Data Collection Survey
On
Energy Sector
In
The Republic of El Salvador

Final Report

March 2014

Japan International Cooperation Agency

Nippon Koei Co., Ltd.
KRI International Corp.

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(As of February 26, 2014)

LOCATION MAP (EL SALVADOR)

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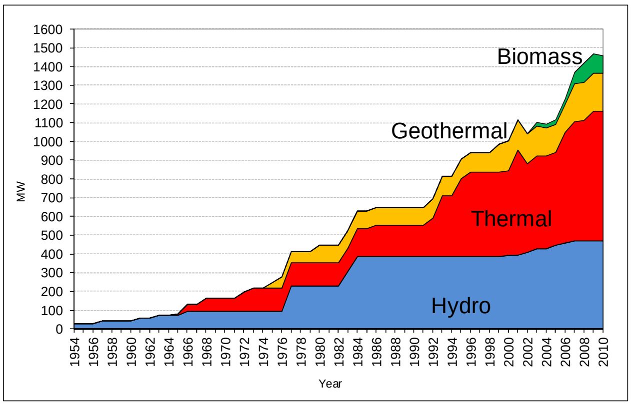
Abbreviations

Abbreviations	Spanish	English
AES	Corporación AES	AES Corporation
ANDA	Administración Nacional de Acueductos y Alcantarillados	National Administration of Aqueducts and Sewers
B/C	Costo/Beneficio	Benefit/Cost
BANDESAL	Banco de Desarrollo de El Salvador	El Salvador Development Bank
BTU	Unidad Térmica Británica	British Thermal Unit
CECSA	Compañía Eléctrica Cucumacayán S.A. de C.V.	Cucumacayán Electric Company Inc
CEL	Comisión Ejecutiva Hidroeléctrica del Río Lempa	Hydroelectric Executive Committee of the Lempa River
CFL	Lámpara Fluorescente Compacta	Compact Fluorescent Lamp
CNE	Consejo Nacional de Energía	National Energy Council
DD, D/D	Diseño Detallado	Detailed Design
DELSUR	Distribuidora de Electricidad del Sur, S.A. de C.V.,	Distributor of Electricity of South Variable Capital Company
EIA	Evaluación de Impacto Ambiental	Environmental Impact Assessment
EMI	Inducción Magnética	Electromagnetic Induction
ESCO	Empresas de Servicios de Energía	Energy Services Companies
FS, F/S	Edtudio de Factibilidad	Feasibility Study
GAL	Galón (3.785 litro)	Gallon (3.785 liter)
GWh	Gigawatts hora	Gigawatt hour
HP	Caballos de Fuerza	Horse Power
HPMV	Mercurio de alta presión	High Pressure Mercury Vapour
IDB (BID)	Banco Interamericano de Desarrollo	Inter-American Development Bank
IRR	Tasa Interna de Retorno	Internal Rate of Return
JICA	Agencia de Cooperación Internacional del Japón	Japan International Cooperation Agency
kV	Kilo voltios	Kilo volt
kW	Kilo watt	Kilo watt
kWh	Kilowatt hora	Kilowatt hour
LED	Diodo Emisor de Luz	Light Emitting Diode
MARN	Ministerio de Medio Ambiente y Recursos Naturales	Ministry of Environment and Natural Resources
MCDA	Análisis de Decisión Multicriterio	Multi-Criteria Decision Analysis
MEGATEC	Modelo Educativo Gradual de Aprendizaje Técnico y Tecnológico	Gradual Learning Educational Model Technical and Technological
MP, M/P	Plan Maestro	Master Plan
MW	Megawatts (=1,000 kW)	Megawatt (=1,000 kW)
MWh	Megawatts hora	Megawatt hour
NPV	Valor Presente Neto	Net Present Value
Pre-F/S	Estudio de prefactibilidad	Pre Feasibility Study

Abbreviations	Spanish	English
SIGET	Superintendencia General de Electricidad y Telecomunicaciones	General Superintendency of Electricity and Telecommunications
TOR	Términos de Referencia	Terms of Reference

1. Background of the Survey

The energy demand of El Salvador was recorded at 5,650 GWh in 2010, which was fulfilled by an energy matrix composed of hydropower (36.8%), thermal (34.9%), geo thermal (25.1%) and biomass thermal (3.2%). According to the forecast by the National Energy Council (CNE), the energy demand is expected to increase with an annual average growth rate of 4.7% until 2026. Recently, the increased power demand has been covered through the power production of diesel power plants which were invested by the private sector in El Salvador. However, as the diesel power plants electricity is susceptive to the fuel price which is highly volatile, shift to low-cost energy sources and introduction of renewable energy which is indigenous to the country is increasingly important.



Source: SIGET Power Statistics (June 2010)

Figure 1.1.1 Historical Variation of Power Source (2010)

According to the energy policy of El Salvador which was formulated in 2010, the diversification of the energy matrix, the promotion of energy savings, and regional energy integration are taken account as important agendas. Along with the diversification of the energy matrix, the government of El Salvador promotes renewable energy and the study of the introduction of LNG to the country. Under such circumstances, JICA conducted the study of "The Project for Master Plan for the Development of Renewable Energy in the Republic of El Salvador" (herein after referred as "Renewable Energy MP") in 2012. After the Renewable Energy MP it is expected that the small hydropower projects listed in the MP are to be realized.

On the other hand, JICA and IDB have been working together supporting Central America and the Caribbean region under the scheme of "the Co-financing for Renewable Energy and Energy Efficiency" (hereinafter referred to as "CORE Scheme"). El Salvador is included as one of the CORE scheme countries. As base policy material for energy sector support, IDB intends to prepare the "Note of the Energy Sector for El Salvador" (hereinafter referred to as Sector Note) jointly with JICA as a partner of the CORE Scheme.

Considering the possibilities of Japanese technology application in El Salvador, small hydropower and energy savings are the prospective technologies, and IDB is also interested such themes. Under such circumstances, JICA decided to conduct this survey jointly with IDB to collect required information for examination of prospective and priority projects to be developed.

2. Objectives of the Survey

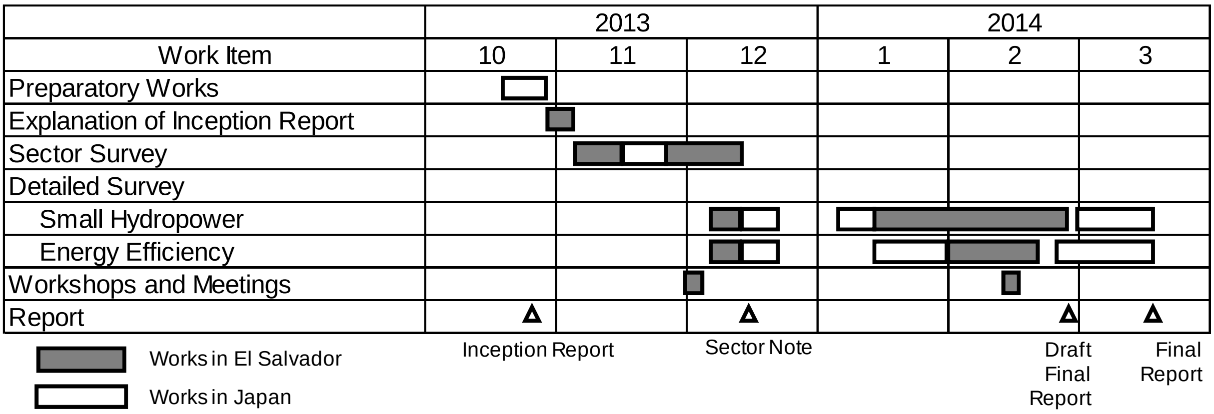
The purpose of the survey is composed of following three items.

a) Preparation of the Sector Note by studying the current situation and issues in the energy sector in El Salvador
b) Data collection, and analysis for formulating projects on energy savings and renewable energy (small hydropower) in view of future candidates for yen loan. (Detailed Survey)
c) Preparation of the materials for political dialogue on energy sector for the new regime in June 2014.

Of the above three items, compiled results of item a) "current situation and issues in the energy sector in El Salvador" are not included in this report, considering the convenience of the Government of El Salvador and the Inter-American Development Bank (IDB) who is closely related with this survey, because such results are to be used for the dialogue with the new government which is scheduled to take place in June 2014.

3. Overall Workflow of the Survey

The overall schedule of the survey at the time of inception report preparation is as shown below:



4. Detailed Survey on Small Hydropower

4.1 Purpose of the Detailed Survey on Small Hydropower

The private sector has legally taken initiative of small hydropower development in El Salvador. However, due to disagreement of the community against the small hydropower development, the development has little progress so far due to difficulty in obtaining consent of communities, although good potential sites has been identified in the renewable energy master plan in 2012. In order to promote the small hydropower development in El Salvador, it is necessary that public sector initiates several projects emphasizing the community involvement to promote sustainable development of small hydropower. Under such circumstances, the detailed survey aims to select good projects as the model hydropower to be implemented by the public sector, and to propose plans for small hydropower development.

In the detailed survey, the current situation and issues, related laws and regulations for small hydropower development were confirmed, then the prospective potential sites as future candidates for the model projects were selected through screening of small hydropower potential sites in El Salvador.

4.2 Current Situation and Issues of Small Hydropower

4.2.1 Current Situation of Small Hydropower

(1) Existing Small Hydropower Stations

According to information provided by SIGET, there are 16 small hydropower stations in operation as of January 2014 with a total installed capacity of 15.4 MW as listed below.

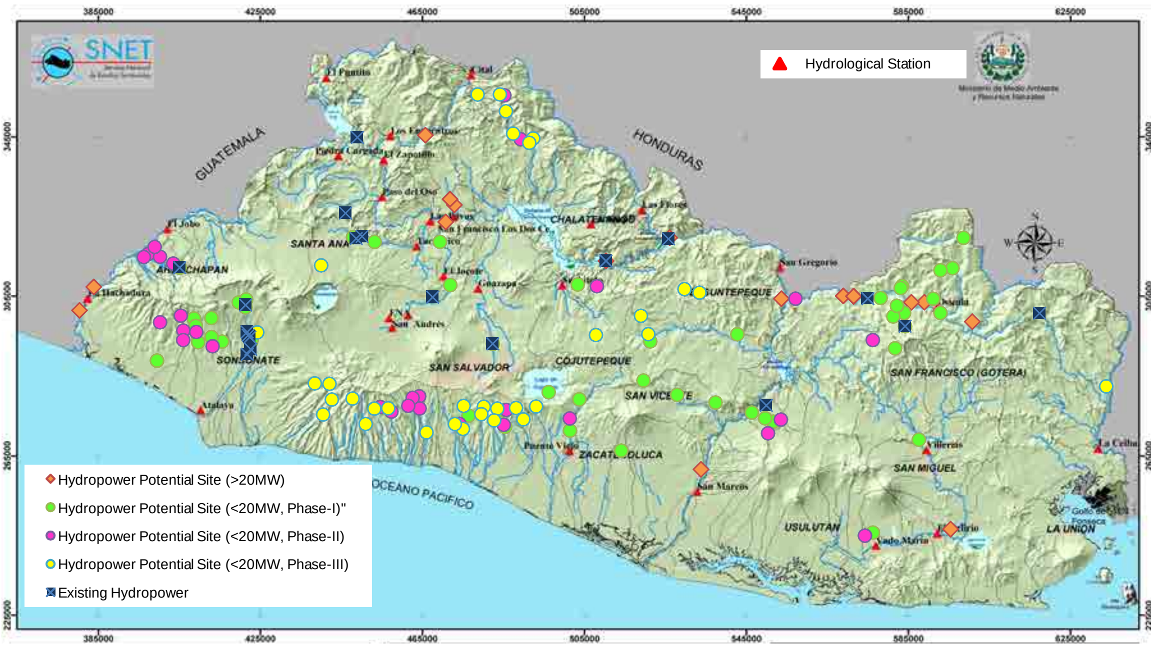
Table 4.2.1 Existing Small Hydropower Stations in El Salvador

No.	*Hydropower Station* *Central Generadora*	*Department Location* *Departamento Localización*	*Installed Capacity (kW)*	*Owner*
1	Sensunapán Nahizalco	Sonsonate	2,797.50	Private
2	Papaloate	Sonsonate	2,000.00	Private
3	La Calera	Sonsonate	1,448.00	Private
4	Cucumacayán	Sonsonate	2,256.00	CECSA
5	Bululú	Sonsonate	680.00	CECSA
6	Sonsonate	Sonsonate	740.00	CECSA
7	San Luis I	Santa Ana	600.00	CECSA
8	San Luis II	Santa Ana	740.00	CECSA
9	Cutumay Camones	Santa Ana	298.00	CECSA
10	Río Sucio	La Libertad	2,500.00	CECSA
11	Milingo	San Salvador	640.00	CECSA
12	Atehuasías	Ahuachapán	600.00	CECSA
13	La Chacra	San Miguel	25.00	Private
14	Miracapa	San Miguel	34.00	Private
15	Junquillo	Morazán	18.00	Private
16	El Calambre	Morazán	58.00	Private
		Total	15,434.50	

Source: SIGET

(2) Potential of Small Hydropower

According to the renewable energy master plan prepared in 2012 by CNE-JICA, 209 sites were identified for potential development. Total capacity is estimated at 180.8 MW and the estimated mean annual energy is 756 GWh. Most of the potential sites are located in the western region, especially in the Departments of Ahuachapán, Sonsonate and La Paz. Of the identified 209 sites, 123 sites[1] were selected as candidate projects for the master plan to be implemented in three phases as shown in the figure and the table below.



