Republic of Costa Rica

Ex-Post Evaluation of Japanese ODA Loan

Pirris Hydroelectric Power Development Project

External Evaluator: Hiromi Suzuki S., IC Net Limited

0. Summary

The project aimed to improve the stability of electric supply capacity in Costa Rica by constructing a hydroelectric power plant in the middle stretches of the Pirris River which runs through the central plateau of the country.

The project was in line with Costa Rica's national development plans, development needs and Japan's assistance policies, both at the time of the appraisal and at the time of the ex-post evaluation. Therefore its relevance is high. The main indicators which reflect the effects of the Pirris Hydroelectric Power Plant (PHPP) have either mostly achieved its targets or are improving. In addition, in a country where hydroelectric power generation is the base load, the project has not only strengthened the hydroelectric generation capacity, but it has also contributed to a more stable electric supply capacity as well as to solving future electricity supply-demand gaps. These effects can be recognized as the PHPP is connected to the National Electricity System (SEN), through the Parrita-Lindora transmission line (230kV, 118km)[1] which was constructed as a separate project of the Executing Agency. Based on the above, the project effectiveness is evaluated to be satisfactory. In addition, other positive impacts were observed such as afforestation activities and effects from the construction of access roads, among others, thus the project's level of achievement of its intended effects and impacts is high. The efficiency of the project is evaluated to be low, because both project period and project cost significantly exceeded the plan. With regard to the sustainability of the effects of the project, no major problems have been observed in the institutional, technical and financial aspect of operation and maintenance, therefore sustainability of the project effect is high.

In light of the above, this project is evaluated to be satisfactory.

1. Project Description

Project Location

Pirris Hydroelectric Power Plant RCC[2] Dam
(provided by Costa Rican Institute of Electricity, ICE)

[1] From the time of appraisal, the construction of the Parrita-Lindora transmission line was a precondition for the realization of the effects of the project.

[2] RCC (Rolled Compacted Concrete) is an extremely stiff consistency concrete with less amount of cement. Because it is possible to place large amounts of concrete at once, it has the advantages of shorter construction periods and less construction costs, characteristics that make it a reasonable construction method (Reference: Website of the Japan Concrete Institute and the Japan Dam Foundation).

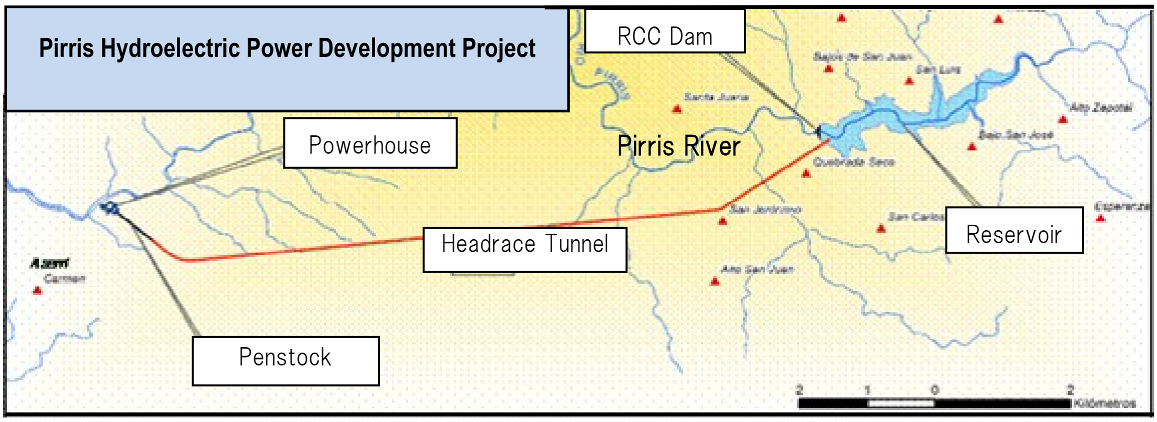
1.1 Background[3]

Costa Rica was one of the most politically stable countries in Central America, and it was achieving a high economic growth especially under the "National Development Plan 1994-1998", which attracted high-tech industries and increased exports based on the establishment of tax-free processing zones. On the other hand, in order to continue with the National Development Plan and to maintain a sustainable economic growth, it was imperative to develop economic and social infrastructure including power sources. Especially in regard to electricity demand, it was increasing year by year as the economy grew, and it was estimated to continue increasing by an annual rate of 5.7% until 2020. Thus there was a pressing need to improve the reliability of a stable electric power supply.

Electricity in Costa Rica was supplied mainly by the Costa Rican Institute of Electricity (ICE), who was developing electric power sources by utilizing the country's water and geothermal resources. In particular, hydroelectric power generation accounted for three-quarters of the total electric power supply and was considered to be the country's base load. In 2001, the country did maintain the necessary power generation infrastructure to cover the power demand, but it would soon become difficult to fill the electricity demand-supply gap which was estimated to occur from 2006 onwards, thus it was urgent to take specific actions.

1.2 Project Outline

The objective of this project is to improve the stability of electric supply capacity in Costa Rica by constructing a hydroelectric power plant with a 128MW generation capacity in the middle stretches of the Pirris River which runs through the central plateau, located 70km to the south of San Jose, the capital of the country, thereby contributing to solving the future electricity demand-supply gap and to improving the hydroelectric power generation capacity which is the base load of the country.



Source: ICE

Figure 1: Pirris Hydroelectric Power Development Project

3 Based on JICA's appraisal documents and press releases.

Loan Approved Amount/ Disbursed Amount	16,683 million yen / 16,402 million yen
Exchange of Notes Date/ Loan Agreement Signing Date	April 2001 / April 2001
Terms and Conditions	Interest Rate: 2.2% Repayment Period: 25 years (Grace Period: 7 years) Conditions for Procurement: General Untied
Borrower / Executing Agency	Instituto Costarricense de Electricidad (ICE)
Final Disbursement Date	October 2011
Main Contractors (Over 1 billion yen)	Holcim (Costa Rica) / Toxement (Costa Rica) (JV), Astaldi Spa. (Italy), Andritz Hydro Gmbh (Austria)
Main Consultant (Over 1 million yen)	Electric Power Development Co., Ltd. (Japan)
Feasibility Studies, etc.	1992: "Pirris Hydroelectric Power Development Study Plan" (JICA) 1998: "Pirris Hydroelectric Power Basic Design Plan" (ICE)
Related Projects	[Japanese ODA Loan] "Miravalles Geothermal Power" (Completed in March 1994); "Geothermal Sector Loan Enforcement Promotion Project in Costa Rica" (Loan Agreement: August 2014) [Other Donors' Projects] Inter-American Development Bank "Angostura Hydroelectric Project" (Completed in October 2000)

2. Outline of the Evaluation Study

2.1 External Evaluator

Hiromi SUZUKI S. (IC Net Limited)

2.2 Duration of Evaluation Study

Duration of the Study: September 2013-November 2014

Duration of the Field Study: November 24- 29, 2013 and April 20-23, 2014

3. Results of the Evaluation (Overall Rating: B[4])

3.1 Relevance (Rating: ③[5])

3.1.1 Relevance to the Development Plan of Costa Rica

3.1.1.1 Relevance to the Development Plan at the Time of Appraisal

The development plan at the time of the appraisal was the "National Development Plan (1998-2002)" formulated by the Ministry of National Panning and Economic Policy (MIDEPLAN). Development of social infrastructure, including electric power, improvement of public services, and sustainable utilization of natural resources were among the 15 development objectives of the said Plan. With regard to the electric power sector, in order to respond to the growing electricity demand, which was estimated to increase steadily, the Ministry of Energy (MINAE) formulated the "Third National Energy Plan (2000-2020)". The Plan required that ICE, which was the entity in charge for electric power supply in Costa Rica[6], formulate a concrete Electric Power Development Plan, so as to fill the future demand-supply gap. Based on these Plans, ICE formulated the "Electric Power Development Plan (2012-2024)" which planned to construct 29 electric power plants by 2020, in order to fill the above-mentioned demand-supply gap. Specifically, this project (Pirris Hydroelectric Power Plant, 128MW) was the second largest project after the Angostura Hydropower Plant (Starting of operations: 2000, 177MW) and it was considered as one of the most important national projects.

3.1.1.2 Relevance to the Development Plan at the Time of Ex-Post Evaluation

The development plan at the time of the ex-post evaluation was the "National Development Plan 2010-2014". In the energy sector, its purpose is to "protect the environment and achieve sustainable development", and seeks also to achieve "Carbon neutrality" which offsets greenhouse gas emissions with absorptions by 2021 through the development of clean energy sources such as hydro and geothermal power. Based on the said National Development Plan, MINAE formulated the "Sixth National Energy Plan (2012-2030)" in which electricity demand is expected to continue growing as a result of Costa Rica's economic growth estimations and improvement in the living of standards of its people. In order to cope with this growth, the said Plan targets the development of renewable, low-cost energy sources; restrain negative effects to the environment as much as possible; and improve health and living standards of the people of Costa Rica. ICE formulated the "Electric Power Development Plan (2012-2024)" based on the above plans, in which aims to secure a stable electricity supply, reduce dependence to fossil fuels and reduce greenhouse gas emissions. In addition, while hydroelectric

4 A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

5 ③: High, ②: Fair, ①: Low

6 Costa Rica's electricity sector is called "National Electric System (SEN)". Companies engaged on power generation, besides ICE, who accounts for 70% of the total power generation capacity, are CNFL -an ICE subsidiary-, Rural Electrification Cooperatives (four), Public Electric Companies (two), and a private company. ICE is the only company engaged in transmission, and companies engaged in distribution are ICE, CNFL, Rural Electrification Cooperatives (four) and Public Electric Companies (two).

power generation continues to be the country's base load, it also seeks to achieve the ideal balance between hydro, wind, and geothermal energy[7].

