggests that hydro power generation on the scale of the Yuncan HPP can avoid the discharge of some 400,000 tons of CO₂ a year compared to thermal power generation.

3.5 Sustainability (Rating: a)

3.5.1 Structural Aspects of Operation and Maintenance

ENERSUR has been awarded a usufruct contract to assume the entire operation of the power plant for a period of 30 years from September, 2005. ENERSUR operates the power plant from its control room in the capital of Lima in accordance with commands issued by the COES. Given the strained relationship with some local residents, the minimum number of maintenance staff is stationed at the power plant, while remote control from Lima has not encountered any problems. ENERSUR employs rural development experts (a sociologist and an agricultural expert) who plan and manage the social contribution activities in coordination with local residents and local administrations.

EGECEN owns the facilities constructed under the Project and supervises the operation of the power plant by ENERSUR in accordance with the terms of the usufruct contract. Apart from on-line monitoring of the state of operation, EGECEEN receives regular reports from ENERSUR and also conducts annual technical audit using an external contractor. In December, 2009, EGECEEN became part of ACTIVOSMINEROS but this merger has not caused any special problems as the responsibility for the operation of the power plant has been transferred to ENERSUR under the usufruct contract¹⁹.



Control Room in Lima

At the time of the commissioning of the power plant, ENERSUR controlled the operation of the underground power house and two intake facilities from the office building on the premises of the Santa Isabel Substation. After the peaceful occupation of an intake facility by residents of the Huachon District in November, 2008, a stand-by control room was set up in Lima for remote control of the operation in preparation for

¹⁹ Refer the footnote 1.

the occurrence of a similar incident. After the violent occupation of an intake facility by local residents of the Paucartambo District in August, 2009, ENERSUR immediately commenced remote controlled operation from Lima. At the same time, ENERSUR withdrew 17 employees, excluding four maintenance engineers, to Lima. The company plans to continue remote controlled operation even if the relationship with residents improves. However, the strength of the maintenance staff will be increased.

3.5.2 Technical Aspects of Operation and Maintenance

ENERSUR has implemented a series of measures to improve the efficiency of the operation and maintenance of the Yuncan HPP. These include, among others, (i) the introduction of a remote control system to operate the plant, (ii) the introduction of a remote video monitoring system to ensure safety and security at the Yuncan HPP and (iii) the introduction of software to assist the efficient planning of operation and maintenance. The technical audits conducted by EGEcen in 2006 through 2009 found that the availability ratio of the Yuncan HPP was high and that no serious problems existed with the operation and management. Given the contents of the various improvement measures and the high plant availability ratio, the technical standard of ENERSUR is judged to be sufficiently high.



Stock of Spare Parts at the Project Site

3.5.3 Financial Aspects of Operation and Maintenance

Under the usufruct contract for the Yuncan HPP, ENERSUR earns income from the sale of electricity generated. ENERSUR is responsible for the operation and maintenance of the Yuncan HPP and pays a total of US\$ 205 million to EGEcen up to 2022 as the usufruct fee. ENERSUR is allowed to make its own investment to improve the facilities of the Yuncan HPP but the ownership of these additional facilities will be transferred to EGEcen (now ACTIVOS MINEROS) when the contract comes to an end.

Table 5 Profit from Operation of Yuncan HPP and Overall Operating Profit for ENERSUR (Unit : US\$1,000)

	2007	2008	2009
Expenditure for usufruct fee	9,506	9,335	9,146
Operation and maintenance expenditure	926	1,531	1,108
Investment in improvement measures	697	733	349
Income from sale of electricity (Note)	26,555	54,631	25,173
Operational profit of Yuncan HPP	15,426	43,032	14,570
Overall operational profit of ENERSUR	107,893	159,326	NA

Note: The income from the sale of electricity is not directly linked to the electric energy generated as the market price of electricity fluctuates.

Sources: EGEcen and ENERSUR

As shown in Table 5, ENERSUR earns sufficient profit from the operation of the Yuncan HPP and no problems are anticipated for the company to secure a sufficient operation and maintenance budget. The overall operating profit of ENERSUR is sufficient, suggesting that there are no specific problems for the financial sustainability of the Yuncan HPP.

3.5.4 Current Status of Operation and Maintenance

Both the findings of the field survey and explanations given by ENERSUR indicate the good working order of all of the facilities of the Yuncan HPP. ENERSUR has introduced software designed to improve the efficiency of the operation and maintenance. Maintenance engineers in the field are conducting periodical inspection, preventive maintenance, repair and stocking as well as management of spare parts in accordance with the optimised maintenance programme.

Based on the above evaluation, the operation and maintenance of the Project presents no problems in terms of the institutional, technical and finance aspects. Accordingly, the sustainability of the positive effects produced by the Project is ranked high.

4. Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

The Project was included in the power development programme for the power sector which is one of the priority sectors of the Government of Peru for the economic development of the country. Because of the continual increase of the power demand, there is still a strong need for a further increase of the generating capacity. As the Project was compatible with Japan's ODA policies, its relevance is high. The scale of the generating capacity of the constructed Yuncan HPP is as planned and the overall project cost was also almost as planned. However, the completion of the Project was delayed by two years and eight months due to the delayed commencement of the construction work caused by the stringent government finance and several suspensions of the work. Accordingly, the efficiency of the Project is judged to be medium. The high operating rate of the Yuncan HPP and achievement of 90% of the originally planned generation of electric energy indicate the high level of effectiveness of the Project. There is a room for further increased generation of electric energy by the Yuncan HPP if the bottleneck in the transmission grid is resolved. This problem has occurred because the rehabilitation of another power plant has increased an overall power supply capacity to the grid. The social contribution activities implemented in connection with the Project have produced positive impacts on the socioeconomic development of the area surrounding the Yuncan HPP. Strained relations with local residents have emerged in one area and ENERSUR is continually trying to resolve the situation through dialogue. The facilities constructed under the Project are in good working condition and ENERSUR which is contracted to operate these facilities under the usufruct contract is believed to possess an adequate operation and maintenance management system, technical expertise and financial strength. As such, the sustainability of the Project is judged to be high.

Based on the above evaluation results, the overall ex-post evaluation status of the Project is very high.

4.2 Recommendations

4.2.1 Recommendations for the Government of Peru and the Project Implementing Body

- To further increase the effectiveness of the Project, it is necessary for the MEM to complete the transmission line expansion project in the section between Nueva Carhuamayo and Paragsha II as planned and thereby remove the constraint to the power generation.
- To ensure the smooth operation of the Yuncan HPP in the years to come, ENERSUR should continue its present efforts to alleviate the strained relations with residents in the Paucartambo District.

4.2.2 Recommendations for the JICA

None

4.3 Lessons Learned

With a hydro power plant construction project which does not directly benefit the surrounding area, direct assistance for the socioeconomic development of such an area can contribute to the establishment of a relationship of trust between the project and the local residents. However, the inadequate management of such social assistance can inadvertently cause dissatisfaction on the part of local residents, risking the emergence of conflict between the project and local residents. Accordingly, when social contribution activities are to be introduced to ensure the smooth progress of a project which does not directly benefit the surrounding area, it is essential to set up a suitable management regime to promptly implement priority activities.

Comparison Between the Original Plan and Actual Results

Item	Original	Actual
1. Outputs	<p><Power Plant Component></p> <ul style="list-style-type: none"> • Uchuhuerta Intake <ul style="list-style-type: none"> Intake dam Intake (max 20m³/sec.) Settling basin Tunnel No.1 (non pressure, 12.3km) Tunnel No.2 (pressure, 569.5m) • Huallamayo Intake <ul style="list-style-type: none"> Intake dam Intake (max. 30 m³/sec.) Tunnel No.3 (pressure, 283.8m) Tunnel No. 4 (pressure, 7,036m) Surge tank Penstock line (784m) • Underground Powerhouse <ul style="list-style-type: none"> Tail Race Tunnel (976m) Outlets Turbine (43.3MW x 3 units) Generator (47MW x 3 units) Transformer (15.7MW x 10 units) <p><Power Transmission Component></p> <ul style="list-style-type: none"> • Transmission line (130km) • Substations <ul style="list-style-type: none"> Santa Isabel substation (construction) Oroya Nueva substation (expansion) Carhuamayo substation (expansion) <p><Others></p> <ul style="list-style-type: none"> • Harnessing of glacial lakes ; 2 lakes • Procurement of maintenance equipment for water canal, and access road • Consulting services 	<p><Power Plant Component></p> <ul style="list-style-type: none"> • Uchuhuerta Intake : as planned <ul style="list-style-type: none"> Intake dam : As planned Intake (max 20m³/sec.) : as planned Settling basin : as planned Tunnel No.1 (non pressure, 11.2km) : slightly shorter Tunnel No.2 (pressure, 1.6 km) : longer than planned • Huallamayo Intake : as planned <ul style="list-style-type: none"> Intake dam : slightly smaller in capacity Intake (max. 30 m³/sec.) : as planned Tunnel No.3 (pressure, 247.0m) : slightly shorter Tunnel No. 4 (pressure, 7,010m) : slightly shorter Surge tank : as planned Penstock line (709m) : shorter • Underground Powerhouse <ul style="list-style-type: none"> Tail Race Tunnel (869m) : slightly shorter Outlets : as planned Turbine (44.5MW x 3 units) : slightly larger Generator (48.2MW x 3 units) : slightly larger Transformer (48.2MW x 3 units) : slightly smaller <p><Power Transmission Component></p> <p>Part of the planned scope was excluded due to financial constraints and implemented by other funding. Transmission line was reduce to 50km; 80km was implemented by private sector.</p> <ul style="list-style-type: none"> Santa Isabel substation (construction) : GIS→Conventional technology Oroya Nueva substation (expansion) : Out of scope (implemented by private sector) Carhuamayo substation (expansion) : Out of scope (implemented by private sector) <p><Others></p> <ul style="list-style-type: none"> • Harnessing of glacial lakes : cancelled • Procurement of maintenance equipment for water canal, and access road : cancelled • Consulting services : as planned
2. Project Period	February 1996 – November 2002 (80 months)	September 1996 – August 2008 (108 month)
3. Project Cost		
Foreign Currency	¥19,315 million	¥9,234 million
Local Currency	¥24,682 million (S/.555 million)	¥33,577 million (S/.957 million)
Total	¥43,997 million	¥42,811 million
of which JICA Loan	¥33,000 million	¥30,669 million
Exchange Rate	US\$1=S/.2.25=¥100 (September 1996)	US\$1=S/.2.85=¥116.5 (Weighted average during 1996 – 2005)