Source: Renewable Energy Master Plan, CNE-JICA, 2012

Figure 4.2.1 Location Map of Selected Small Hydropower Potential Sites for Master Plan 2012-2027

Table 4.2.1 Summary of Master Plan for Small Hydropower Development (up to 20 MW)

Fase Phase	Condiciones Conditions	Nomber of Projects	Potencia Potential (MW)	Energía Energy (MWh/Año)	Plant Factor	Inversión Total Investment Cost (x 1,000 US$)	Costo/kW (US$)	Base del Inversionista (con préstamo del Banco) Investment Base (with Bank TIR FIRR (Average) (%)	VAN NPV (Average) (x1,000 US$)	B/C (Average)
Phase-I (2012-2017)	Under Const.,with B/D, F/S & Pre-F/S	59	103.9	436,100	48%	305,100	2,937	27.7%	4,500	1.58
Phase-II (2017-2022)	B/C >=1, P>=0.25 (MW), 50% of Potential	32	33.5	146,100	50%	92,500	2,761	29.3%	3,500	1.72
Phase-III (2022-2027)	B/C >=1, P>=0.25 (MW), 50% of Potential	32	25.3	89,200	40%	85,800	3,391	17.6%	1,400	1.33
TOTAL		123	162.7	671,400	47%	483,400	2,972	24.7%	3,248	1.52

Source: Renewable Energy Master Plan, CNE-JICA, 2012

[1] Up to 1 MW: 85 projects, 1 to 5 MW: 33 projects and 5 to 20 MW: 5 projects.

Among renewable energy sources such as small hydropower (up to 20 MW), solar PV, solar thermal, wind, biomass, and biogas, considering the investment cost under the available technology, small hydro can be the first option to start investment as indicated in the renewable energy master plan. In the master plan, the generation cost is assumed at 10 to 14 US cents/kWh and it is expected to lower the current generation cost of thermal by 2 to 8 cents/kWh.

4.2.2 Issues on small hydropower development

Initiated by an introduction of electricity market mechanism that started in 1996, participation of private companies became possible in the field of power generation. Through such mechanism, it was expected that introduction of power generation projects including small hydropower development would be positively promoted.

However, in reality, a lot of diesel power generation projects were introduced because of their low initial investment costs and relatively easy repayment of the initial investment costs. Development of small hydropower has not implemented as expected.

A survey was made to know the reasons why small hydropower development is not well implemented, through the review of existing materials and interview survey to relevant organizations. The results are as follows:

1) Longer time required for studies on small hydropower development, and longer time for obtaining development concession from the government, compared with thermal or biomass power generation.
2) Due to insufficient discharge observation data, it is rather difficult to estimate accurate power generation amount of small hydropower, and it is difficult to judge the viability of the development.
3) In case of small hydropower development by a private company, there is less chances for dialogue with local residents, which makes it difficult to grasp the expectations and needs of the local residents to the development. In this connection, it is difficult to obtain the local residents' understandings and cooperation to the development.
4) There are cases of leak of information related to the development, which results intentional land occupation required for the small hydropower development.

In case of power generation by thermal or biomass, the required land is secured by the power company for its exclusive use for power generation purpose. On the other hand, in case of power generation by small hydropower, in most cases, it is necessary to use a part of natural resources which have already utilized by the local residents such as land or river water. Therefore it is necessary to have cooperation of the local residents for the development of small hydropower.

However, in case of development by private companies, as more priority is put on the benefit from the project, less effort is made on dialogues with local residents, and on understandings of the needs of the local residents to be reflected to the development. Under such situations, the development itself seems to be not in good progress.

On the other hand, CECSA, which is one of the representing private companies of El Salvador, well communicates with local residents for smooth implementation of the development. CECSA listens to the needs of the local residents, and hire the local residents as workforces for the construction works of the small hydropower development, or construct a simple bridge or roads for local residents to reflect the local needs to the development within the possible range. CECSA has good examples for the development as these activities (to be detailed in section 4.11).

To settle the above mentioned issues, and for smooth implementation of small hydropower development, it is hoped that the public sectors including the government should actively participate in the development. It is hoped to implement a model project that can take up the needs of local residents for smooth implementation of the development. Lessons learnt from the model project should be reflected to the future small hydropower development projects. For the implementation of the model project, it is important to reflect good examples of CECSA as mentioned above or other good examples from other countries.

4.3 Laws and Regulations Related to the Small Hydropower Development

(1) List of laws and regulations related to small hydropower development

The laws related to renewable energy that includes small hydropower are covered by various aspects such as environment, concession and constitution aspect. The laws and regulations related to small hydropower development is as shown in Table 4.3.1.

Table 4.3.1 Legislation Related to Small Hydropower Development

Legislation	Function
<Environment Issues>	
Constitution of the Republic of El Salvador	- Prescribe environmental and social issues in a general manner (Articles 36, 60, 65, 69, 101, 102, 113 and 117). - Article 105 states the maximum ownership area size of 245 Hectareas. This is not applicable to cooperative associations nor country community association.
Environmental Law	- Articles. 16-27 and 29 refer to everything related to environmental impact assessment (EIA); Articles 62-65 are about the use of natural resources; and Article 86 contemplates all those actions considered as environmental infringements, etc.
General Regulations of the Environmental Law	- Prescribe that MARN is responsible for preparing the terms of reference (TOR); according to the magnitude of the activities, works or projects, the head officer must prepare the environmental impact evaluation, EIA, or not. Articles 12, 20 and 32 are on public consultation; Article 22 is on environmental classification; Article 19 is on the environmental evaluation process; Article 21 is on environmental form; Articles 23-28 are on contents of EIA and its components; and Articles 34-39 on environmental permits, finances and audit.
Project Categorization According to the Environmental Law	- Present criteria to environmentally categorize projects under Articles 21, 22, etc.
Irrigation and Drainage Law	- Prescribe the use of water, soil, flora and fauna, mineral and energy resources, environmental sanitation and natural resources.
Municipal Ordinances and Code	- All ordinances issued by the municipality: environmental management ordinances, ordinances about specific taxes for the activity to be carried out, etc. - Prescribes the territorial planning of the municipality, covering forests, water, soil, flora and fauna, mineral and energy resources and environmental sanitation.
Penal Code	- Establish the corresponding penalties for infringements to environmental legislation
<Power and Electricity>	
General Law of Electricity, SIGET	- Prescribes the fundamental issues related to electricity. This law prescribes the activities on generation, transmission, distribution and commercialization of electrical energy. - Article 13 states that an EIA is required to obtain concession previously approved by competent authorities on this matter. Article 106.
Law of the Creation of the National Energy Council, CNE	- Proposes, requests, and contributes with corresponding organizations for the approval of energy strategies that contribute to the country's socioeconomic development in harmony with the environment. (Legislative Decree No. 404, of November 2007) - According the Article 5, the joint directorate is conducted by Ministry of Economy, Ministry of Housing, Ministry of Environment, Ministry of Public Works and Technical Secretary of the President.
Decree 460 – Regulating Law for Awarding Concessions of Small Scale Power Generation Projects.	- Determines procedure for obtaining a concession in projects of capacity lower than 5MW. A natural or legal person may be awarded with more than one concession if total power capacity is lower than 5MW.
SIGET Agreement 30-E-2011	- Technical normative for electrical interconnection and access to the transmission grid for End Users.
Decree No. 462 - 2007.	- Tax Incentives Act to Promote Renewable Electricity Generation

Source: JICA Study Team

(2) Environmental Categorization of Small Hydropower

The hydropower developers are mandated to carry out the environmental impact assessment. According to MARN, the requirement of environmental consideration differs to the scale of the project. Such requirement is classified to the categories as follows;

Table 4.3.2 Group and Category of Environmental Requirement

Group	Category and Requirement
Group A	*Low environmental impact*, which means that the holder of the project *need not* submit environmental documentation
Group B	Category 1: low potential environmental impact, *which does not require the submittal of an EIA but simple environmental study is required.*
	Category 2: moderate or high potential environmental impact, *requiring the submittal of EIA*

Source: MARN

For the case of hydropower development, the hydropower with its installed capacity less than 100 kW is classified to Group A. The project with its capacity greater than 100 kW and less than 1MW is classified to Category 1 in Group B. The project with its capacity over 1MW is classified to Category 2 in Group B. As shown in Table 4.3.2, the hydropower project which is categorized to Category 1 in Group B is not required to submit the EIA report; instead it is required to submit the simple evaluation report of environmental impact assessment. According the hearing to hydropower developers in El Salvador, the duration of obtaining environment permit for category 1 is in between two to six months, meanwhile for category 2 in Group B, the duration is in between eight to ten months.

(3) Concession Awarding Procedures

The small hydropower developers are required to obtain the concession no matter the developer is private or public. The general procedure to awarding the concession is as follows;

- (Procedure 1) Obtaining the environmental permit from MARN
- (Procedure 2) Obtaining study permit on hydroelectric and geothermal resources from SIGET
- (Procedure 3) Request the concession awarding to SIGET after completing the study.
- (Procedure 4) After reviewing the application documents by SIGET, the application is transferred to Congress for approval.
- (Procedures 5) Concession is awarded to developer upon approval of Congress.

The current law of concession does not stipulate the duration of the time for evaluation and approval of awarding concession. There are several cases that take years to obtain the concession in El Salvador.

4.4 Related Institutions for Small Hydropower Development

The related institutions and its role of small hydropower development are summarized in Table 4.4.1. Among these institutions listed in Table 4.4.1, SIGET and MARN are the important institutions related to the small hydropower development.

Table 4.4.1 Institutions Responsible for Relevant Aspects in Development of Renewable Energies

Entity	Responsibilities
Department of Public Assets Control in the Republic's Attorney General Office	- Participate in the approval process of notarization. - Inscription of real estate acquired in the respective Real Estate Property Registry.
Civil Unit of the Attorney General Office	- Participation in titling procedures for real estate that have no duly registered property titles. - Participation in expropriation trials if necessary.
Courts with Territorial Jurisdiction	- Participation to solve cases of dispute or conflict, when owners do not reach an agreement on the terms of indemnification of the real estate to be occupied. - Participation in the processes of solving legal problems on real estate
National Registry Center	- The institution responsible for cadaster registry provides documentation regarding updated status of real estate, approval of plans of simple segregation, registration and disencumberment, and transference of real estate.
Department of Housing and Urban Development	- Construction permits and work acceptance.
National Energy Council (CNE)	- The institution responsible for establishing and promoting the energy policy and strategy on promoting renewable energy development.
General Superintendence of Electricity and Telecommunications (SIGET)	- The institution responsible in applying the regulations on electricity and telecommunications. - Implementation of the actions, contracts and operations that are necessary to comply with the objectives established by laws, regulations and other provisions that rule the sectors of electricity and telecommunications.
Municipal Governments	- Regulations and development of plans and programs destined to the preservation, restoration, rational use and improvement of natural resources, according to the law. - Issuance of local ordinances and regulations. - Prepare tax rates and reforms, and propose them as laws to the Legislative Assembly. - Construction permits.
Ministry of Environment and Natural Resources (MARN)	- Article 22 of the Environmental Law establishes that MARN will classify the activity, work or project, according to its magnitude and to the nature of the potential impact. With that, the type of environmental documentation that the holder must submit, technically and legally, could be determined. Thus this facilitates the EIA, understood as the process or collection of procedures that allows the state, based on such EIA, to evaluate the environmental impacts that the execution of a specific work, activity or project can cause to the environment
General Superintendence of Electricity and Telecommunications	- Coordinate Concessions Award
Congress	- Legal Award of Concessions
Municipalities	- Authorize permit of construction in the municipality. Determine taxes based on assets and construction budget.
Communities	- Participate in Public Consultation

Source: JICA Study Team

4.5 Small Hydropower Potential

4.5.1 Small Hydropower Potential indentified in Renewable Energy Master Plan Project

As mentioned in the section 4.2.1, the renewable energy master plan prepared in 2012 by CNE-JICA, identified 209 sites potential development. Total capacity is estimated at 180.8 MW and the estimated mean annual energy is 756 GWh. Of the identified 209 sites, 123 sites were selected as candidate projects for the master plan.

4.5.2 Identification of Small Hydropower through Desk Study

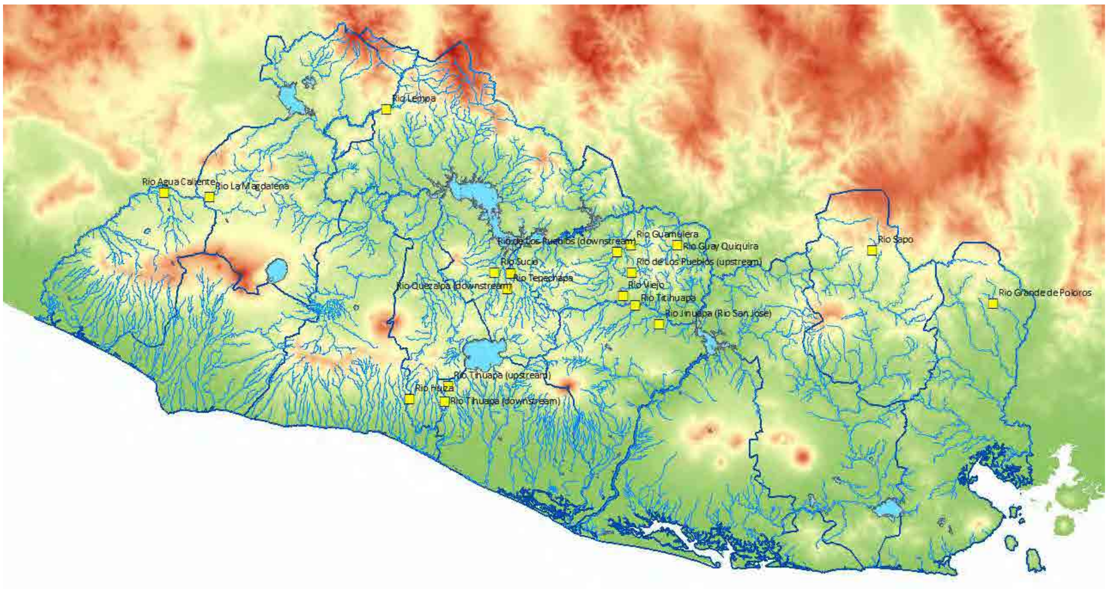
In the renewable energy master plan, the small hydropower master plan was formulated as an indicative development plan based on assumed development capacity by referring to the existing small hydropower study results.