As stated above, both at the time of appraisal and the ex-post evaluation, Costa Rica's National Development Plans, National Energy Plans, and ICE's Electric Power Development Plans consider filling the electricity demand-supply gap and achieving a stable supply of electric power as their development objectives. It also continues to put emphasis on renewable energies including hydroelectricity -which utilizes the country's own natural resources- to achieve these goals. In this sense, the project is highly relevant to Costa Rica's development policies both at the time of appraisal and the ex-post evaluation.

3.1.2 Relevance to the Development Needs of Costa Rica

3.1.2.1. Development Needs at the Time of Appraisal

At the time of appraisal, electricity demand in Costa Rica was growing year by year. Actual electricity demand grew by an annual average of 5.5% between 1985 and 1997, and by 6.5% between 1998 and 2000. Furthermore, electricity demand was expected to grow by 2020 at an annual average rate of 5.7%, mostly due to the advance of high-tech industries into the country. On the other hand, according to the construction plans of new power generation plants and renovation of existing obsolete power plants that existed at the time, it was estimated that after 2006, it would not be possible to secure a stable electric power supply. In addition, with ICE's limited budget, it was deemed difficult to construct the 29 power generation plants that were planned to be completed by 2020 according to the Electric Power Development Plan, and to simultaneously conduct the necessary construction of transmission facilities in a prompt manner. Thus it was necessary to take urgent measures to secure a stable supply of electricity.

ICE's power generation capacity by the end of 2000 was 1,470MW (hydro 1,098MW (75%), thermal 234MW (16%), geothermal 137MW (9%)), and electric power generation capacity (MW) was above electricity demand. However, Costa Rica has a tropical wet and dry climate in which there is a serious lack of water during the months of December to April, which is the dry season. Because the energy source for hydroelectric power generation drops dramatically during this period, there was a risk of a serious demand-supply gap during the peak periods of the dry season (February to April), which could cause a decrease in the reliability of a stable electric power supply. Although the lack of capacity in electric power supply was served by thermal power generation, Costa Rica does not have fuel for thermal power generation, making it necessary to rely on imports. However, an over-dependence on thermal power generation was not in line with the country's development plans. Therefore, if measures were not taken, there was a risk of an increased dependence on fuel imports from 2007, which was a major concern for ICE. Under these circumstances, the need to develop a hydroelectric power plant with a dam that utilizes national water resources was extremely high in

[7] At the time of the ex post evaluation, among the power generation plants that ICE was putting emphasis on, were included the hydroelectric power plants of Reventazón (292 MW), Diquis (623 MW), Tacares (7MW), and Savegre (160MW).

order to both increase the county's electric power supply capacity and improve the stability of such capacity[8].

3.1.2.2. Development Needs at the Time of Evaluation

Costa Rica's electricity demand grew at an annual average rate of 2.9% from 2009 to 2012, which was not as high as it was expected at the time of appraisal, mainly due to the global financial crisis which was caused by the 2008 Lehman Shock, but is on a stable upward trend. According to the most recent electricity demand estimations announced in 2011 by the National Energy Planning Center (CENPE), the entity that makes such estimations, the annual average electricity demand growth rate by 2024 will be 4% and the estimated demand is 18,148GWh. As can be seen, the development need of securing a stable power supply for the future continues to exist. ICE's power generation capacity in 2011 was 2,590MW, which was more than the electricity demand of 1,598MW. However, the marginal supply capability[9] was 7%, failing to achieve the criteria of 8%-10% that secures a stable electric power supply, making it necessary to continue strengthening such capacity. Based on CENPE's demand estimates, in its "Electric Power Generation Plan (2012-2024), ICE is planning to increase the participation of hydropower generation capacity from 65% to 72% as shown in the table below, thereby increasing the total power generation capacity to 4,304MW by 2024, corresponding to an estimated demand of 2,962MW.

Table 1: Electricity power demand, supply and power generation capacity in Costa Rica

		2011 Actual		2024 Estimation / Plan	
Electricity demand		1,598MW		2,962MW	
Total Power Generation Capacity		2,590MW	100%	4,304MW	100%
	Hydro	1,691 MW	65%	3,099MW	72%
	Wind	129 MW	5%	301MW	7%
	Geothermal/Biomass	234 MW	9%	344MW	8%
	Thermal	537 MW	21%	560MW	13%

Source: CENPE (2011) "Electricity Demand 2011-2033" and ICE "Electric Power Development Plan (2012-2024)"

As stated above, electricity demand continues to grow in Costa Rica and the development need to strengthen power generation by using water, which is one of its natural resources in order to secure a stable electric supply capacity can be recognized at the moment of the ex-post evaluation as well.

3.1.3 Relevance to Japan's ODA Policy

Japan's assistance policy towards Costa Rica was not formulated at the time of appraisal.

[8] Besides this project, ICE has conducted the "Miravalles Geothermal Power Plant Development Project" (Japanese ODA loan project, completed in March 1994, 55MW) and the Inter-American Development Band funded "Angostura Hydroelectric Project" (starting operations in October 2000, 177MW), actively promoting the development of renewable power sources that would not depend on imported resources.

[9] The marginal supply capability is an indicator that shows the excess supply capacity against electricity demand. [(Peak supply capacity – estimated maximum demand) / estimated maximum demand] x 100. Ordinary, it is considered to be from 8% to 10% (Reference: Website of the Ministry of Economy).

Therefore, for the ex-post evaluation, the consistency of the project was checked with JICA's "Medium-Term Strategy for Overseas Economic Cooperation Operations (1999-2002)", which was formulated based on the basic strategies and policies of Japan's Official Development Assistance (ODA). The said Strategy's main objective is to reduce poverty in developing countries. It also aims to achieve a sustainable economic growth through the development of economic and social infrastructure and creation of industries; and to support a fair distribution of the fruits of economic development through poverty alleviation and social development measures. Based on these objectives, it established six focus areas that included strengthening of infrastructure for production and environmental protection measures. With regards to assistance strategies towards Central and South America, it focused on the development of infrastructure for the alleviation of income disparities as well as regional disparities. It also planned to actively assist projects that would contribute to the preservation of regional environment, as well as projects that were aiming to solve global environmental problems. In light of the above, the project is consistent with the Japanese Government assistance sectorial strategy as well as with the assistance strategy towards Central and South America[10].

This project has been highly relevant with the development plans and development needs of Costa Rica, as well as Japan's ODA policy. Therefore its relevance is high.

3.2 Effectiveness[11] (Rating: ③)

3.2.1 Quantitative Effects (Operation and Effect Indicators)

With respect to the project's operation indicators, evaluation was conducted based on the indicators for which targets were set at the time of appraisal, as well as indicators that are used as main indicators by ICE that have internally set targets. The target year is 2013 which is two years after the project was concluded. In the table below, actual data and their target achievement levels for 2011 and 2012 are also indicated for reference. In order to conduct the evaluation of the project's operation and effect indicators, it is necessary to consider the role that the PHPP plays in Costa Rica's SEN. Hydroelectric power plants have some advantages over other plants such as the ability to operate not only during dry season, and to quickly respond when sudden increases in electricity demand occur. In addition, time necessary to restart the plant after stopping operations is only a few minutes compared to thermal power plants[12], which enables hydroelectric power plants to immediately supply electricity in case of an emergency[13].

All four operation indicators have either achieved more than 80% of the target, or have achieved

[10] With the objective of contributing to Costa Rica's sustainable growth by increasing electric supply capacity, as well as by easing climate change effects through the promotion of renewable energy, the Loan Agreement of the "Guanacaste Geothermal Development Sector Loan" (ODA loan amount 16,810 million yen) was signed on August 18, 2014 between the Government of Japan and the Government of Costa Rica.

[11] Sub-rating for Effectiveness is to be put with consideration to impact.

[12] Thermal generation plants require from more than 15 minutes to few hours to restart operations.

[13] According to ICE, when PHPP is compared with other hydroelectric plants in Costa Rica, PHPP has the following two characteristics that strengthen its backup role: (1) Pelton turbines that make it especially easy to start and stop operations and can automatically adjust to changes in voltage, and (2) emergency power generators that enable it to restart operations in case of emergency, without having to depend on other power plants.

the target in 2013, which is two years after the project was completed. As mentioned above, when the backup role for electric power supply capacity is taken into consideration, the "Operability Factor" which indicates the probability of the power plant to be in a state that can be operated, as well as the "Reliability Factor" which indicates the probability that a power plant does not fall into a forced outage condition, are important indicators. In this project, both indicators have achieved their targets. Since periodical inspections are conducted properly, non-planned outage hours have improved to less than a quarter of the target.

Table 2: Operation and Effect Indicators

Name of Indicator	Target Value Two years after project completion	Actual Value (Target achievement levels are indicated within parenthesis)		
		2011 Project completion year	2012 (One year after project completion)	2013 (Two years after project completion)
Operation Indicators				
1. Operability Factor[1]	ICE Target 100%	—	94.6% More than 80% of target	92.8% More than 80% of target
2. Reliability Factor[1]	ICE Target 100%		99.5% More than 80% of target	99.6% More than 80% of target
3. Hydro Utilization Factor[2]	90%	80% (Aug. to Dec.) (88%) More than 80% of target	89% (99%) Target almost achieved	84% (93%) More than 80% of target
4. Non-planned Outage Hours[3] (Due to mechanical problems)	Annual Total Maximum: 175 hours	118.2 (Improved to 65% of target) Target Achieved	195.4 (Over 20 hours of target) Target Not Achieved	42.0 (Improved to 24% of target) Target Achieved
5. Planned Outage Hours[4]	Reference: 525 hours /year	609.6	759.9	1,219.7
Effect Indicators				
6. Net Electric Energy Production (GWh/year)	571	312.5 (55%) Target Not Achieved	499.2 (87%) More than 80% of target	446.2 (78%) Target Not Achieved
<Reference Indicators> Annual Total Volume of Inflow to the Reservoir (million m^3/year)	310.3 [5]	144.7 (47%)	231.1 (74%)	158.3 (51%)
7. National Electricity Consumption[6] (MWh)	Preferable to be in an upward trend	8,601,761	8,914,576	9,006,031
8. Electrification Rate (%)	More than 94.8% (Actual for 2000)	99.3% More than reference value	99.4% More than reference value	99.4% More than reference value

Source: JICA Appraisal documents, ICE.

1: "Operability Factor (probability that a plant is in operable conditions throughout a year, based on actual operation records)" and "Reliability Factor (probability that a plant does not suffer forced outages throughout a year)" are indicators used commonly by ICE as operation indicators. Since a hydroelectric power plant that is linked to the national system plays the role as a backup plant as well, these indicators were considered relevant to be included in the evaluation as quantitative indicators.

2: Hydro Utilization Factor is based on ICE's definition. Hydro Utilization Factor = (Annual Volume of Electricity Generation (GWh) ÷Annual Potential Volume of Electricity Generation (GWh)) x100. Where "Annual Potential Volume of Electricity Generation" is the sum of the values of the "Weekly Potential Volume of Electricity Generation" for 52 weeks; and Weekly Potential Volume of Electricity Generation (GWh) = [weekly average inflow (m^3/s) x power generation factor (7.4932MW/(m^3/s))x168 hours÷1000]

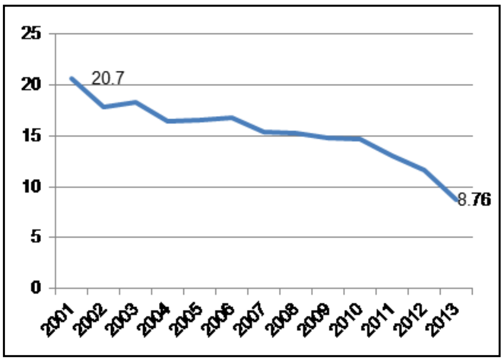
3: Non-planned outages can be caused by (1) machine failure, (2) human error, and (3) natural disasters, among others. There were no non-planned outages caused by (2) and (3), thus the total value indicated in the table is due totally to machine failure.

4: Reference indicator. Non-achievement of the target does not necessarily result in a low evaluation.

5: Estimation of the annual total volume of inflow to the reservoir used in the Detailed Design.

6: Reference indicator. There is no target value set, as it is not appropriate to do so separately from the value of the demand forecasted within the Electric Development Plan.

Annual planned outage hours were verified as an indicator that reflects the improvement in the stability of electric supply capacity. While in 2001 the value was 20.7 hours, in 2013 it decreased considerably to 8.76 hours. Compared to the time of appraisal, it can be seen that stability of electric supply in the national system has absolutely improved (Figure 2).



Source: ICE

Figure 2: Annual planned outage hours

With respect to the effect indicators, the only one for which a target was set at the time of appraisal was the Net Electric Energy Production, which has failed to meet the target from 2011 to 2013. The main reason is that due to the reduction in rainfall seen in recent years, the Annual Total Volume of Inflow to the Reservoir has significantly decreased respectively to 47%, 74% and 51% of the Annual Total Volume of Inflow to the Reservoir estimated in the Detailed Design (310.3 million m^3/year). National amount of electricity consumption is on an upward trend, and Electrification Rate has considerably increased from 94.8%, which was the reference value for the year 2000, to 99.4% in 2013.

From the above, among the six indicators for which either target values or reference values were set, the only indicator that did not achieve its target in 2013 was the Net Electric Energy Production. The rest of the indicators have either achieved more than 80% of the target or have achieved the target, thus quantitative effects of the project can clearly be recognized.

3.2.2 Qualitative Effects

The qualitative effects of the project expected at the time of appraisal can be considered as effects at the project impact level, and thus these were analyzed under “Section 3.3 Impact”.

3.3 Impact

3.3.1 Intended Impacts

The expected impacts of the project were: improving hydroelectric power generation capacity, filling the future demand-supply gap, improving investment environment as well as increasing the potential for economic development, through the construction of the power plant.

3.3.1.1 Improving Costa Rica’s hydropower generation capacity and filling the future demand-supply gap

As mentioned above, according to CENPE’s most recent demand estimation, electricity demand will grow at an annual average rate of 4% by 2024, and estimated amount of electricity demand will be 18,148 GWh, indicating that a stable supply of electricity will continue to be necessary (for details see “3.1.2.2 Development Needs at the Time of the Evaluation”) . Improving ICE’s capacity of hydroelectric power generation, which accounts for 70% of the total power generation capacity as well as the total volume of electricity generated for Costa Rica's SEN, means a stable supply of electricity for the country. The PHPP, which was completed in 2011, is connected to the national system through the Parrita-Lindora transmission line, and in 2012, it accounted for 5% of SEN's electric generation capacity as well as volume of electricity generated respectively, indicating that the project is clearly contributing to the improvement of hydropower generation capacity, as well as filling the future demand-supply gap.

Table 3: Project's contribution to the National Electricity System

	2010		2012	
Power Generation Capacity				
	KW	Participation in the SEN (%)	KW	Participation in the SEN (%)
Total SEN	2,605,295		2,723,181	
Total ICE	1,902,939	73%	2,080,190	76%
Hydro	1,119,709	43%	1,258,869	46%
Pirris HPP	-	-	140,272	5%
Thermal	627,270	24%	612,601	22%
Geothermal	136,160	5%	187,910	7%
Wind	19,800	1%	19,800	1%
Solar Power	-		1,010	0.04%
Electric Power Generated				
	MWh	Participation in the SEN (%)	MWh	Participation in the SEN (%)
Total SEN	9,503,002		10,076,344	
Total ICE	6,655,309	70%	7,459, 250	74%
Hydro	5,291,523	56%	5,349,469	53%
Pirris HPP	-		503,653	5%
Thermal	335,637	4%	830,284	8%
Geothermal	963,837	10%	1,190,398	12%
Wind	64,312	1%	79,804	1%
Solar Power	-	-	295	0.003%

Source: ICE.

The project's impact is not limited to improving the hydroelectric power generation capacity as mentioned above; it also plays the role of a backup power source during dry season, and during sudden changes in electricity demand. It also contributes to the improvement of the Central Pacific Ocean region's electricity service, as well as the Central American Electrical Interconnection System[14] (SIEPAC), to which it is connected through the Parrita Substation, playing a strategic role in the Central American electricity market. Through the above-mentioned roles, the project is contributing greatly both to the improvement of hydropower generation, which is the base load of Costa Rica, and to the strengthening of the SEN.

3.3.1.2 Improvement in the investment environment and economic development potential of Costa Rica, by improving the stability of electric supply capacity

[14] The Central American Electrical Interconnection System (SIEPAC) is a system that interconnects six Central American countries (Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama) with a 1,793km long transmission line, which enables selling and buying electricity within the region. It is operated by the Network Owner Company (EPR) which was established by the electric utility companies of the six countries.

In order to grasp the project's impact, a survey was conducted to large consumers[15]. Opinions in reference to the stable power supply, importance of electricity as a determinant for investment, and the positive and negative changes brought about by the project were gathered.

1) Stable power supply

All companies have a power contract for medium voltage (34.5KV) or high voltage (230KV, 138KV), thus their power supply is stable, and "power quality (changes in voltage)" is high. With regard to "Stable power supply, 9 out of 10 companies answered that they are "very satisfied or satisfied". The reason one company was not satisfied, was related to electricity rates which will be discussed below, and ICE's response during non-planned outages. With respect to ICE's response during non-planned outages (especially when transmission lines and electric poles are damaged due to hurricanes and/or accidents), nine other companies also mentioned that "even if the outage is short, there are significant damages to the machinery, thus a quick response by ICE is expected". As mentioned above, although the non-planned outage hours have significantly improved, it became clear that a better response when non-planned outages occur is required. On the other hand, with respect to planned outages, all 10 companies responded that "it has improved compared to how it was three years ago" and although it is necessary to coordinate dates and time with ICE, seven out of 10 companies said that these coordination opportunities are a good way to communicate with ICE and build a good relationship with them. At the moment of the ex-post evaluation, companies were using the planned outages as an opportunity to conduct machinery maintenance, and no specific effects or problems such as damages were observed.