In the existing hydropower studies, there are many projects conducted by universities and private companies without information on catchment areas, discharges and heads. To clarify such information and to review prospective small hydropower potential sites all over the country from the view point of catchment areas and heads, the desk study was conducted. 54 topographic maps with 1/50,000 scale covering the entire country were used for the desk study.

The desk study was conducted by taking into account of two major aspects, i.e., (i) the candidate sites should have at least around 40 km^2 of catchment area in view of securing required discharge for power generation, and (ii) the candidate sites should have at least 40 m heads in the topographic maps.

As a result of the desk study, 18 sites were selected as prospective candidate sites for small hydropower development.

The hydropower potential sites identified in the JICA Study Team are as shown in Figure 4.5.1.



Source: JICA Study Team

Figure 4.5.1 Small Hydropower Potential Sites Identified in the Study

The sites and related details of the potential sites identified in the desk study are shown in Table 4.5.1.

Table 4.5.1 Small Hydropower Potential Identified in the Study

No.	Project Name	Department	Catchment Area (km²)	Design Discharge (m³/s)	Gross Head (m)	Potential (MW)	Energy (MWh/Year)	Plant Factor
1	Rio La Magdalena	Santa Ana	41	1.5	20.	0.267	698	30%
2	Rio Agua Caliente	Ahuachapan	176	2.5	20	0.428	2,349	63%
3	Rio Sucio	Cuscatlan	72	2.2	50	0.965	4,419	52%
4	Rio Lempa	Chalatenango	1,105	12.3	40	4.264	24,376	65%
5	Rio de Los Pueblos (upstream)	Cabañas	40	1.0	40	0.365	1,501	47%
6	Rio de Los Pueblos (downstream)	Cabañas	112	3.4	10	0.291	1,333	52%
7	Rio Titihuapa	Cabañas	297	5.5	30	1.410	9,013	73%
8	Rio Jinuapa (Rio San Jose)	San Vicente	49	0.8	60	0.444	2,127	55%
9	Rio Viejo	Cabañas	25	0.5	100	0.472	2,745	66%
10	Rio Tepechapa	Cuscatlan	38	1.3	30	0.348	1,428	47%
11	Rio Quezalpa (downstream)	Cuscatlan	200	5.6	20	0.974	4,763	56%
12	Rio Sapo	Morazan	46	3.0	120	3.174	9,968	36%
13	Rio Grande de Poloros	La Union	45	3.0	110	2.898	6,408	25%
14	Rio Tihuapa (upstream)	La Paz	18	1.3	110	1.215	2,891	27%
15	Rio Tihuapa (downstream)	La Paz	35	1.7	50	0.756	2,262	34%
16	Rio Huiza	La Liberdad	35	1.7	110	1.667	4,987	34%
17	Rio Guamulera	Cabañas	40	1.2	40	0.427	1,954	52%
18	Rio Guay Quiquira	Cabañas	45.7	1.3	40	0.447	2,185	56%

Source: JICA Study Team

4.6 Screening of Small Hydropower Potential Sites

The hydropower potential sites which are listed in the renewable energy master plan and the hydropower potentials identified in this study are further examined to find potential sites for future candidate of the small hydropower investment by JICA-IDB. The procedure of the screening is as follows:

(1) Procedure

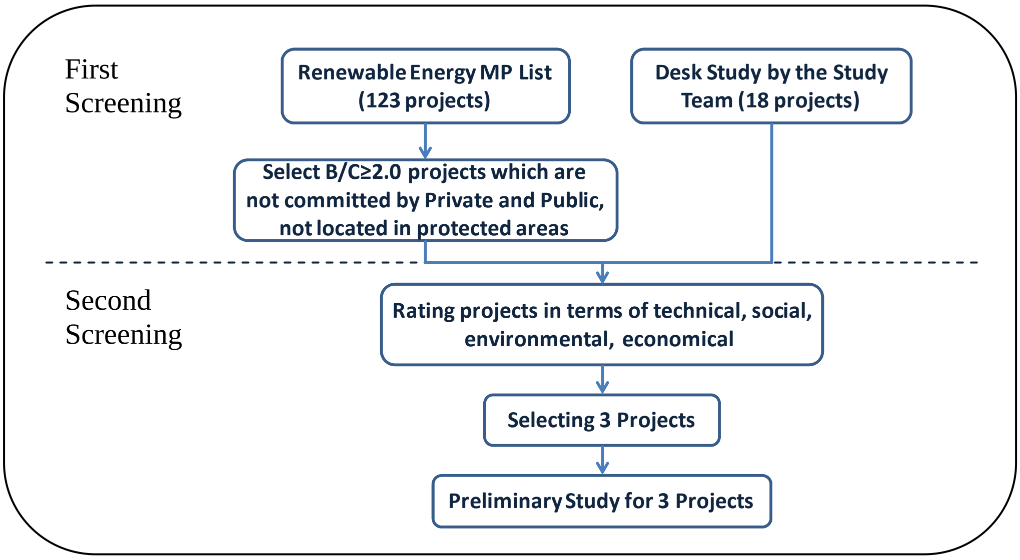
First Screening

At first, the projects which have B/C value more than around 2.0 are selected from the 123 potential sites which are listed in the renewable energy master plan. The number of the selected project is 21. For this selection, potential sites located in the natural protected area were excluded. And the potential sites where private developers or public company has already committed for development were also excluded. Meanwhile, this study identified 18 small hydropower projects as described in sub-section 4.5.2. Therefore total numbers of 39 projects were selected as the result of the first screening.

Second Screening

As second screening, 39 small hydropower potential sites selected in the first screening were further evaluated with applying various criteria with respect to technical, social environment, natural environment, and economical. Based on the evaluation in the second screening, three projects were selected for further detailed survey.

The procedure of the project screening is as shown in Figure 4.6.1.

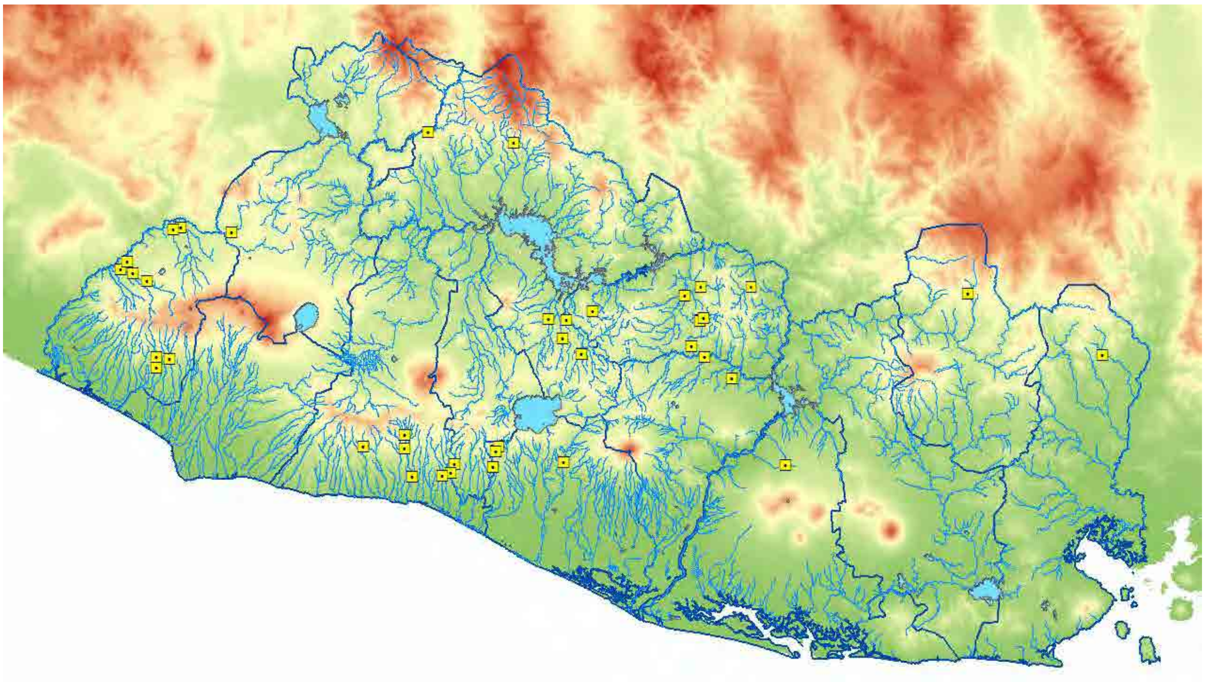


Source: JICA Study Team

Figure 4.6.1 Procedure of the Project Screening

(2) First Screening

The locations of 39 projects selected by the first screening are shown in Figure 4.6.2.



Source: JICA Study Team

Figure 4.6.2 Project Selected by the First Screening

(3) Second Screening

The selected 39 projects were evaluated using a method called "Multi-Criteria Decision Analysis" (MCDA). This method aims to make a proper decision for selecting the best options among others by evaluating them with several criteria. In MCDA, several criteria are set and each of the criteria has its own sub-criteria. The options are evaluated by the sub-criteria, and aggregated to count the total score. In this study, the selected 39 potential hydropower potential sites were evaluated by four criteria, namely "technical", "social environment", "natural environment", and "economic". Each of the criteria had sub-criteria, for example, the technical criteria had sub-criteria of "hydrological risk", "geological risk", and "access difficulty". The evaluation criteria used in the study is as shown Table 4.6.1.

Table 4.6.1 Evaluation Criteria

Criteria	Technical		Social Environment		Natural Environment		Economic	
	Sub Criteria	Full Score	Sub Criteria	Full Score	Sub Criteria	Full Score	Sub Criteria	Full Score
1	Hydrological Risk	8.33	No. of houses affected	12.5	Length of A/R of intake	12.5	Benefit – Cost Ratio	12.5
2	Geological Risk	8.33	Water use near project	12.5	Length of A/R of Powerhouse	12.5	Project Scale	12.5
3	Access Difficulty	8.33						
Total Score	25		25		25		25	

Source: JICA Study Team, A/R: Access Road

(4) Rating Result

The result of the rating of each criterion is as shown in Table 4.6.2.

Table 4.6.2 Rating Result of Small Hydropower

Technical Weighted		Social Weighted		Natural Weighted		Economic Weighted		Overall Ranking		
Ranking	Project Location	Ranking	Project Location	Ranking	Project Location	Ranking	Project Location	Score	Ranking	Project Location
1	Rio Sucio	1	Los Hervideros I	1	Rio Agua Caliente	1	Los Hervideros I	69.2	1	Los Hervideros I
2	Rio Agua Caliente	2	Rio Viejo	2	Rio de Los Pueblos (downstream)	1	Malancola	68.3	2	Rio Agua Caliente
3	Río Frío / Agua Caliente	3	Loma de San Juan	3	Rio Viejo	3	Rio Lempa	67.5	3	Copinula III
4	Los Hervideros I	4	Rio Quezalpa (downstream)	3	Copinula III	4	Rio Sapo	67.5	3	Rio Sucio
4	Copinula III	5	Rio Agua Caliente	5	Rio Sucio	5	Rio Viejo	67.5	3	Rio Viejo
6	Rio de Los Pueblos (downstream)	6	Rio Huiza	6	Rio Guay Quiquira	5	Rio Sucio	66.7	6	Malancola
7	Malancola	6	Rio Guamulera	7	Los Hervideros I	5	Loma de San Juan	65.0	7	Loma de San Juan
8	Rio Tepechapa	8	Copinula III	7	San Juan Buenavista	5	Copinula III	64.2	8	Rio Sapo
8	Rio Quezalpa (downstream)	8	Rio Sucio	9	Rio Tepechapa	9	Rio Grande de Poloros	64.2	8	Rio de Los Pueblos (downstream)
10	San Juan Buenavista	8	Chilama III	10	Malancola	10	Rio Agua Caliente	64.2	8	Rio Quezalpa (downstream)