2) Importance of electricity and its rates as determinants of investment

Improvement of electricity rates was what all the companies were most hoping for. Nine out of 10 companies do business not only in the domestic market, but use Costa Rica as a production base to export their products to markets in North America, South America and Asia. The companies responded that electricity rates are a major concern, as electricity cost can even reduce their competitiveness. A common opinion was that "in Costa Rica's case, a major determinant for direct investment is its political and economic stability, which is the reason why there are no big fluctuations in direct

[15] Details of the large customers survey is as follows. (1) Survey period: end of November 2013 to mid-January 2014; (2) Number of companies surveyed: ten (six foreign-owned companies); Industry: Food processing (three), dairy (one), aquaculture (one), auto parts (one), electric parts (two), metal processing (one), services (one); (4) number of years operating in Costa Rica: less than 10 years (two), 10 to less than 15 years (one), 15 to less than 20 years (six), 20 years or more (four); (5) percentage of electricity cost in the product's cost price: 10% (one), 15% (one) 17% (two), No response (six); (6) geographical distribution by province: San Jose (three), Alajuela (three); Puntarenas (three) Cartago (one); (7) method of selection: selected from the large consumer list taking into consideration the geographical distribution and industry classification. Originally request to participate in the survey was made to 15 companies, but no cooperation could be obtained from five companies.

investment. But if electricity rates continue to increase, competitiveness will decrease, and foreign companies will be forced to withdraw from the country[16]".

3) Positive and negative changes brought about by the project

With respect to the project, three companies said to "know it very well" and seven said "to have heard of it". From the former three companies, one actually had visited the project. A common opinion among these three companies was that "the project cost was very high; however, it was important and necessary in order to secure a stable power supply and to reduce dependence on fossil fuels in Costa Rica". With respect to social effects, environmental changes and problems related to resettlement and land acquisition brought about by the project, they said "not to have heard of anything in particular".

From the above, among the expected impacts, it was possible to recognize the improvement of Costa Rica's hydroelectric power generation capacity, and filling the future demand-supply gap by improving the stability of power supply as the project's impacts. On the other hand, with respect to the relationship between the project and the investment environment, as well as the improvement of economic development potential, it is difficult to probe a direct causal effect between those and the project to begin with, because the electricity generated by the project is transmitted to the whole country through the SEN. However, large consumers said that "in a before-after comparison, Costa Rica's power supply is more stable and quality of electricity has improved from a general point of view". From this statement it can be said that the project has contributed to strengthen the SEN. In addition, when economic growth rates and Foreign Direct Investment to Costa Rica before and after the project were compared, the former increased from 2.7% in 2008 to 3.6% in 2013, and the latter increased from 2,078 million U.S. dollars in 2008 to 2,682 million U.S. dollars in 201317. These data support the fact that, together with other economic and social infrastructure, this project has contributed to some extent as a determinant to attract investment and improve the potential for economic development.

3.3.2 Other Impacts

3.3.2.1 Impacts on the Natural Environment

In Costa Rica, all projects that can cause a change in the natural and living environment are obliged to conduct an Environmental Impact Assessment (EIA) and obtain an approval from the

[16] According to a survey conducted by the Costa Rica Chamber of Industries, electricity tariffs in the country have increased from an annual average of 0.069 U.S. dollars/kWh in 2003, to 0.196 U.S. dollars/kWh in 2013, resulting in a 284% increase, which is an obstacle in terms of competitiveness and further attraction or foreign direct investment. However, according to the foreign direct investment statistics of the Ministry of Trade (COMEX), although foreign direct investment to Costa Rica, which was 2,078 million U.S. dollars in 2008, fell to 1,346 million U.S. dollars in 2009 due to the global financial crisis, it recovered to 2,682 million U.S. dollars in 2013. Therefore, the direct causal effect of electricity tariffs is not as clear as the industrialists say. In addition, according to announcements by the Economic Commission for Latin America and the Caribbean (ECLAC, 2012), Costa Rica's main foreign direct investment attraction factors are high level of education and skills of its people, and socioeconomic stability, and it points out that electricity tariffs are the lowest in the Central American region. The discussions on electricity tariffs in Costa Rica have been going for a long time, and due to its political factor, it needs to be handled with care. Therefore, large consumers' opinions on electricity tariffs obtained in this ex-post evaluation were considered only as reference information.

[17] Economic growth rates are from the Central Bank of Costa Rica, and foreign direct investment amounts are from COMEX (See footnote 16 for details).

National Environmental Technical Secretariat (SETENA). ICE conducted the project's EIA from 1997 to 1998, and obtained the approval from SETENA in June 1999[18].

In regard to the environmental impact during the execution of the project, three activities were assumed to be conducted, namely, environmental monitoring and measures during construction period, afforestation activities and water quality monitoring.

As mentioned below under "3.5.1 Institutional Aspects of Operation and Maintenance", an Environmental Management Department was established inside the Pirris Hydroelectric Powerhouse Construction Administration Office (PHP), which was the entity in charge of the management of the project. The said Department conducted the environmental monitoring and implemented necessary measures, afforestation activities and water quality monitoring.

1) Environmental monitoring and measures during the construction period

As indicated in the table below, construction works were conducted strictly observing national standards, and efforts to minimize negative impacts to the environment were taken as much as possible. However, especially with respect to vibration, it affected the neighborhood residents' houses (please refer to "3.3.2.2 Land Acquisition and Resettlement" for details).

Table 4: Environmental impact measures and monitoring status during project execution

	Monitoring contents and measures during construction works
Gas Emission	Periodical inspections of vehicles (including contractor vehicles) were conducted at ICE's repair plant. By making car inspection necessary, vehicle's gas emission rules were strictly followed.
Waste Disposal Treatment	A "Waste disposal management program" was implemented. Solid wastes were recycled or reused as much as possible within the project or in other ICE projects (approximately 59 tons of waste were recycled between 2009 and 2011). Liquid wastes were treated by using filters. Scrap was partially sold to scrap processors (2,780 tons of scrap was sold between 2009 and 2011).
Dust	In highly populated sections, roads were paved with concrete. In other sections and in the construction sites, water was sprinkled frequently, and measures such as cleaning plants covered with dust were also taken.
Muddy water	Especially in concrete plants and sites with a lot of drilling (RCC dam, headrace tunnel), sedimentation devices were introduced. Water quality (suspended solids) were monitored at some points of the river and ensured that national standards would be strictly met.
Noise	Noise was monitored in neighborhood communities; measures such as coordinating hours to operate machinery were taken, and national standards were strictly followed. Workers were required to use earplugs.
Vibration	Vibrations occurred mostly during the drilling works for the headrace tunnel. Status of infrastructure in neighborhood communities was monitored, and effects of vibrations on other infrastructure were reduced by adjusting drilling works.

2) Afforestation activities

There were some coffee fields in the area of the reservoir which was submerged (about 141ha), but there were neither natural parks nor designated protected forests. Vegetation around the reservoir was

[18] Approved EIA reports were distributed to provincial authorities, and are also available to the public at ICE's reference room.

also poor and almost no wild animals were found. Thus negative effects of the project to the natural environment were assessed to be minimal at the time of project appraisal. However, in large-scale public projects such as this, there are cases where opposition activities by neighborhood residents and NGOs occur. This project was no exception, and especially at the beginning, there were some opposition movements by neighbor residents of the dam site. However, in order to minimize the negative impact of the project to the natural environment, ICE created a plant nursery where young trees were grown for afforestation. Efforts were made in conducting afforestation activities and environmental education in the project area, gaining the understanding of the neighbor residents[19].

3) Water quality monitoring

At the time of appraisal, there was a concern that the waste water from the coffee refineries located upstream of the Pirris River would flow and accumulate in the reservoir, worsening water quality. The EIA especially pointed out the necessity to monitor the concentration of Biochemical Oxygen Demand (BOD)[20]. The reason why BOD concentration is high both at the time of appraisal and the ex-post evaluation is that coffee plantations use a considerable amount of water in their bean refinery process, and the waste water that contains pulp (skin) is discharged without sufficient treatment into the Pirris River. ICE's role in the water quality issue was to monitor water quality since even before starting the project, and to inform SETENA if it did not meet the national standards[21]. Monitoring of water quality during project execution was done by ICE's Environment Management Department, mainly at 14 monitoring points that included the Pirris River and the powerhouse. An average of six to seven points were selected and monitoring was conducted twice a month for 11 water quality indicators[22]. BOD concentration was especially high in January registering levels between 111mg/L to 118 mg/L, when the volume of waste water from the coffee refineries located upstream reached the highest levels; thus not meeting the national standards sometimes. With respect to other water quality indicators, these differed by period, but there were no major issues.

Environmental impact at the moment of the ex-post evaluation was possible to assess through the water quality monitored mainly at the Pirris River, reservoir, and power house. The entity in charge of monitoring water quality is ICE's Department of Hydrology of the Projects and Related Services, who monitors a total of 20 water quality indicators at seven points in reservoir, five at the power house, and four at the Pirris River. Similar to the project execution period, BOD and Chemical Oxygen Demand

[19] With ICE's afforestation activities, approximately a total of 300,000 trees were planted around the dam site, the power house, and neighboring communities from 2002 to 2011.