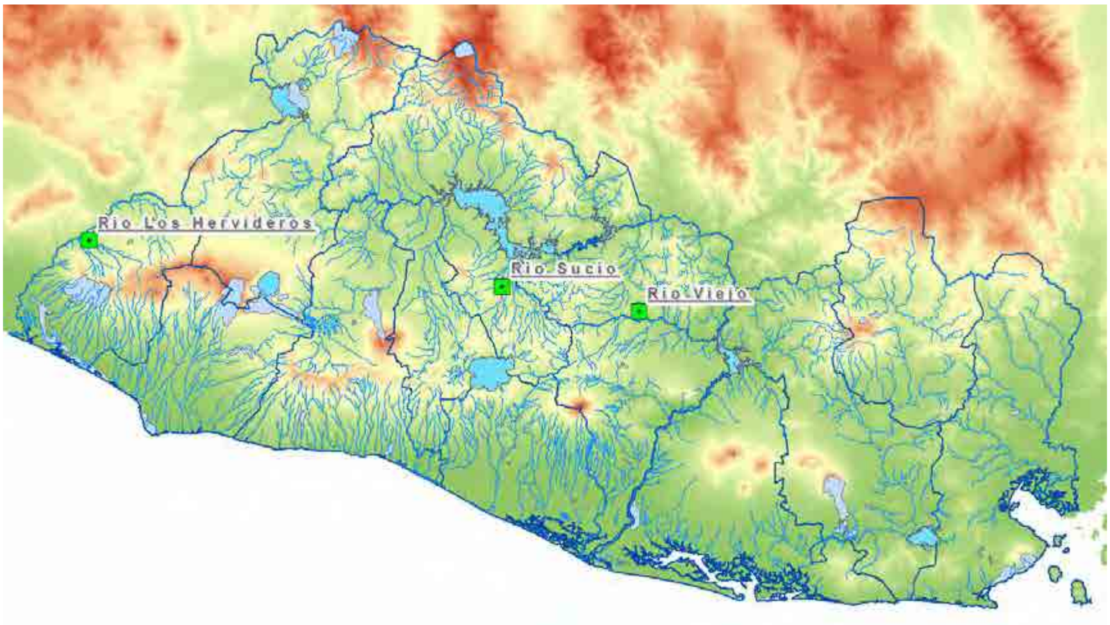
Source: JICA Study Team

From the information in Table 4.6.2, the overall ranking of the small hydropower potential sites was obtained as shown in Table 4.6.3. As shown in the table, top three projects are located in Ahuachapán department. This is due to that the mountain range in Ahuachapán department has abundant hydropower potentials because of stable flow quantity throughout the year by large annual precipitation and by the abundant groundwater runoff. However, since the projects will be implemented as pilot projects to demonstrate the hydropower development in El Salvador, it is preferable that the projects are selected from entire country rather than those from one department. Therefore the study team selected only one project which is located in Ahuachapán department. As the result, the study team selected Los Hervideros I from Ahuachapán department, a potential site located along Rio Sucio in the Cuscatlan department, and a potential site located along the Rio Viejo in Cabañas. The locations of the selected three potential sites are shown in Figure 4.6.3.

Table 4.6.3 Selection of Three Projects

Overall Ranking		Department	Selected
Ranking	Project Location		
1	Los Hervideros I	Ahuachapan	✓
2	Rio Agua Caliente	Ahuachapan	
3	Copinula III	Ahuachapan	
3	Rio Sucio	Cuscatlan	✓
3	Rio Viejo	Cabañas	✓
6	Malancola	San Salvador/La Paz	
7	Loma de San Juan	San Salvador/La Paz	
8	Rio Sapo	Morazan	
8	Rio de Los Pueblos (downstream)	Cabañas	
8	Rio Quezalpa (downstream)	Cabañas/Cuscatlan	

Source: JICA Study Team

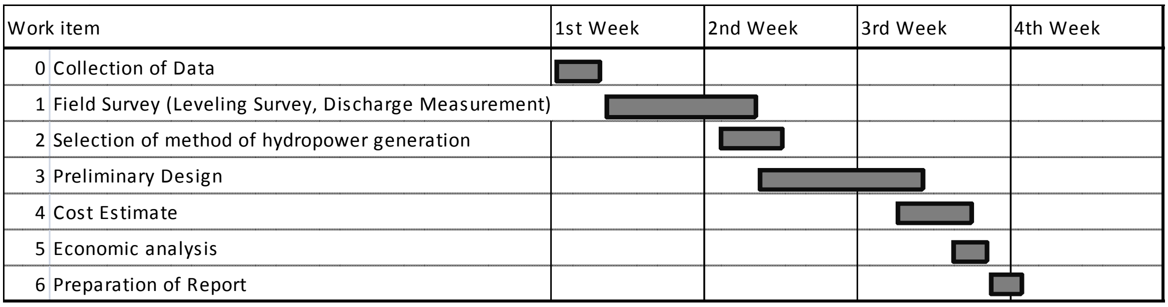


Source: JICA Study Team

Figure 4.6.3 Selected Project for Detailed Survey

4.7 Detailed Survey of Three Small Hydropower Potential Sites

The detailed survey of the three small hydropower potential sites was conducted by a local consultant under the supervision of the JICA Study Team. The work schedule of the detailed survey is as shown in Figure 4.7.1.



Source: JICA Study Team

Figure 4.7.1 Work Schedule of Detailed Survey of Three Small Hydropower Projects

4.7.1 Design Assumption

The assumptions used for the preliminary design are described as below.

(1) Intake Weir

The type of intake weir was assumed to fix concrete weir type. The type of energy dissipater was set to be of ski jump type or endsill type depending on the riverbed condition.

(2) Maximum Design Discharge

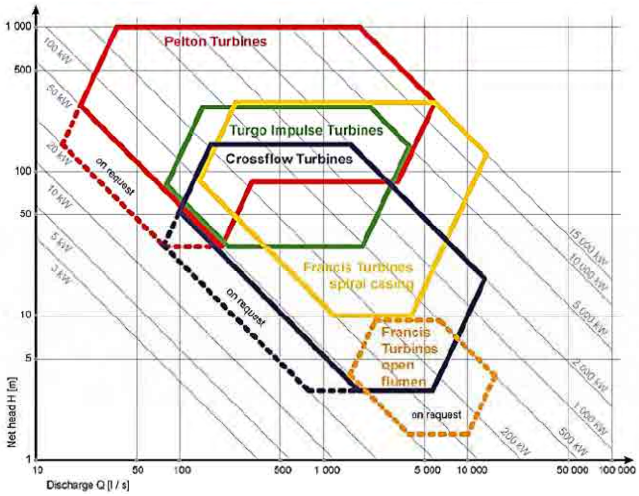
The maximum design discharge of the plant was set at 25% of flow duration curve, as the design discharge of the plant were generally in between 20% and 30% in El Salvador.

(3) Hydraulic Head

The hydraulic head was measured from the head tank water level to the center of the turbine. The loss of hydraulic head includes friction loss and miscellaneous losses such as screen loss at intake.

(4) Turbine Type Selection

The type of the turbine was selected using monogram with hydraulic head and maximum design discharge per unit as shown in Figure 4.7.2,



Source: Ingendehsa S.A. de C.V.

Figure 4.7.2 Design Monogram for Selection of Turbine

(5) Construction Cost

The construction cost was estimated using the relation between the cost and the weir size, or between the cost and the channel size which were generally applicable in Latin American region. The cost of distribution line was estimated to 20,000US$/km which included land acquisition and construction cost.

(6) Financial Evaluation

The financial evaluation of the project assumed conditions that project life to be 50 years, interest of loan to be 8%, the grace period to be 2 years, repayment years to be 10 years after the grace period. The selling price of electricity was derived from the average price of energy of CLESA (a distribution company) has been authorized for the years 2008-2013 by SIGET, and further eliminating the margin of distribution company, which results in a value of US$ 0.158/kWh. The price was increased by 3% annually based on price changes for the project period. The operation and maintenance cost was 0.35US$/MWh with an annual increase of 2 %. The income tax to gross profit of 30% starting the eleventh year of operation was considered (according to the new Renewable Energy Law passed in December 2007). For the calculation of B/C, the discount rate of 10% was considered.

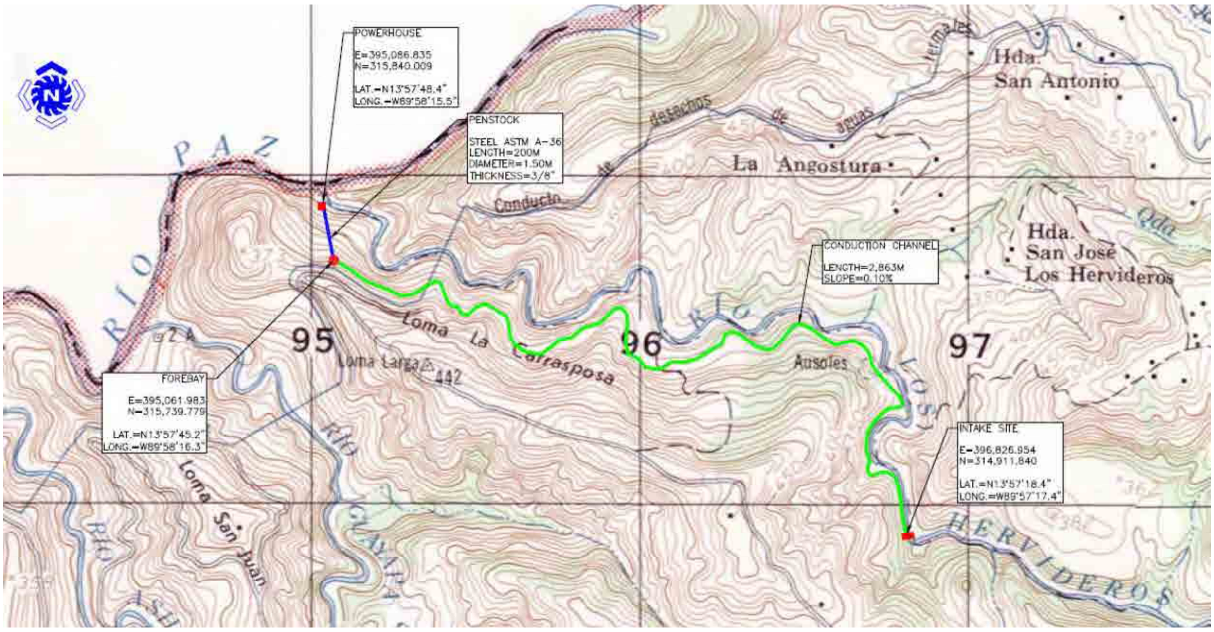
4.7.2 Los Hervideros I Hydropower in Rio Los Hervideros

(1) Location

Hydropower potential site of Los Hervideros I is located along the Los Hervideros River which flows along the boundary of Takuba municipality and Ahuachapán municipalities. The location of the site is close to the boarder to Guatemala. The powerhouse is located at 100 m upstream from the point of confluence between the Los Hervideros River and La Paz River which shapes the border of Guatemala and El Salvador.

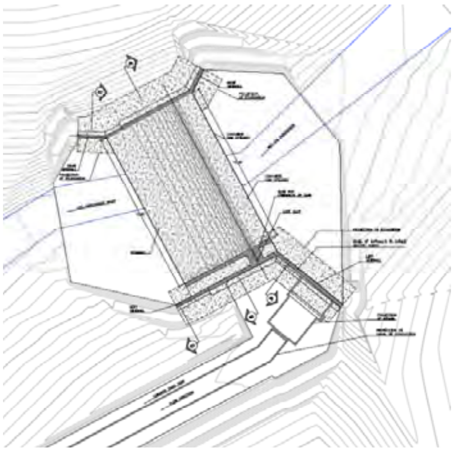
(2) General Layout

The Los Hervideros I hydropower is designed as run-of-river type hydropower. The water is taken at a weir with 9 m width and 5 m height, and then conveyed through 2.8 km waterway to the head tank. From the head tank, the water is transported to the powerhouse through a steel penstock with diameter of 1.50 m and a length of 200 m. The turbine-generator equipped with Francis turbines is designed in the powerhouse. The turbine flow is discharged back to Los Hervideros River through a tailrace canal with a length of 10 m.

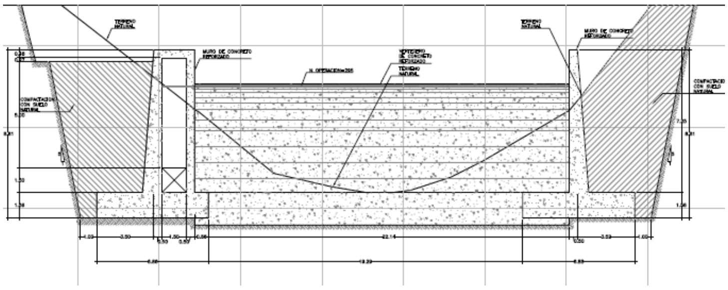


Source: JICA Study Team

Figure 4.7.2 General Plan of Los Hervideros I Project



Plan of Water Intake



Section of Water Intake

Source: JICA Study Team

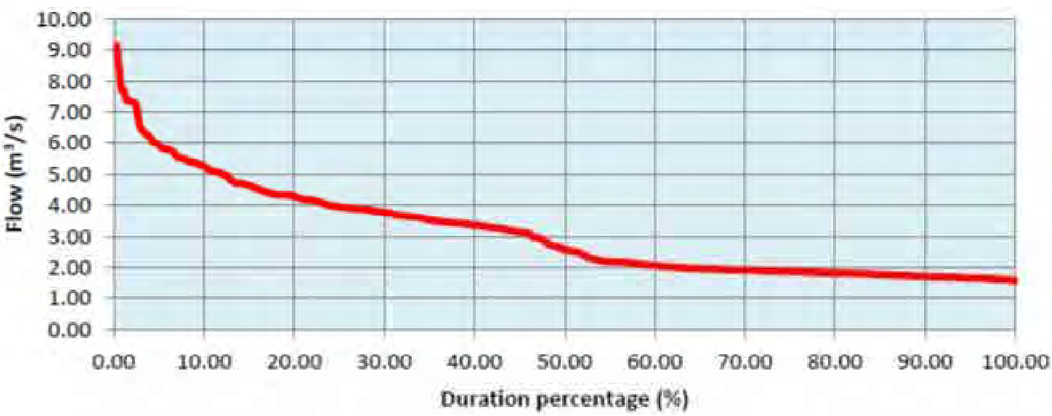
Figure 4.7.3　Plan and Section of Water Intake

(3) Geological Condition

At the intake weir site, rock of volcanic agglomerate somewhat altered with small fractures was observed. There is also evidence of an inactive fault upstream of the proposed intake weir. At the powerhouse site no recent landslides or flooding influencing on the stability of the site were observed.