[20] BOD is the amount of oxygen that is consumed when organic matters in the water go through a biochemical oxidation and decomposition. The bigger the value, the more polluted is the water (Source: Website of the Japan Ministry of the Environment)

[21] In order to conduct water quality monitoring, ICE signed a water quality management agreement with the Ministry of Agriculture and Livestock, which is the relevant authority in matters related to coffee production, the Ministry of Health, and the Ministry of Environment. Water quality monitoring was conducted based on such agreement.

[22] Items that were monitored were temperature, pH, turbidity, dissolved oxygen, BOD, SS (Suspended Solids), COD (Chemical Oxygen Demand), phosphate ion, ammonium nitrogen, nitrate and dissolved solids.

(COD) were high in January[23], however, with the exception of January, water quality meets the national water quality standard classification III to V[24] required for hydro power generation.

Table 5: Water quality after project completion: Reservoir of Pirris Hydroelectric Power Plant (2013)

	BOD	COD	SS	pH
Minimum value	1.3 mg/L (September)	30mg/L (July)	1 mg/L (April)	6.24 (July)
Maximum value	31 mg/L (January)	1,044mg/L (January)	6 mg/L (January)	7.12 (April)
Water Quality Standard	III-IV*	25 to <50 mg/L	<10 mg/L	6.0 to 9.0
		III～V	I	III

Source: ICE.

Note: BOD, Ammonium Nitrogen and Dissolved Oxygen are given a score from 1 to 5 according to the range. Water quality is then classified into five levels that go from I (not contaminated) to V (seriously contaminated) based on the total points.

In regard to the issue of high BOD levels, just as during the project execution period, the basic role of the Department of Hydrology of the Projects and Related Services is to monitor water quality, and inform SETENA if quality does not meet the levels required for hydroelectricity generation. However, it is worth mentioning that ICE is doing efforts working together with the government (mainly the Ministry of Agriculture and Livestock and MINAE) as well as research institutions, conducting joint research on environmentally friendly coffee production procedures. In addition, PHPP itself conducts maintenance of the reservoir to keep a stable water quality as much as possible. Especially, water intake management is conducted in order to avoid low water levels at the reservoir, and to keep BOD levels within the acceptable range.

3.3.2.2 Land Acquisition and Resettlement

The process of resettlement and land acquisition was conducted based on “Law No. 6313 on Acquisitions, Expropriations and Easements by ICE”. The Law establishes that an appraisal of the land and/or construction must be conducted by a third party, and the amount resulting from the appraisal shall be paid in case of land acquisition, while in the case of resettlement, a relocation site of an equal value must be provided to the residents.

The area of land that was planned to be acquired at time of appraisal was 364ha, but the actual area was 398.5ha, 109% compared to the plan. This was because it was necessary to add another camp site for ICE construction workers at the dam site. The land that was subjected to acquisition was mainly those for the powerhouse, switchyard[25] and the coffee plantations of at the reservoir that went under water. A total of 509 people were affected directly and indirectly by the project at the powerhouse and

[23] Although the coffee production period is from November to March, the peak production season is January.

[24] National water quality standards in Costa Rica are stipulated under MINAE Decree No. 33903 MINAE-S. The basic classification is as follows: I=drinking water, II=aquaculture, III=hydropower generation, IV=navigation (can also be used for aquaculture and hydroelectricity generation subject to limitations), V=navigation (can also be used for hydroelectricity generation subject to limitations).

[25] A device that starts or stops (opens and closes) the flow of electricity generated at the power plant to the transmission line, and it helps to stabilize electricity supply.

switchyard sites. As for the coffee plantation land that was submerged in the reservoir, 152 land owners were affected, but besides these land owners, ICE did not know the number of people that might have possibly been affected indirectly such as seasonal workers. With regard to land acquisition[26], especially, negotiations on the compensation amount at the power house were prolonged, causing a delay in the project. However, all procedures were conducted properly based on the aforementioned Law.

In regard to resettlement, the planned number of households to be resettled at the time of appraisal was a total of 18, that is, seven at the reservoir and its preservation area, and 11 at the access road areas. In case of the latter, resettlement became unnecessary due to a change in route of the access road. Thus, a total of eight households, the original seven plus an additional household, located at the reservoir and its preservation area were resettled (73% compared to plan). From these eight households, two had already been resettled at the time of appraisal. For five out of the remaining six households, the risk of a landslide at the original residential area had already been recognized before the beginning of construction works, but the risk increased with the vibrations of the civil works, thus their resettlement was imperative. The household that was added was outside the landslide risk area at the time of appraisal, but it was included after starting of civil works, as the landslide risk due to vibrations was recognized. The six households that were resettled after the project started were done so based on the aforementioned Law No. 6313, and a relocation place of the same value as the appraisal value was secured at Santa Marta de Tarrazu, as requested by the residents, and their relocation was completed without problems.

3.3.2.3 Other Impacts

Besides the above mentioned expected impacts, the following positive impacts can be recognized in this project[27].

1) Access roads

145km of roads were constructed by the project (including roads for the transportation of materials and equipment). These roads were not only paved with asphalt, but sidewalks, road guards, road signs, bus stops, pedestrian bridges, side ditches and electric poles were installed as well. Some roads to the powerhouse and the reservoir, were checked at the moment of the site inspection, and based on hearings to local residents, socioeconomic effects (for example, transportation safety improvement due to construction of roads, increase in land and real estate prices, increase in number of tourists etc.) to neighboring villages could be recognized.

[26] Average amount of compensation paid for the whole project was 387 colon/m^2.

[27] A beneficiary study for residents was not included in the scope of this ex-post evaluation; thus, socioeconomic effects on the living standards of the residents were assessed based on interviews.

2) Effects on cultural assets

Figure 3: Replica of the burial site next to the reservoir

At the moment of appraisal, some archeological remains were found at the planned site of the reservoir. ICE conducted a survey during the project, and a burial place of 224m^2 was discovered. However, it was concluded that the density of the archeological remains per square meter was low and a permission to continue with the civil works was obtained from the National Institute of Cultural Heritage. A total of 2,120 pieces of pottery were collected from the burial site and all of them were handed to the National Museum. In addition, although on a small scale, an exhibition room has been installed next to the reservoir where explanations on the historical background of the burial site and replicas of the discovered pottery are on display. The excavation site has also been replicated and it is open to the general public. As can be seen, ICE has conducted activities to protect cultural properties as well as educational and public relation activities, based on which it can be judged that negative impacts to cultural properties have been kept at the minimum.

3) Other socio-environmental activities

In order to reduce impacts to the neighboring communities' living environment and to the natural environment, ICE implemented the "Project for Community Infrastructure and Environmental Protection" separately with its own funds. A total 131 projects (construction of parks, restoration of churches, provision of equipment for the construction of health care centers, and repair of water tanks) at 54 communities were conducted.

As can be seen, ICE separately implemented measures to minimize any negative impacts that could arise from the construction of the project, and positive impacts that were not expected can be recognized.

In light of the above, this project has largely achieved its objectives, therefore its effectiveness is high.

3.4 Efficiency (Rating: ①)

3.4.1 Project Outputs

Changes in output occurred mainly with the civil works, but electric equipment and facilities were conducted almost as planned (for details see annex "Comparison of the Original and Actual Scope of the Project").

With respect to civil works, there were changes in all items except quarries and tailrace. Because the geological features of the site where the dam was planned to be constructed were not assessed accurately in ICE's the geological surveys conducted during the 1998 Feasibility Study (F/S)[28] and the Detailed Design, problems with the soil were found after the civil works had started, thus making it necessary to partially change the design of the dam and to do more excavation works as well as foundation work than what was originally planned. The geological survey issue also happened in the building of the power house. Once civil works had started, it was found that the foundation of the ground of the planned construction site was weak. Thus, the design of the power house building was changed from a ground level type to a semi-underground level type. Taking the results of the 1998 F/S, JICA conducted a survey in 1999 previous to the appraisal, in which it advised[29] ICE to improve the accuracy of the geological survey of the dam site. Taking into consideration the 1992 F/S up to the 1998 F/S, at least three geological surveys were conducted related to this project's dam site, and even after construction started, more geological issues were found which caused considerable changes that affected the project cost and project period (refer to "3.4.2 Project Inputs").

Figure 4: Reservoir

Figure 5: Generator

Other major changes in civil work were the increase in the length of access roads for civil works (207% compared to plan) and the number of camp sites (133% compared to plan). As for the former, routes of these roads were changed in such a way that these were laid avoiding villages in order to minimize project impacts to neighboring residents. As for the latter, an additional camp especially for

[28] In this project, two F/S were conducted: one in 1992 and another one in1998. The 1992 F/S was carried out with JICA funds while the 1998 F/S was carried out by ICE with its own funds. In the 1992 F/S, two candidate sites for the construction of the dam were surveyed: one upstream and one downstream. The conclusion was that although both sites were appropriate, the downstream site was more economical. However, it recommended that additional surveys were necessary for the following: (1) topographical survey, (2) geological survey, (3) material testing, and (4) hydrological measurement. Thereafter, from 1993 to 1996, ICE conducted the above mentioned surveys with its own funds and the results were summarized in 1997 in the document "Results of Additional Surveys". In this Survey's hydrogeological evaluation, it was found that the ground of the downstream dam site -the main candidate- was too weak, so the dam was decided to be constructed in the upstream candidate site, and so, in 1998, ICE carried out the F/S at the upstream site with its own funds. In 1999, JICA advised ICE to improve some technical aspects, and in June 2000 it again advised ICE to improve the accuracy of the geological survey. ICE then submitted the countermeasures (measures that it will take in the Detailed Design and the Construction Planning) to the two aspects advised by JICA, who in turn sent an appraisal mission in August 2000 in order to confirm the technical relevance of these countermeasures. When the mission was dispatched, an agreement was reached between JICA and ICE in reference to the project design, construction, employment of a consultant, schedule, costs, urgency of the project and measures to be taken from thereon, which then led to the signing of the loan agreement in 2001.

[29] JICA internal documents.

ICE construction workers (approximately 200 workers) had to be constructed at the dam site, as halfway of the RCC dam construction, ICE had to take over the work from the contractor Astaldi[30].

3.4.2 Project Inputs

3.4.2.1 Project Cost

The planned project cost was 29,443 million yen (foreign currency portion: 15,144 million yen, domestic currency portion: 14,299 million yen), out of which 11,383 million yen from the foreign currency portion and 5,300 million yen from the domestic currency portion were subject to the Japanese ODA loan. The actual project cost was 79,056 million yen, out of which 16,402 million yen[31] was subject to the Japanese ODA loan. The project cost was 269% of the planned cost, significantly higher than planned.

Table 6: Details of the Project Cost

Item	Planned (million yen)			Actual (million yen)			% change against plan
	ODA loan	Others	Total	ODA loan	Others	Total	
Civil Works	5,333	4,039	9,372	10,124	34,675	44,799	478%
Electric machinery and Equipment	8,973	3,411	12,384	6,030	5,719	11,749	95%
Land Acquisition	0	611	611	0	491	491	80%
Administrative Cost	0	2,602	2,602	0	10,349	10,349	398%
Price Escalation	493	130	623	0	0	0	0
Physical Contingencies	1,092	977	2,069	0	0	0	0
Consulting Services	791	0	791	248	0	248	31%
Interest During Construction	0	990	990	0	11,419	11,419	1,153%
Total	16,683	12,760	29,443	16,402	62,654*	79,056	269%

Source: JICA appraisal documents, ICE.
*: ICE's own resources accounted for 42,729 million yen of the 62,654 million yen of the "Other" financial resources, and 19,924 million yen were borrowed from the Central American Bank for Economic Integration.
<Planned values> Exchange rate 1 U.S. dollar=108.36 yen / 1Costa Rican colon=0.3506 yen / Price escalation rates: foreign currency 0.8%, domestic currency: 0.7% / Physical contingency rates: above ground civil works 10%, underground civil works: 15%, electrical machinery and equipment: 5% / Cost calculation reference period: November 2000.
<Actual Values> Exchange rate was calculated by the executing agency using annual exchange rates.

The major change in the total project cost was civil works (478% of the planned cost). Electric machinery and equipment, as well as land acquisition were more than planned in terms of U.S. dollars,

[30] Civil works of the dam were subcontracted to Astaldi; however, because the 2008 tropical storm Alma caused considerable damages in the dam site, the company stopped working for 84 days. As the work interruption period was prolonged, originally, ICE was planning to demand Astaldi to terminate the contract and conduct a new bidding. However, taking into consideration the time required for a new bidding process, it decided to withdraw the demand and avoided further delays in the construction period. Specifically, in 2009 a clause was added to the contract with Astaldi, which indicated that ICE would take over the responsibility of the construction of the RCC dam, spillway and installation of electrical machinery and equipment. As a result, out of the components of the civil works, ICE took charge of the preparatory works, river improvement, headrace tunnel, power house and switchyard, grouting of the dam site, RCC dam, spillway, and installation of electrical machinery and equipment. Grouting of the dam site was assisted by the consultant and a specialist in RCC dams.

[31] According to ICE, the actual amounts are all recorded in U.S. dollars, and are not classified into "foreign and domestic currency". Planned amounts were calculated by the evaluator using the exchange rate indicated in Table 6.

but were within planned in terms of yen due to a strong yen. The reasons for the major change in civil works were modifications in the Detailed Design of the dam after a problem in the ground at the construction site was found once civil work had already started; subsequent changes in excavation and ground work which exceeded the plan; and additional costs due to delay in the construction period. The fact that ICE took over the RCC dam construction from Astaldi, and delays in the construction period also significantly affected the project cost by increasing administrative costs by 398% compared to planned. In addition, the project cost that was planned to be financed by the Japanese ODA loan and ICE's own funds at the time of appraisal, had to be financed also by borrowing from the Central American Bank for Economic Integration (CABEI) and issuance of bonds, after changes in output and delays in the project period were made. These in turn resulted in a significant increase in interests during construction which was 1,153% compared to planned.

3.4.2.2 Project Period

The planned project period was 76 months from April 2001 to July 2007, but the actual project period was 131 months from April 2001 to February 2012. The actual project period was 172% of the planned period, which was significantly longer than planned.

Table 7: Project Period

Procedure	Planned (Appraisal documents)	Actual	Actual vs. Planned	Delay in starting
Signing of the L/A	April 2001	April 2001	—	
Preparatory Works	January 2001 to May 2005 53 months	January 2001 to September 2010 117 months	221%	None
Main Works	January 2001 to July 2007 79 months	June 2002 to October 2010 101 months	128%	10 months
1. RCC Dam	August 2001 to March 2007 68 months	June 2002 to November 2011 114 months	168%	10 months
2. Headrace Tunnel	January 2001 to April 2007 76 months	July 2002 to May 2011 107 months	141%	18 months
3. Powerhouse	January 2003 to July 2007 55 months	August 2005 to October 2010 55 months	As planned	19 months
Electric Machinery and Equipment	July 2003 to March 2007 45 months	July 2003 to February 2012 104 months	231%	None
Land Acquisition	January 2001 to June 2004 42 months	January 2001 to December 2006 72 months	171%	None
Consulting Services	June 2001 to June 2007 73 months	July 2002 to May 2009 83 months	114%	13 months
Total Project Period	April 2001 to July 2007 76 months	April 2001 to December 2012 131 months	172%	—

Source: Planned values are from JICA appraisal documents, actual values are from ICE.

The main reasons for the delay were as follows.

1) Delays due to changes in civil works: the aforementioned change in the design of the dam resulted mainly in the delay of preparatory works (221% compared to plan). It also became necessary

to secure labor and add and/or change access roads in order to deal with such changes. In addition, regarding all sorts of ground works including grouting32 of the planned construction site of the dam, it took longer than expected to procure the necessary machinery due to lack of domestic funds. Another reason for the delay was that the water inflow in the tunnel connecting the RCC dam and the powerhouse was more than planned, which resulted in frequent flooding. However, the executing agency introduced a shift-work system and took measures such as using part of the equipment used in other projects. As for the construction of the power house, land acquisition was not completed until 2005 also causing a delay.

2) Delays due to the contract of Consulting Services: General competitive bidding is basically the public procurement procedure applied in Costa Rica. However, the project's consulting services were directly appointed based on the "Guidelines for the Employment of Consultants under ODA Loans". ICE had to provide necessary explanations for that the said Guidelines are superior to Costa Rica's national procurement laws in implementing ODA loan projects and had to carry out necessary coordination with Costa Rica's government and related entities . This resulted in a 13 month delay in signing the contract with the consultant, which in turn resulted in a delay in the items that were included in the consultant's Terms of Reference (TOR), such as Detailed Design and procurement procedures of the civil works.

3) Delays due to the tropical storm Alma: Due to the 2008 tropical storm Alma, civil works at the dam site had to be interrupted, and as mentioned earlier, contract with Astaldi had to be modified. Negotiations and procedures took time, which resulted in delays in the construction period. In addition, even after ICE took over the construction from Astaldi, it had to secure the necessary labor force by itself, which required time. Furthermore, the closing of access roads due to landslides resulted in delays in the delivery and installation of equipment[33].

3.4.3 Results of Calculations of Internal Rates of Return (IRR)

At the time of appraisal only the Economic Internal Rate or Return (EIRR) was calculated at 12.2%. Costs used for EIRR calculation were project costs and operation and maintenance costs, while benefits used were the income from sales of electricity and benefits deriving from avoiding blackouts. Project life was 40 years. At the time of the ex-post evaluation, although it was possible to obtain information on costs, it was difficult to obtain accurate information on the project benefits; therefore EIRR was not recalculated.

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[32] Filling voids with cement milk and/or mortar in other to improve the foundation ground of a dam site (Source: website of the Japan Dam Foundation).

[33] One reason for the difficulty to secure labor force was that during the same period, a private company was carrying out a tourist developing project in Puntarenas and Guanacaste on the Pacific Ocean side, and they were offering higher wages, and therefore labor force was drawn into that project. In an effort to minimize any effects on the project, ICE carried out several "Job fairs" for Pirris neighboring residents. It also added a camp in the dam site where accommodation facilities, meals and buses for transportation were offered.