(4) Hydrological Condition

There was no discharge measuring station along the Los Hervideros River. In order to estimate the plant discharge of Los Hervideros I, the record of discharge measured at Papaloate hydropower station was used. The Papaloate hydropower station is located along the Rio Grande de Sensunapán which is originated from the mountain range in Ahuachapán department. The discharge of the Los Hervieros River was estimated by multiplying a ratio of catchment area between that of Papaloate (Catchment area: 95.94 km^2) and Los Hervideros I (Catchment area: 24.04 km^2). The flow duration curve estimated for Los Hervideros I is as shown in Figure 4.7.4.



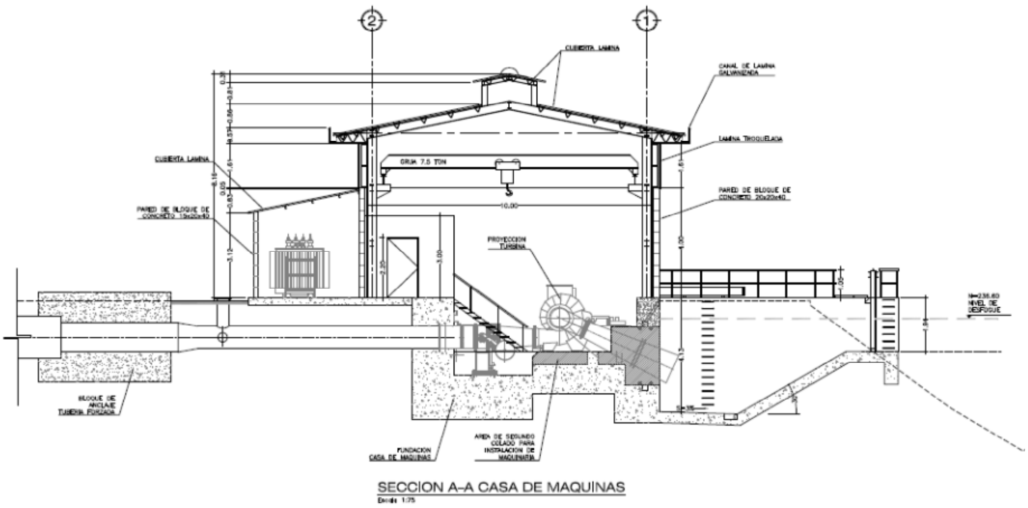
Source: JICA Study Team

Figure 4.7.4　Flow Duration Curve at Intake Site of Los Hervideros I

According to the discharge measurement conducted on February 4, 2014 when it is considered in the dry season, the measured discharge at the site was 2.38 m^3/s, and this quantity was greater than the 90% discharge of 1.7 m^3/s in the flow duration curve.

(5) Installed Capacity

The installed capacity of Los Hervideros I hydropower was determined based on the design discharge of 4.00 m^3/s, an effective head of 54.59 m and the efficiency of the turbine-generator equipment. The maximum capacity of the project has been estimated at 1,870 kW. The annual energy was estimated at 9,177,706 kWh, which corresponded to a plant factor of 0.56.



Profile of Powerhouse

Source: JICA Study Team

Figure 4.7.5 Profile of Powerhouse of Los Hervideros I Project

(6) Financial Evaluation

Los Hervideros I hydroelectric project has an installed capacity of 1,870 kW, annual energy generation of 9,177,706 kWh and a plant factor of 0.56. According to this result, the preliminary financial evaluation results were obtained as follows:

o Total investment US$ 7,900,000

o Internal Rate of Return 24.81%

o Benefit-Cost Ratio 2.85

o Cost per kW US$ 4,225

(7) Summary

The result of the detailed survey of the Los Hervideros I project is summarized as below.

Table 4.7.1 Summary Table of Los Hervideros I

Item	Unit	Value/Name
Project Name		Los Hervideros I
River Name		Rio Los Hervideros
Catchment Area	sq.km	95.94
Average Discharge	cms	3.10
Dam height	m	5.00
Waterway length	m	2,900
Turbine Type		Francis with horizontal axis
Capacity of Turbine	kW	935
Nos. of unit	unit	2.00
Total Capacity	kW	1870
Annual Energy	kWh	9,177,706
Design Discharge per unit	cms	2.00
Effective Head	m	55
Transmission Line	m	11.00
Generator Type		Synchronous, Triphasic
Project Cost	US$	7,900,000
Project IRR	%	24.8
Repayment Year	year	5.7

Source: JICA Study Team

(8) Anticipated Issues on Development

The anticipated issues for development of Los Hervideros I is as follows:

1) Land acquisition for distribution line construction

The electricity generated at Los Hervideros I is necessary transmitted to the grid through 13.2 kV distribution lines. However, such high voltage distribution lines are not placed near the planned powerhouse location. Therefore, this study assumes that 11 km length distribution lines are constructed to connect to the substation in Tacuba city from the powerhouse. It is anticipated that the land acquisition for the new distribution lines take some time.

2) Water-use of the community

The water of the Los Hervideros River is utilized by local communities for their daily life such as bathing or washing. If the project is implemented, it is proposed to provide water supply facilities for local communities.

(9) Photograph of Site

The photograph of the candidate site for the water intake and the powerhouse are shown in the photos as follows.

	
Planned Intake Site	Planned Powerhouse Site
Site Pictures of Planned Intake and Powerhouse of Los Hervideros I	

Source: JICA Study Team

4.7.3 El Manzano Hydropower in Rio Sucio

(1) Location

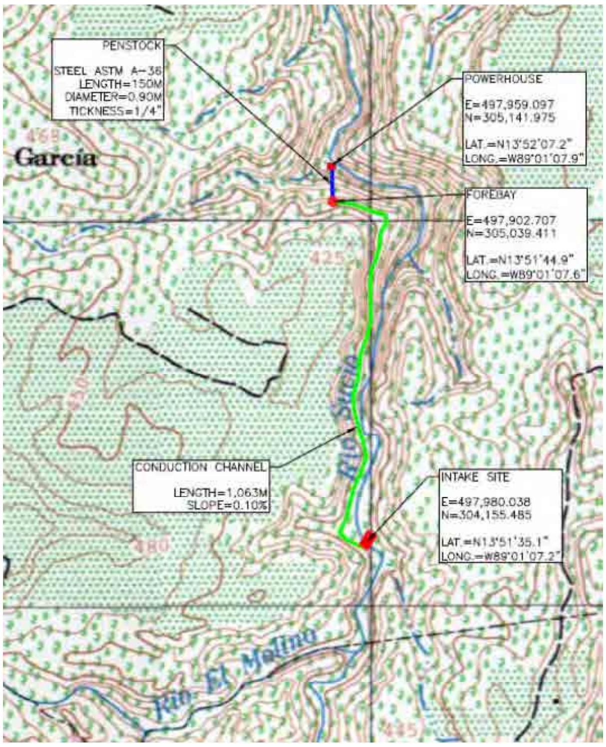
The El Manzano hydropower potential site is located eight kilometers down to south direction from the Suchitoto town in Suchitoto municipality, Cuscatlan Department. The site is located 11 km upstream from the outlet of the Sucio River to the Cerron Grande reservoir.

(2) General Layout

The El Manzano hydropower project is designed as run-of-river type hydropower. El Manzano project is consisted of an intake weir with 10 m width and 2.50m height, waterway with a length of 11,063 m, a head tank, a sand trap, a steel penstock and a powerhouse. The steel penstock has a diameter of 0.90 m, and a length of 150 m. The turbine-generator equipped with Francis turbine is designed in the powerhouse. The turbine flow is discharged back to the Sucio River through a tailrace canal with a length of 10 m. The general layout of the project is as shown in Figure 4.7.6.

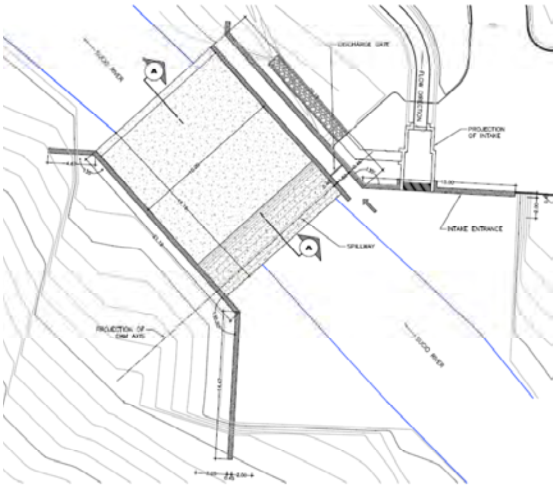
(3) Geological Condition

At the dam site andesitic-basaltic rock compact with large crystals was observed with porfiditica texture, somewhat altered. The site rock is stable. In addition, contact with volcanic tuff and agglomerate was observed. At the site of the powerhouse a stable structural terrace with a high average gradient resting on lithic tuff rock type was observed. Small landslides were observed bear the powerhouse site, however, such landslides were judged not to affect to the powerhouse site.

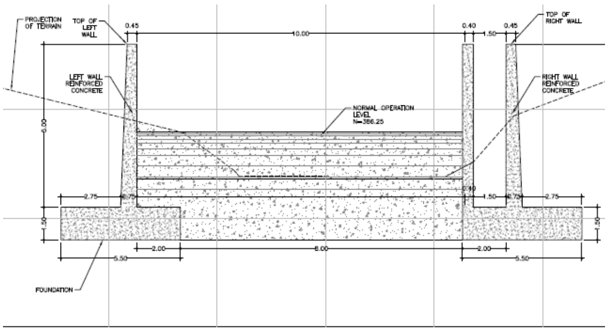


Source: JICA Study Team

Figure 4.7.6 General Plan of El Manzano



Plan of Water Intake



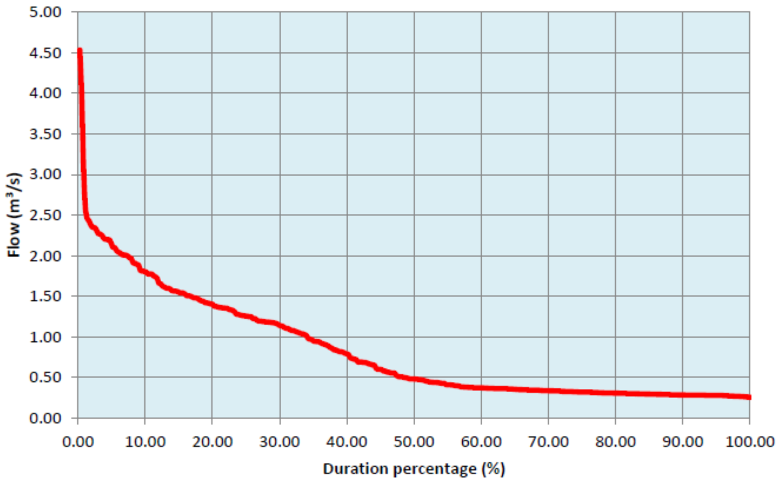
Section of Water Intake

Source: JICA Study Team

Figure 4.7.7 Plan and Section of Water Intake of El Manzano Project

(4) Hydrological Condition

A 12-year historical average daily flow series of the Suchitoto station, located in the Quezalapa River approximately 8 kilometers downstream of the El Manzano hydroelectric project intake weir site, was obtained. This 12 years series data was transposed to the project intake weir site using the ratio of the catchment area of the project intake weir site (Catchment area: 73.68 km^2) and the drainage area of the Suchitoto station (Catchment area: 407 km^2).



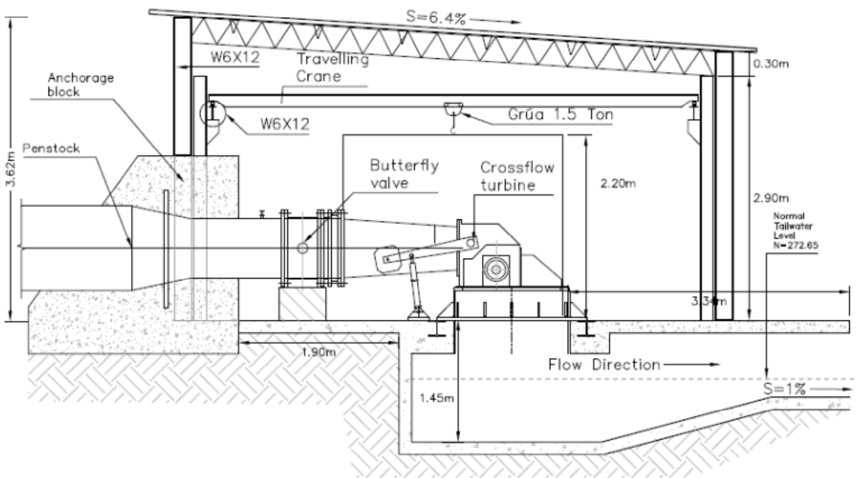
Source: JICA Study Team

Figure 4.7.8 Flow Duration Curve of Intake Site of El Manzano

According to the discharge measurement conducted on February 10, 2014 when it is considered in the dry season, the measured discharge at the site was 0.3 m^3/s, and this quantity was almost the same to the 90% discharge of 0.28 m^3/s in the flow duration curve.