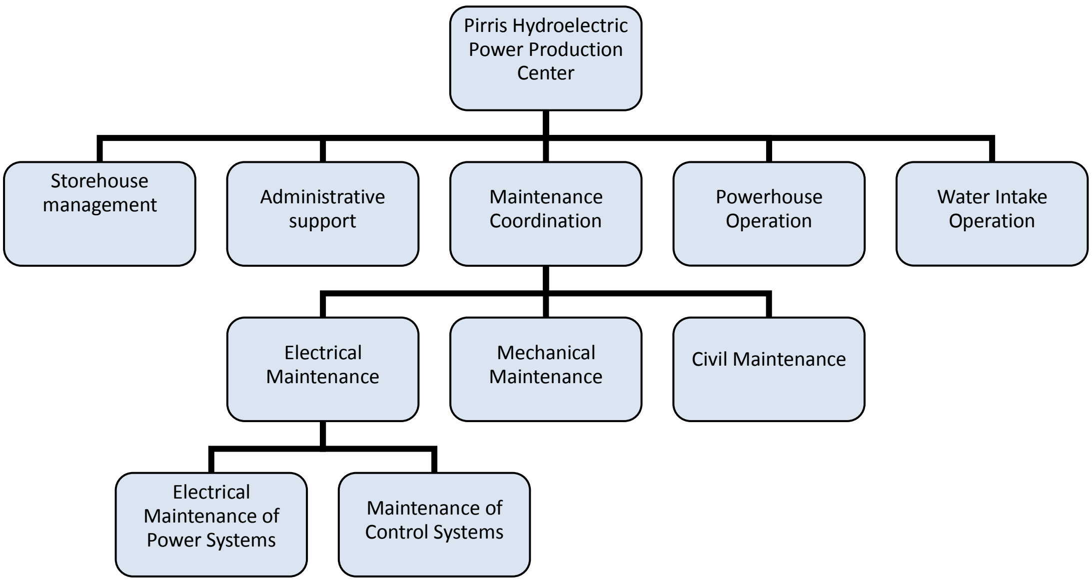
Both project cost and project period significantly exceeded the plan, therefore efficiency of the project is low.

3.5 Sustainability (Rating: ③)

3.5.1 Institutional Aspects of Operation and Maintenance

The project's operation and maintenance during project execution was conducted as planned by the PHP established under the Strategic Business Unit for Projects and Related Services (UEN-PySA) of ICE Electricity (ICELEC). The Project Manager was the head of PHP, under whom there were a total of 14 departments including Project Management, Operation Planning, Quality Control, Materials and Equipment Procurement, Labor Safety Management, Environmental Management, IT Management, Civil Works, and Engineering among others. From June 2009 to October 2010, which was the project's peak period, there were 2,884 persons engaged. In addition, during emergency periods such as when tropical storm Alma hit the country, labor force was reinforced. From these, it can be said that there were no major problems in general terms in ICE's basic organization during project execution.

The operation and maintenance of the PHPP at the moment of the ex-post evaluation is conducted by the Pirris Hydroelectric Power Production Center (Figure 6). There are a total of 45 employees, including engineers, technicians and skilled workers, engaged in the operation and maintenance, and the average years of service are nine years, which is relatively long. In addition, when there is a vacancy, employees within ICELEC are invited to fill up such vacancy. The status of the operation and maintenance and work site at the moment of the ex-post evaluation, as well as interviews to employees including technicians, showed that there is a high level of ownership by these employees toward the plant and that the operation and maintenance of PHPP is in good order.



Source: ICE.

Figure 6: Organization chart of Pirris Hydroelectric Power Generation Center

3.5.2 Technical Aspects of Operation and Maintenance

With respect to the technical level of the personnel in charge of PHPP is as follows: four out of the 45 are university graduates, 29 are technicians, six are administrative personnel, six are skilled workers, and judging from the maintenance status, in general terms, technical level is sufficient. However, ICE is aware that although the current technical level is enough, for the future, it is necessary to improve employee's skills through trainings related to power generation techniques and maintenance. ICE has a "Training Program to Fill Skill Gaps" which is provided to all its employees. These trainings have the objective of both filling the skill gap that exist between any employee and the skills that his/her job requires, as well as further improving skills. Through this program, the skills of the personnel in charge of the operation and maintenance of PHPP are also being improved. The following table indicates some of the trainings that the maintenance personnel of PHPP took during 2013 and those that were planned for 2014.

Table 8: Examples of trainings of PHPP's maintenance personnel

Examples of trainings conducted in 2013		Examples of trainings planned for 2014		
Title of training course	No. of persons	Title of training course	No. of persons	No. of hours
Mathematics for Technicians	16	Metrology	3	16 hrs.
How to read a Plan	15	Basic Knowledge on Centrifugal Pumps	3	16 hrs.
Basic Electrical Engineering	23			
IT (software including API-PRO)	30	How to read a Plan	6	16 hrs.
Thermography Measurement I	5	Civil Work Project Budget and Management	6	40 hrs.
Reliability-Centered Maintenance(RCM)	2			
		Automation Theory	18	48 hrs.
Vibration Measurement and Alignment	2	Human Relations in the Workplace	45	8 hrs.
		Procedures for Sustainable Improvement	45	8 hrs.

Source: ICE.

Some of the engineers and technicians that are in charge of the maintenance used to belong to the PHP during project execution, and because of that experience, they have full knowledge of the PHPP, which in turn results in a high technical level of the operation and maintenance of the plant.

Maintenance of PHPP is conducted based on detailed maintenance manuals and plans of the respective equipment provided by the manufacturers. The original maintenance manuals are kept in the library of the PHPP, and the detailed information (maintenance procedures of each equipment, frequency, records, etc.) has been digitalized and are managed using the maintenance system "API-PRO". Maintenance procedures of all equipment strictly follow the standards of ISO9001, 14001 and 18001. Maintenance is conducted by equipment, and there are daily inspections as well as

Figure 7: View of the Storehouse

preventive maintenance[34] (every week, month, semester, year, and every other year). With respect to corrective maintenance, the warranty period of almost all the equipment was until December 2013, thus repairs were conducted free of charge by the manufacturers up to that date. After the expiration of the warranty period, those repairs that can be done by ICE's maintenance coordination department are done in-house, and those repairs that cannot be conducted internally, are done by the manufacturers with charge. All the information on maintenance procedures and measures taken are inputted by the person in turn into the API-PRO. Thus, information including the person in charge of maintenance, date when the maintenance was conducted and number of spare parts used, is always updated. In addition, this system is also used for the management of spare parts, and the Storehouse Management Department manages the spare parts based on this system. At the moment of the ex-post evaluation, it was possible to see the whole maintenance procedure using the API-PRO, and also to confirm the coordination that exists with the storehouse department, from which it can be said that the technical level of maintenance that exists at the PHPP is high.

3.5.3 Financial Aspects of Operation and Maintenance

ICELEC has been in the black for the past five years with the exception of 2011 in which the effects of the global financial crisis were still present, and so financial sustainability has no major problems. Although capital-to-asset ratio in 2012 was 51%, which was lower than the 59% recorded in 2009, it is still high; operating profits is constantly increasing indicating that operation and maintenance costs is being covered with the income from the electricity bills[35].

Table 9: ICELEC Profit and Loss Statement

(Unit: Million Colon)

	2009	2010	2011	2012	2013 (up to November)
Operating Income (A)	521,995	539,889	553,255	575,862	652,004
Electricity business	516,697	532,234	546,273	569,118	645,451
Others	5,297	7,655	6,982	6,744	6,554
Operating Cost (B)	441,503	479,420	517,541	525,327	486,161
Maintenance cost	381,245	417,294	438,457	443,397	479,782
Operation cost	60,258	62,126	79,084	81,930	63,739
Operating profit (A) –(B)	80,492	60,470	35,714	50,535	165,843
Non-operating income	24,101	183,506	119,406	112,108	87,138
Non-operating cost	66,246	140,133	161,030	156,545	112,651
Income from dividends of subsidiary companies	5,486	8,275	(699)	4,993	-
Current Net Profit	43,832	112,117	(6,609)	11,090	82,970

Source: Financial Statements provided by ICELEC.

Electricity tariffs in Costa Rica are fixed based on the Regulatory Authority for Public Services

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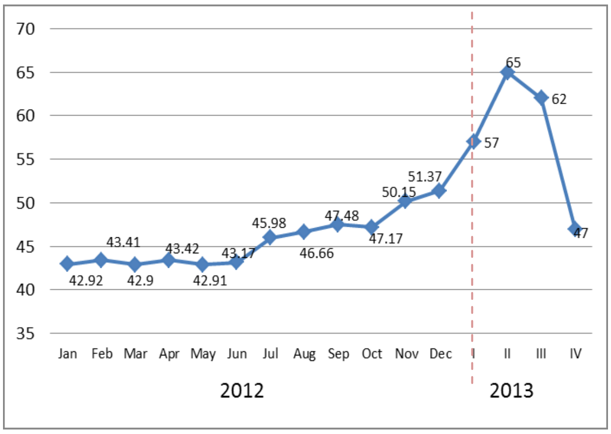
[34] Preventive maintenance is the maintenance conducted in a planned manner before facilities and equipment breakdown or deteriorate. On the other hand, corrective maintenance is to repair facilities and equipment that are already damaged.