(5) Installed Capacity

The installed capacity of the El Manzano hydropower project was determined based on the design discharge of 1.25m^3/s, an effective head of 66.07m and the efficiency of the turbine-generator equipment. The maximum capacity of the project has been estimated at 664 kW. The annual energy is estimated at 2,223,247 kWh, corresponding to a plant factor of 0.38.



<u>Profile of Powerhouse</u>

Source: JICA Study Team

Figure 4.7.9 Profile of Powerhouse of El Manzano Project

(6) Financial Evaluation

The El Manzano hydroelectric project has an installed capacity of 664 kW, annual energy generation of 2,223,247 kWh and a plant factor of 0.38. According to this result, the preliminary financial evaluation results were obtained as follows:

o Total investment US$ 2,400,000

o Internal Rate of Return 11.22%

o Benefit-Cost Ratio 1.16

o Cost per kW US$ 3,614

(7) Summary

The results of the detailed survey of the El Manzano project are summarized below.

Table 4.7.2 Summary Table of El Manzano

Item	Unit	Value/Name
Project Name		El Manzano
River Name		Rio Sucio
Catchment Area	sq.km	73.68
Average Discharge	cms	0.83
Dam height	m	2.50
Waterway length	m	1,100
Turbine Type		Crossflow
Capacity of Turbine	kW	664
Nos. of unit	unit	1.00
Total Capacity	kW	1870
Annual Energy	kWh	2,223,247
Design Discharge per unit	cms	1.25
Effective Head	M	67.00
Transmission Line	M	4.00
Generator Type		Synchronous, Triphasic
Project Cost	US$	2,400,000
Project IRR	%	10.0
Repayment Year	year	7.2

Source: JICA Study Team

(8) Anticipated Issues on Development

The anticipated issues for development of El Manzano are as follows:

1) Foundation of intake weir site

During the site visit, it was observed that the gravel material was accumulated in the riverbed of the planned intake weir site. The designing of intake weir foundation requires careful assessment of geology.

2) Access to planned powerhouse site

As the planned powerhouse is located at the bottom of the steep valley, the construction of access road may have difficulty in excavation and stabilization of slope. The careful consideration of geology and treatment of slope is required.

3) Land acquisition

It was found that the land close to the planned intake weir site was cultivated for farmland, and the land should be acquired for project implementation. The necessity of land acquisition of farm land was also anticipated for construction of the access road to the planned powerhouse.

4) Financial Feasibility

IRR of the El Manzano project was resulted to 10 % and the result did not indicate that the project is financially good project. It is necessary to confirm the project viability though updating the discharge estimate by conducting the discharge measurement and updating estimation of power generation.

(9) Photograph of Site

The photographs of the candidate site for the water intake and powerhouse are shown in the following photos.

Planned Intake Site

Planned Powerhouse Site

Site Pictures of Planned Intake and Powerhouse at El Manzano

Source: JICA Study Team

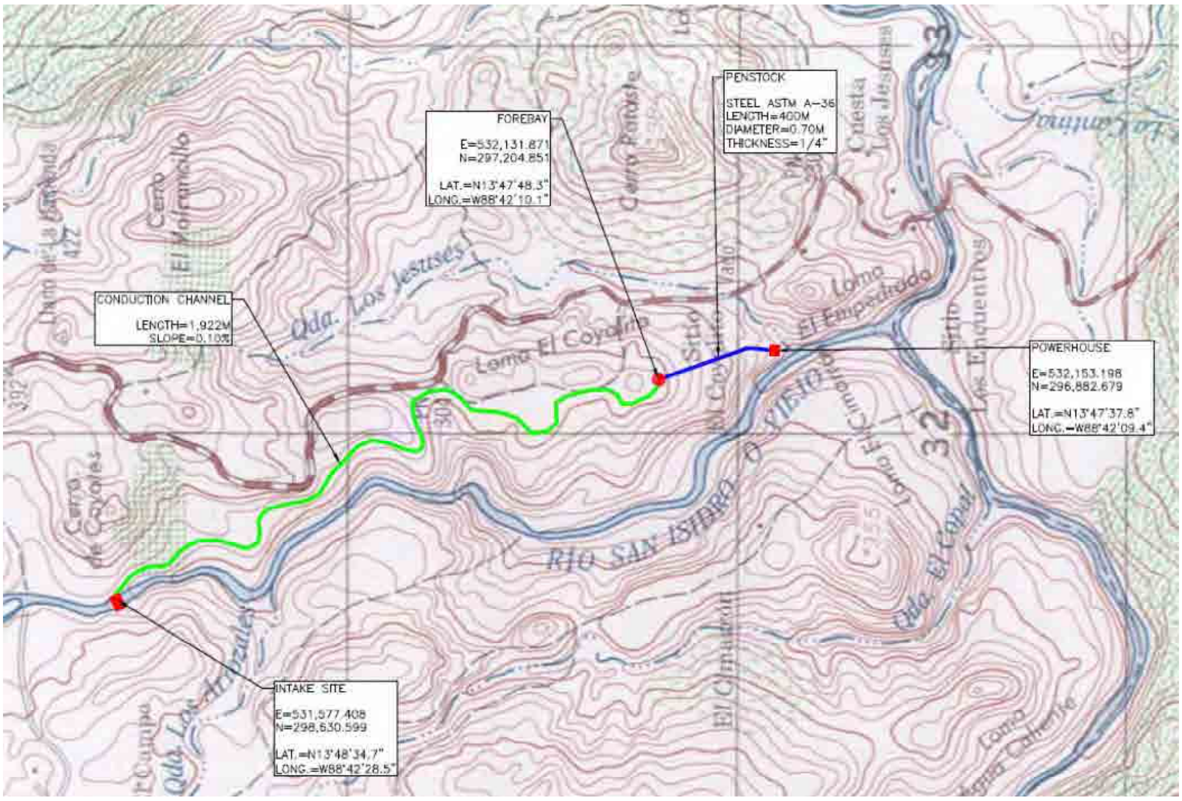
4.7.4 Los Coyotes Hydropower in Rio Viejo

(1) Location

The Los Coyotes hydroelectric project is located three kilometers down to south direction from the town of San Isidro, Cabañas department. The site is located three kilometers upstream from the confluence between the Viejo River and the Titihuapa River.

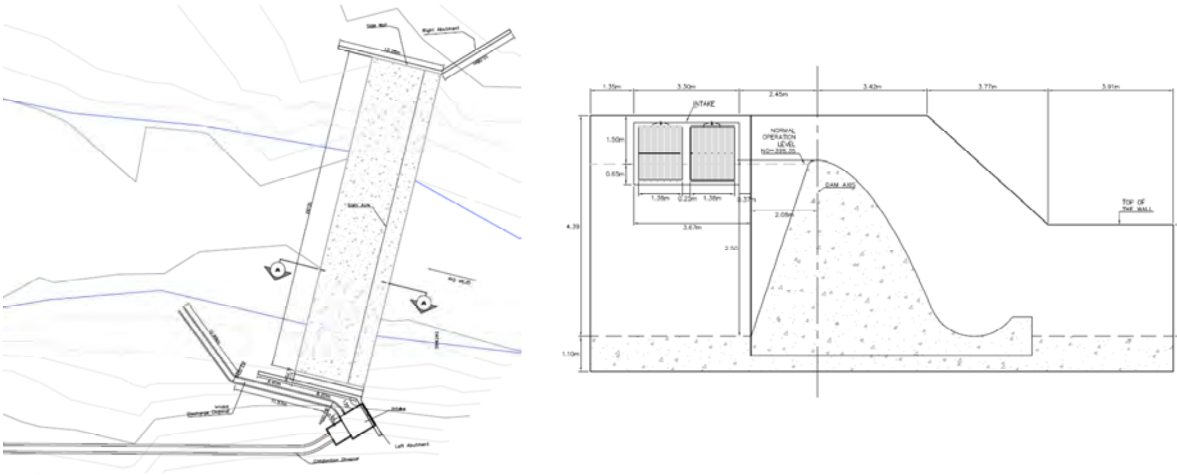
(2) General Layout

The Los Coyotes hydroelectric project is designed as a run-of-river type hydropower. Los Coyotes project consists of an intake weir with a width of 10 m and a height of 2.50 m, waterway with a length of 1,922 m, a head tank, and steel penstock with a diameter of 0.70 m and a length f 400 m. The turbine-generator equipped with a Pelton turbine is designed in the powerhouse. The turbine flow is discharged back to the Viejo River through a tailrace canal with a length of 10 m.



Source: JICA Study Team

Figure 4.7.10 General Plan of the Los Coyotes Project



Plan of Water Intake

Profile of Water Intake

Source: JICA Study Team

Figure 4.7.11 Plan and Profile of Water Intake

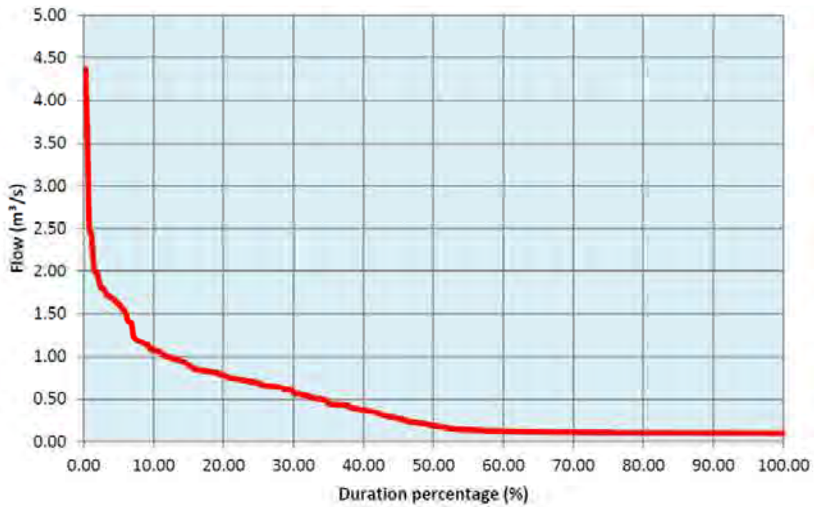
(3) Geological Condition

At the intake weir site andesitic volcanic rock type was observed with fractures filled with quartz. Its appearance shows vesicles that have generated voids in the rock as a result of the weathering and erosion to which they have been exposed. This rock is very stable and compact, ideal for building an intake weir.

The intake weir site has very stable slopes and large-scale landslides in this area have not been recognized. At the site of the powerhouse is a stable structural terrace. No recent landslides have been observed and the slopes are stable. Nor does evidence of influence of river flooding exist. Outside the planned powerhouse area, fallen tuff blocks are observed, so the selected place is considered the most suitable for the location of the powerhouse.

(4) Hydrological Condition

A 9-year historical average daily flow series of the Vado García station, located in the Titihuapa River approximately 3 kilometers downstream of the Los Coyotes hydroelectric project intake weir site, was obtained. This nine year time series of data was transposed to the project intake weir site using the ratio of the catchment area of the project intake weir site(Catchment area: 28.79 km^2) and the catchment area of the Vado García station (Catchment area: 559 km^2).



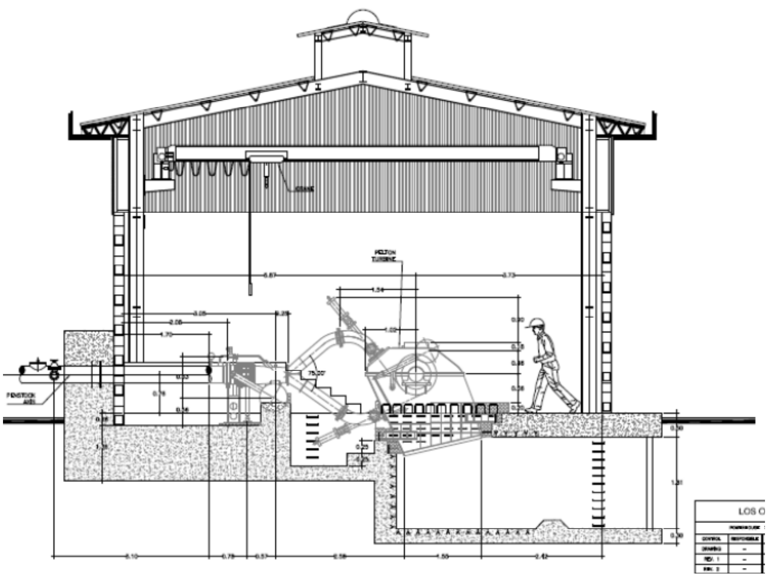
Source: JICA Study Team

Figure 4.7.12 Flow Duration Curve of Intake Site of the Los Coyotes Project

According to the discharge measurement conducted on 10th February 2014 when it is considered in the dry season, the measured discharge at the site was 0.03 m^3/s, and this quantity was much less than the 90% discharge of 0.1 m^3/s in the flow duration curve.

(5) Installed Capacity

The installed capacity of the Los Coyotes hydropower project was determined based on the design discharge of 0.70m^3/s, an effective head of 122.10m and the efficiency of the turbine-generator equipment. The maximum capacity of the project has been estimated at 687 kW. The annual energy was estimated to 1,771,104 kWh, which corresponded to a plant factor of 0.29.



Profile of Powerhouse

Source: JICA Study Team

Figure 4.7.13 Profile of Powerhouse of Los Coyotes Project

(6) Financial Evaluation

The Los Coyotes hydroelectric project has an installed capacity of 687 kW, an annual energy generation of 1,771,104 kWh and a plant factor of 0.29. According to this result, the preliminary financial evaluation results were obtained as follows:

o Total investment US$ 2,700,000

o Internal Rate of Return 1.20%

o Benefit-Cost Ratio 0.37

o Cost per kW US$ 3,943

(7) Summary

The results of the detailed survey of the Los Coyotes project are summarized below.

Table 4.7.3 Summary Project Feature of Los Coyotes

Item	Unit	Value/Name
Project Name		Los Coyotes
River Name		Rio Viejo
Catchment Area	sq.km	28.79
Average Discharge	cms	0.46
Dam height	m	2.50
Waterway length	m	1,900
Turbine Type		Pelton
Capacity of Turbine	kW	687
Nos. of unit	unit	1.00
Total Capacity	kW	687
Annual Energy	kWh	1,771,104
Design Discharge per unit	cms	0.70
Effective Head	m	123.00
Transmission Line	m	6.00
Generator Type		Synchronous, Triphasic
Project Cost	US$	2,700,000
Project IRR	%	1.2
Repayment Year	year	10.1

Source: JICA Study Team

(8) Anticipated Issues on Development

The anticipated issues for development of Los Coyotes are as follows:

1) Extremely low flow in dry season

The discharge measurement conducted in the preliminary survey found that the discharge in dry season is quite lower than expected in the desk study. Desk study estimated 0.18 m^3/s while actual discharge was only 0.03 m^3/s. Houses are densely located along the arterial road running across the catchment of the Los Coyotes. It is likely that surface runoff is caught by the road and the water is used for domestic use or irrigation. The low quantity of discharge may worsen the IRR of 1.2% and this indicates that the project is not viable.

(9) Photographs of Site

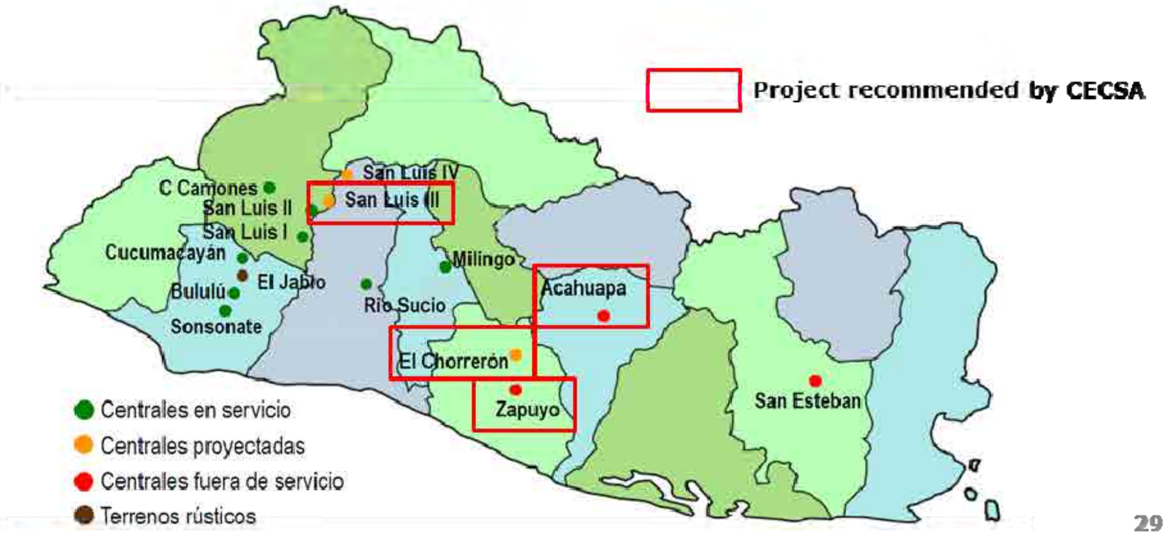
The photographs of the candidate site for the water intake and powerhouse are shown in the following photos.

Planned Intake Site	Planned Powerhouse Site
Site Pictures of Planned Intake and Powerhouse at Los Coyotes	

Source: JICA Study Team

4.8 Projects of CECSA

In order to examine the existing small hydropower studies developed by the public sector, the JICA Study Team received four feasibility study reports from CECSA. The locations of the projects provided by CECSA are shown in Figure 4.8.1.



Source: CECSA

Figure 4.8.1 Location of Projects Provided by CECSA

After reviewing the contents of the provided feasibility study reports, the JICA Study Team found that the feasibility study of Zapuyo and Acahuapa were not complete because the final design was not clearly defined although alternative studies were conducted in the feasibility study report. The feasibility study of El Chorreron project showed the project features of the final layout of the project, but the layout plan of facility and profile of project structure was still not clear, and it was judged that the study was still incomplete.

It was found that the feasibility study of San Luis III was still insufficient as the geology of the project site was not assessed in the study, however, since the principle feature and layout of the project was clearly defined, it was expected that the study could be completed with conducting additional survey such as geological survey. In this connection, San Luis III project was taken up in this detailed survey as a prospective project. However, since the study report was provided from CECSA just before the end of field survey in El Salvador, the JICA Study Team did not conduct the field survey of San Luis III due to limited available time. The content of the study should be confirmed through the field survey prior to the project implementation.

The details of the San Luis III project are described as follows.

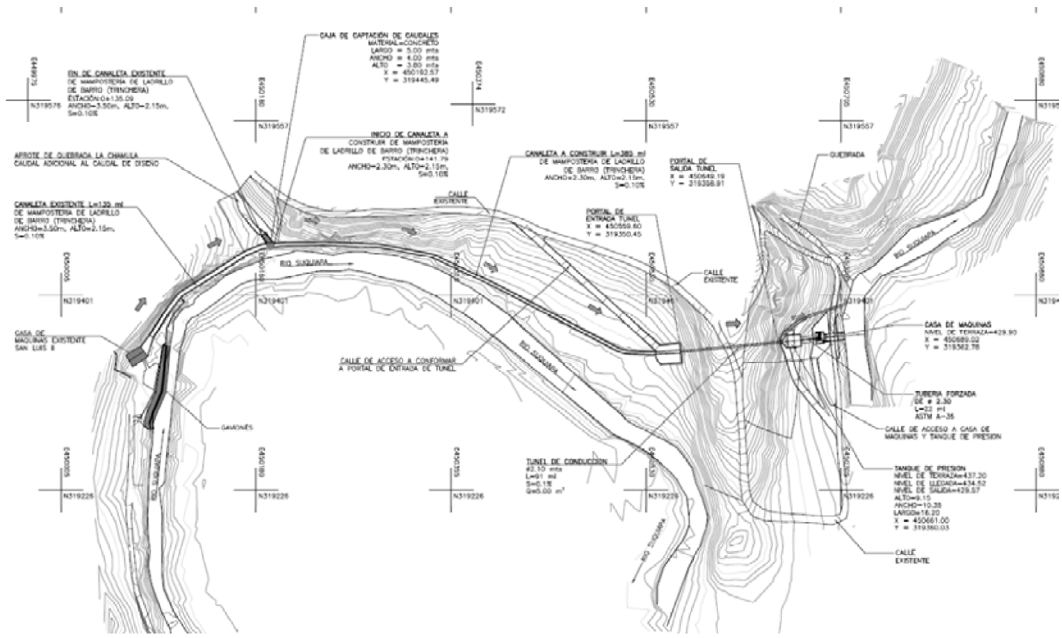
4.8.1 San Luis III Project

(1) Location

San Luis III hydropower is a hydroelectric project of run-of-river type located immediately downstream of existing hydropower station of San Luis II hydroelectric power plant in the Squiapa river. The project is located in Cantón Nancintepeque, Santa Ana department.

(2) General Layout

San Luis III hydropower is planned to use tailwater of San Luis II. The intake channel of San Luis III is designed to connect to tailrace of existing San Luis II. Thus a large scale intake structure is not necessary. Water is conveyed to the head tank by a tunnel waterway of 91m and open channel of 385m. After the head tank, the water is conveyed through penstock having diameter of 2.30m and a length of 22m. The electricity is generated with Crossflow turbine and back to the Squiapa River through 16m length tailrace channel.



Source: CECSA

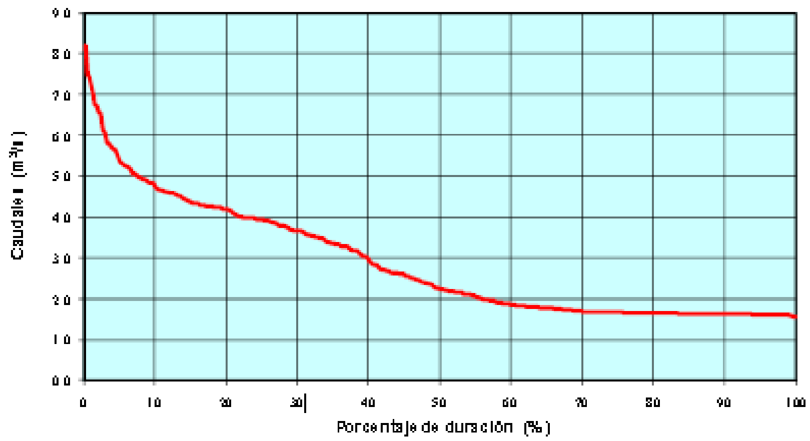
Figure 4.8.2 General Layout of the San Luis III Project

(3) Geological Condition

There is no statement about the geological conditions in the feasiblity study report. It is very risky to design the tunnel type waterway without propoer geological evaluation. Therefore in the next stage of the study, careful examination should be made on the geological investigation for open channel section, tunnel section and powerhouse location to consider the appropriateness of tunnel construction.

(4) Hydrological Condition

The catchment area is 165.47 km^2 and the annual average of the basin rainfall was estimated at 1,646 mm per year. The hydrological study was conducted using 20 years duration of the discharge data from 1967 to 1986 and from 2001 to 2007 measured at Tacachico measuring station (Catchment area 308 km^2). The average discharge is 2.86 m^3/s and the design discharge is 5 m^3/s. The estimated flow duration curve of the project is as shown below.

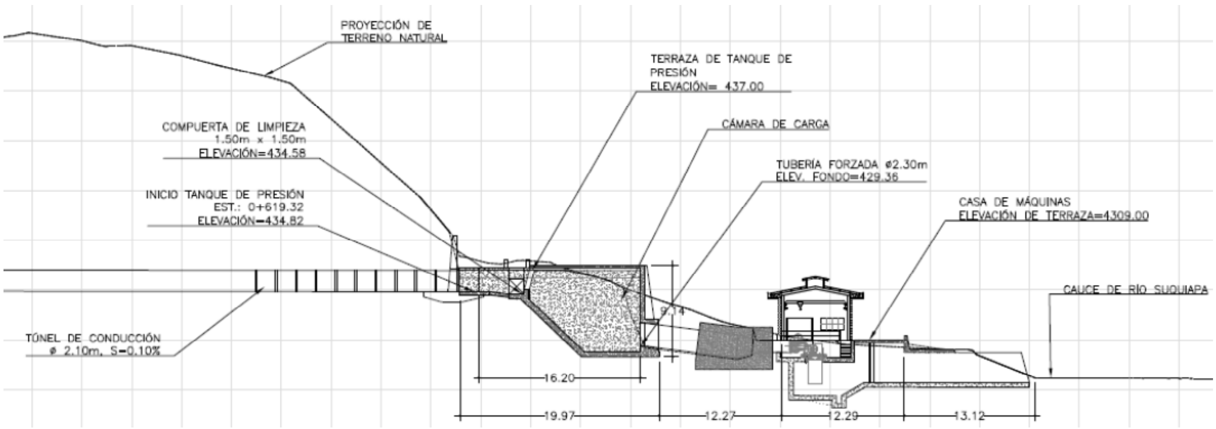


Source: CECSA

Figure 4.8.3 Flow Duration Curve of San Luis III Project

(5) Installed Capacity

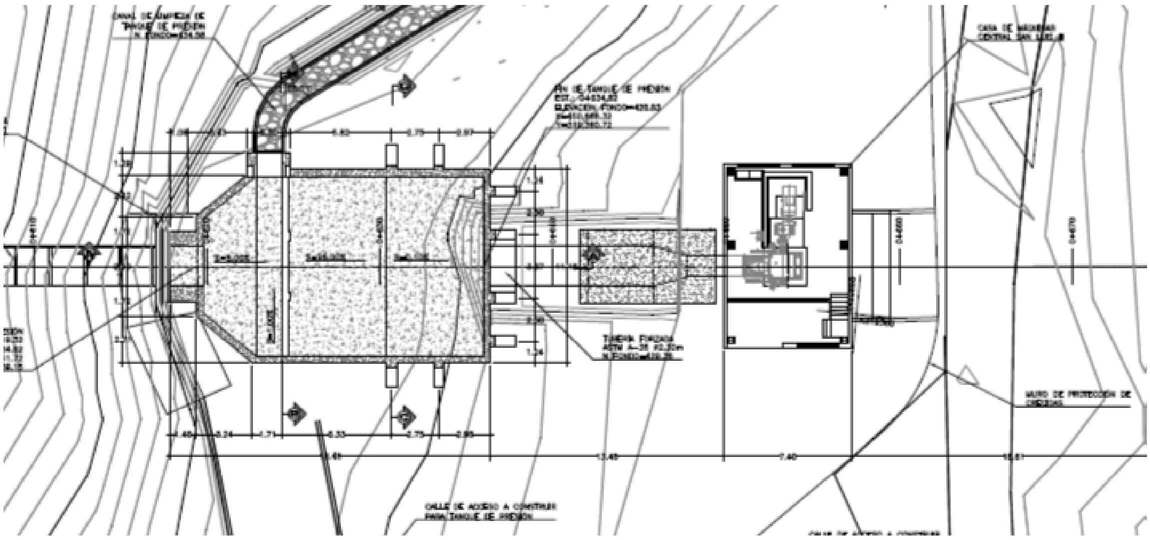
The installed capacity of San Luis III project was designed at 405 kW with conditions of design discharge of 5.0 m^3/s, an effective head of 9.63m and the efficiency of turbine and generator. The type of turbine is Crossflow and number of unit is one. The profile and plan of the powerhouse is show in Figure 4.8.4 and 4.8.5, respectively.