[35] Moody's, one of the major bond rating organizations, gave ICE a credit rating of Baa3 in September 2013, and changed the future prospect to "Negative". However, it gave a positive evaluation of "Stable" to ICELEC's electricity business.

(ARESEP) Law No. 7593. This Law is based on the principle that "electricity tariffs shall be enough to cover the necessary cost for the provision of electric services, create competitive benefits and secure proper development". Since January 2013, it was approved that fluctuation of fuel costs be reflected on electricity tariffs on a quarterly basis. As can be seen, the electricity tariff system is established in such a way that it secures the tariff income to cover the operation and maintenance costs. However, it is also true that the industrial sector, who is arguing that increases in electricity tariffs are putting pressure in the companies' management, decreasing their competitiveness, is increasing movements and lobbying activities to revise electricity tariffs.



Source: ICE

Figure 8: Fluctuation of Electricity tariffs (Colon/kWh)

With respect to the operation and maintenance of PHPP, budget for the ordinary maintenance costs (daily inspection, preventive maintenance and corrective maintenance) is secured and is implemented as planned[36].

Table 10: Operation and Maintenance Budget of the PHPP

(Unit: million colons)

	2011	2012	2013
Operation	101.5	259.2	552.4
Maintenance	81.0	338.4	462.8
Total	182.5	597.6	1,015.2

Source: Pirris Power Generation Center

3.5.4 Current Status of Operation and Maintenance

Operation of the PHPP at the time of the ex-post evaluation was being conducted properly, and facilities and equipment installed by the project were mostly operating normally. At the time of the ex-post evaluation the problems indicated below were identified. With the exception of the concrete

[36] According to the data of the 2013 operation and maintenance budget requested by the Pirris Power Generation Center to ICE, which was made available by the said Center, it became clear that approximately 900 million colons were requested, out of which only 462.8 million colons were approved. After confirming the details, it was confirmed that the difference was mainly the budget for a backup transformer, and that the necessary budget to conduct a proper maintenance of the power plant has been secured. The budget for the backup transformer is planned to be included in the 2015 budget request.

lining in some parts of the headrace tunnel, these problems were not because of deficiencies in the design nor in the construction stage. Measures have already been taken and it was confirmed that these are included in specific repair plans.

Table 11: Maintenance status at the time of project completion and ex-post evaluation

	Problems	Status as per April 2014
RCC Dam	• Problems with the electrical system • Water leakages in the radial gate • Elevator out of order	• Repaired • Repaired • Repaired
Powerhouse	• Elevator out of order • Damages in the hydraulic governor of the Second Turbine	• Repaired • Repaired
Headrace tunnel	• Problems with the valve • Tunnel concrete lining is partially incomplete • Wear of instruments exposed in the valve area • Paint stripping at the high-pressure pipe	• Not repaired. It is necessary to clear the water from the headrace tunnel to do the repair. Thus during 2014, scale, scope and timing of the repair will be assessed, and it will be included in the repair plan after 2015 • Concrete lining is planned to be conducted by including it in the 2015 or 2016 maintenance plan • A shed to protect the exposed instruments is planned to be constructed by the end of August 2014 • Being painted by a contractor
Intake	• Unsuitable operation of the water intake measurement system	• Repaired and being monitored

Source: Based on interviews to ICE Pirris Power Generation Center and responses to the questionnaire.

With respect to spare parts, there is a storage house for materials and equipment inside the premises of the power house, and because it is linked to the maintenance system as mentioned earlier, inventory management is sufficient. In addition, during the ex-post evaluation survey it was possible to confirm that ISO standards related to security management, cleanliness and tidiness are being followed strictly both at the power house and at the RCC dam. From the above, it is clear that operation and maintenance are conducted properly, and from a general point of view, it can be said that the current status of the operation and maintenance is good.

The project's operation and maintenance institutional structure was sufficient both during project execution as well as after project completion and technical level of maintenance is high. Financial status is also in the black with the exception of 2011, and from 2009 operating profits have always been positive, which confirms that electricity tariffs are sufficient to cover operation and maintenance costs. With respect to maintenance status, although there are some issues in some equipment, these have already been included in the 2015 and 2016 maintenance programs in which specific repair and replacements have been planned. From the above, the project's institutional organization, technical level and financial status have no major problems, therefore sustainability of the effect brought about by project is judged to be high.

4. Conclusion, Recommendations and Lessons Learned

4.1 Conclusion

The project aimed to improve the stability of electric supply capacity in Costa Rica by constructing a hydroelectric power plant in the middle stretches of the Pirris River which runs through the central plateau of the country.

The project was in line with Costa Rica's national development plans, development needs and Japan's assistance policies, both at the time of the appraisal and at the time of the ex-post evaluation. Therefore its relevance is high. The main indicators which reflect the effects of the PHPP have either mostly achieved its targets or are improving. In addition, in a country where hydroelectric power generation is the base load, the project has not only strengthened the hydroelectric generation capacity, but it has also contributed to a more stable electric supply capacity as well as to solving future electricity supply-demand gaps. These effects can be recognized as the PHPP is connected to the National Electricity System, through the Parrita-Lindora transmission line (230kV, 118km) which was constructed as a separate project of the Executing Agency. Based on the above, the project effectiveness is evaluated to be satisfactory. In addition, other positive impacts were observed such as afforestation activities and effects from the construction of access roads, among others, thus the project's level of achievement of its intended effects and impacts is high. The efficiency of the project is evaluated to be low, because both project period and project cost significantly exceeded the plan. With regard to the sustainability of the effects of the project, no major problems have been observed in the institutional, technical and financial aspect of operation and maintenance, therefore sustainability of the project effect is high.

In light of the above, this project is evaluated to be satisfactory.

4.2 Recommendations

4.2.1 Recommendations to the Executing Agency

It is desirable that the problems indicated in the Status of Operation and Maintenance section are solved by carrying out the maintenance program exactly as planned. According to the executing agency, especially with respect to the valve of the conveyance works, it might become necessary to empty the tunnel, thus it is imperative to have a clear idea of when to do the repair work. Since this means that the operation of the PHPP would have to be stopped temporarily, the management team of ICELEC is urged to assess possible measures, include them in the repair program and conduct the repair as soon as possible.

4.2.2 Recommendations to JICA

None.

4.3 Lessons Learned

Improving the accuracy of the geological survey at the time of the Detailed Design

In this project, at least three geological surveys were conducted if the 1992 F/S is included. Due to time constraints for the geological survey in the 1992 F/S, it was advised that a more detailed geological survey should be conducted. Afterwards, ICE carried out additional surveys as well as another F/S, until finally reaching the signing of the Loan Agreement. However, after starting of civil works, it was found that there were problems in the soil of some of the construction sites, resulting in design changes. These changes significantly affected the project output, costs and period. Just as ICE itself has indicated as one lesson learned, a more detailed geological survey must have been done. That is, at the time of the detailed design, it would have been possible to minimize changes in the design of the dam by carrying out more accurate geological surveys in terms of boring survey area, frequency, interval and depth. These measures would have led to a more efficient implementation of the project.

End

Comparison of the Original and Actual Scope of the Project

Item	Original	Actual
I. Project Outputs		
[Civil Works]		
1. Preparatory Works		
a. Access roads for works	70km	145km
b. Camp sites	3	4
c. Queries	6	As planned
2. RCC Dam	Effective storage capacity: 30 million m^3 Area:1.14km^2 Height of the dam: 113m	Effective storage capacity: 36 million m^3 Area: 1.4km^2 Height of the dam: As planned
3. Water Intake	Crest length:270m H:58m×L:9m×W:8m Discharge:18m^3/s	Crest length: As planned H:32m×L:7.1m×W:7.1m Discharge: As planned
4. Headrace tunnel from dam to powerhouse	10.6km	10.5km
5. Penstock	1,170m	1,144m
6. Powerhouse	Generation capacity: 128MW Electric power generation: 561GWh L:50m×H:20m×W:30m	Generation capacity: 138MW Electric power generation: 503.65GWh L:43.8m×H:18.6m×W:22.3 m
7. Tailrace	262m / Diameter: 3.3m	As planned
[Electromechanical Equipment and Facilities]		
8. Generator	76MVA, 60Hz, 720RPM, W41×2	As planned
9. Turbine	64MW, 830.7m, 720RPM×2 (Pelton turbine)	69MW, 830.7m,720RPM×2 As planned
10. Main Transformer	13.8/230kV×3	As planned
11. Switchyard	230kV×1	As planned
12. Communication facilities for electrical control	ISDN Optic fiber link Radio system	As planned As planned As planned
[Consulting Services]	Assistance of Detailed Design; review of Tender Documents, assistance of tendering process; assistance of construction supervision; assistance for project management	As planned
II. Project Period	April 2001 - July 2007 (76 months)	April 2001 - December 2012 (131 months)

III. Project Cost Amount paid in Foreign currency Amount paid in Domestic currency Total Japanese ODA loan portion Exchange rate	 15,144 million yen 14,299 million yen (132 million US dollars) 29,443 million yen 16,683 million yen 1 U.S. dollar = 108.36 yen (As of November 2000)	 36,326 million yen 42,729 million yen (415 million US dollars) 79,056 million yen 16,402 million yen 1 U.S. dollar = 103.03 yen (Average of monthly rates between April 2001 and 2011) Source: ICE