Profile of Powerhouse

Source: CECSA

Figure 4.8.4 Profile of Powerhouse of San Luis III Project



Plan of Powerhouse

Source: CECSA

Figure 4.8.5 Plan of Powerhouse of San Luis III Project

(6) Financial Evaluation

The construction cost of San Luis III is 1,400,000 US$, and the construction cost per kW is 3,457 US$/kW. The project IRR is calculated to 19.99%.

(7) Summary

The project feature of the San Luis III project is summarized in Table 4.8.1.

Table 4.8.1 Summary Project Feature of San Luis III

Project Name	Unit	Value/Name
Project Name		San Luis III
River Name		Suquiapa
Catchment Area	sq.km	165.47
Average Discharge	cms	5.0
Dam height	m	-
Waterway length	m	626
Turbine Type		Crossflow
Capacity of Turbine	kW	405
Nos. of unit	unit	2
Annual Energy	kWh	1,804,626
Design Discharge	cms	5
Effective Head	m	9.63
Transmission Line	m	1
Generator Type		Synchronous, 3phase
Project Cost	US$	1,400,000
Project IRR	%	19.9
Repayment Year	Year	5.2

Source; CECSA

(8) Anticipated Issues on Development

The anticipated issues for development of San Luis III are as follows:

1) Geological assessment

The existing feasibility study lacked the geological investigation of the project site. It was unknown whether geological investigation was actually conducted, although it is pertinent for designing of the hydropower structures. The geological investigation should be conducted if the project is implemented.

2) Alignment of waterway

San Luis III has tunnel type waterway designed to lie under the narrow ridge. The design and construction of this tunnel type waterway may be difficult considering the topography of the project site. It is practical to design open channel type waterway instead of tunnel type channel. Alignment and type of waterway should be reviewed together with the appropriate geological assessment.

4.9 Small Hydropower Development in ANDA Facility

(1) Small Hydropower Potentials in ANDA

The JICA Study Team received the information on the small hydropower development plan by ANDA. The candidate sites and expected installed capacities are summarized in Table 4.9.1.

Table 4.9.1 Hydropower Potential Sites of ANDA

No.	Place	Diameter (inch)	Design Discharge (L/S)	Gross Head (m)	Plant Capacity (kW)
1	T-10 (Santa Tecla A)	36	590	30	157
2	Buenos Aires	30	350	60	185
3	T11 (Santa Tecla B)	24	80	65	45
4	Tanque Corinto	10	55	56	27
5	Planta Chilama	10	80	35	25
6	Río Yamabal		800	20	140
7	Río Apuniam		1000	30	475
8	Río Suquiapa (El Jardín)		3000	9	250
9	Río Amulunca		1000	30	400
10	Río El Rosario		1000	150	1000
11	Río Atehuasias		1500	70	825
12	Las Pavas (Río Lempa)		11000	10	1000

Source: ANDA

The projects from Nos. 1 to 5 in the table are the planned small hydropower projects that connect to water distribution system. The projects from Nos. 6 to 12 are the small hydropower projects to be attached to the existing water intake facilities.

The advantages of the small hydropower in the water supply facilities are 1) impact to social and natural environment is minimal because it is built inside the existing facilities, 2) concession is not required since ANDA already has the right of use of water. Currently, ANDA seeks fund from the international donors. However, the studies given by ANDA are still at conceptual levels. Further pre-F/S and F/S are necessary to promote of these projects. It is recommended to conduct F/S and detailed design (D/D) if the prospective sites are found in pre-F/S.

(2) Preliminary Examination of Financial Viability

To examine the financial viability, the repayment years for the hydropower potential sites shown in Table 4.9.2 is roughly estimated with the unit construction cost in Japan (10,000 US$/kW). In general, the unit construction cost of the small hydropower in water supply facilities is higher than that of ordinal small hydropower projects, because the special care in designing and construction are needed. In this preliminary estimation, three kind of plant factors namely 60%, 70% and 80% were used, and the price of selling electricity was set to 0.15 US$/kWh, and the interest of the loan was not considered. The benefit of the small hydropower was the saving of the cost of electricity covered by the small hydropower.

Table 4.9.2 Preliminary Estimation of Repayment Year of the Small Hydropower Potential of ANDA

No	Site	Installed Capacity	Investment Cost	Repayment Year (i=0%)		
		(kW)	(1000 US$)	P.F. = 80%	P.F. = 70%	P.F. = 60%
1	T-10 (Santa Tecla A)	157	1,840	11.1	12.7	14.9
2	Buenos Aires	185	2,160	11.1	12.7	14.8
3	T11 (Santa Tecla B)	45	550	11.6	13.3	15.5
4	Tanque Corinto	27	340	12.0	13.7	16.0
5	Planta Chilama	25	320	12.2	13.9	16.2
6	Río Yamabal	140	1,640	11.1	12.7	14.9
7	Río Apuniam	475	5,490	11.0	12.6	14.7
8	Río Suquiapa (El Jardín)	250	2,900	11.0	12.6	14.7
9	Río Amulunca	400	4,630	11.0	12.6	14.7
10	Río El Rosario	1000	11,530	11.0	12.5	14.6
11	Río Atehuasias	825	9,520	11.0	12.5	14.6
12	Las Pavas (río Lempa)	1000	5,770	5.5	6.3	7.3

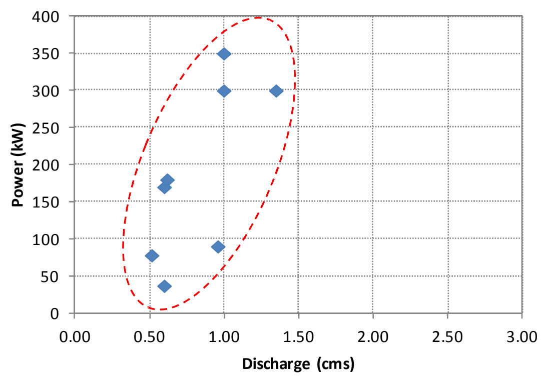
P.F. = Plant Factor,
Source: ANDA, Modified by the JICA Study Team

As shown in the table, the repayment year exceeded 10 years since ANDA procure the electricity with low unit price in between 0.15 and 0.16 US$/kWh. If the unit price of the electricity exceeds 0.20 US$/kWh then the repayment year becomes less than ten years. If the pre-F/S is conducted, the project financial viability should be carefully assessed considering the plant factor and the unit price of electricity.

(3) Example of the Small Hydropower Development in Water Supply Facilities

1) Example of Japan

In Japan, there are plenty of examples of water supply facilities equipped small hydropower generators. The capacity of small hydropower ranges from several dozens to hundreds as shown in Figure 4.9.1. In general, the unit construction cost of the hydropower plant in water supply facilities is 10,000 US$/kW in Japan.



Source: Tokyohatsuden Co., Ltd. (http://www.tgn.or.jp/teg/business/case_micro.htm)

Figure 4.9.1 Relation between the Discharge and Hydropower Capacity Installed in Japan

	
Water Treatment Plant Equipped with Small Hydropower in Toyama City Head: 2.51 m Discharge: 1.157 m^3/s Power output: 20 kW	Water Treatment Plant Equipped with Small Hydropower in Kyoto City Head: 11.76 m Discharge: 0.9 m^3/s Power output: 75 kW

Source：JETRO (http://www.jetro.go.jp/mexico/topics/20100708514-topics/09_Toshiba.pdf)

2) Example of Honduras

In Honduras, JICA is promoting small hydropower project for water distribution system, which is called "The Project of Micro-Hydroelectric Power Generation in Metropolitan Area of Tegucigalpa in the Republic of Honduras." The project is a grant scheme planned to harness unused potential energy by installing small hydropower plant into two existing water treatment plants in Honduras. The project feature of the two small hydropower plants is as shown in Table 4.9.3. The estimated cost of the project is not opened for public.

Table 4.9.3 The project Feature of " Micro-Hydroelectric Power Generation in Metropolitan Area of Tegucigalpa in the Republic of Honduras

Power Plant Name		Unit	Concepcion Hydroelectric Power Plant	Picacho Hydroelectric Power Plant
Maximum power discharge		m^3/s	1.5	0.3
Maximum gross head		m	42.06	91.44
Effective head for rated power		m	27.46	86.16
Installed capacity		kW	250	180
Estimated annual generated energy		MWh	1,650	520
Headrace	Type	-	Buried pipe	-
	Material	-	Ductile cast-iron	-
	Diameter	-	700 mm	-
	Length	m	2,973	-
Powerhouse	Type	-	Open type	Open type
	Structure	-	Single–story reinforced concrete structure	Single–story reinforced concrete structure
	Height	m	7.00	7.00
	Area	m^2	174 m^2 (8.50 x 20.50 m)	174 m^2 (8.50 x 20.50 m)

Source : JICA Preparatory Survey for the Project of Micro-Hydroelectric Power Generation in Metropolitan Area of Tegucigalpa in the Republic of Honduras. March 2013.

The image of powerhouse presented in the report is as shown as follows.

	
Concepcion Hydroelectric Powerhouse	Picacho Hydroelectric Powerhouse

Source : JICA Preparatory Survey for the Project of Micro-Hydroelectric Power Generation in Metropolitan Area of Tegucigalpa in the Republic of Honduras. March 2013.

4.10 Result of Small Hydropower Studies

The detailed survey of three projects conducted during this study and the information given by CECSA are summarized below.

Table 4.10.1 Summary of Small Hydropower Studies

Item	Unit	Project Name			
		Los Hervideros I	El Manzano	Los Coyotes	San Luis III
River Name		Rio Los Hervideros	Rio Sucio	Rio Viejo	Rio Suquiapa
Catchment Area	sq.km	95.94	73.68	28.79	165.47
Average Discharge	cms	3.10	0.83	0.46	5.0
Dam height	m	5.00	2.50	2.50	-
Waterway length	m	2,900	1,100	1,900	626
Turbine Type		Francis	Crossflow	Pelton	Crossflow
Capacity of Turbine	kW	935	664	687	405
Nos. of unit	unit	2.00	1.00	1.00	2.0
Total Capacity	kW	1870	1870	687	810
Annual Energy	kWh	9,177,706	2,223,247	1,771,104	1,804,626
Design Discharge per unit	cms	2.00	1.25	0.70	5
Effective Head	m	55	67.00	123.00	9.63
Transmission Line	km	11.00	4.00	6.00	1
Generator Type		Synchronous, 3phase	Synchronous, 3phase	Synchronous, 3phase	Synchronous, 3phase
Project Cost	US$	7,900,000	2,400,000	2,700,000	1,400,000
Project IRR	%	24.8	10.0	1.2	19.9
Repayment Year	year	5.7	7.2	10.1	5.2

*Assuming selling electricity at 0.15US$/kWh, zero interest rate.

Source: JICA Study Team, CECSA

Among these four projects, Los Hervideros I and San Luis III are recommended to proceed to feasibility studies. The reasons of selection of these projects are as follows:

1) Los Hervideros I project has an abundant stream flow during the dry season. It is advantageous for project feasibility. The planned installed capacity will exceed 1 MW, and this size of install capacity requires full EIA study. However, it is expected that this hydropower project can contribute to improve the power supply quality in the region because the municipality of Tacuba where the project is located has a low electrification rate of 49%. If this project is implemented, it is expected that the project will improve the electrification rate as well as the electricity supply quality. It is noted that Tacuba municipality is considered being in a group of 100 poorest municipalities in El Salvador. Therefore, there can be a various options for community development, and the project can be a model project for small hydropower development in the poor municipality.

2) San Luis III is located just downstream of an existing small hydropower plant. By this nature, the project does not require weir construction and the project cost can be reduced. As CECSA already possesses the land, no land acquisition issue is anticipated. The municipality of Coatepeque where the project is located, is also in the group of the 100 poorest municipalities in El Salvador. And the electrification rate is as low as 65%, which is far below the national average of 93% of electrification rate. San Luis III project can contributes to improve the electricity supply in the rural area and the project can be a model project for small hydropower development in the poor municipality.

The El Manzano is financially not attractive and the project may have geological risks therefore the project is in low priority. The Los Coyotes project is not recommended due to the low project IRR.

4.11 Implementation Plan

4.11.1 Priority of Implementation

As the result of the detailed survey described in the sections 4.7 to 4.10, it is recommended to implement the projects in the following order;

Priority 1: Los Hervideros I

The result of the detailed survey of Los Hervideros I shows high economic feasibility, and the project may help improving the community development and rural electrification.

Priority 2: San Luis III

The feasibility study of San Luis III has high economic feasibility, but the geological conditions and alignment of waterway should be reviewed prior to implementing the project.

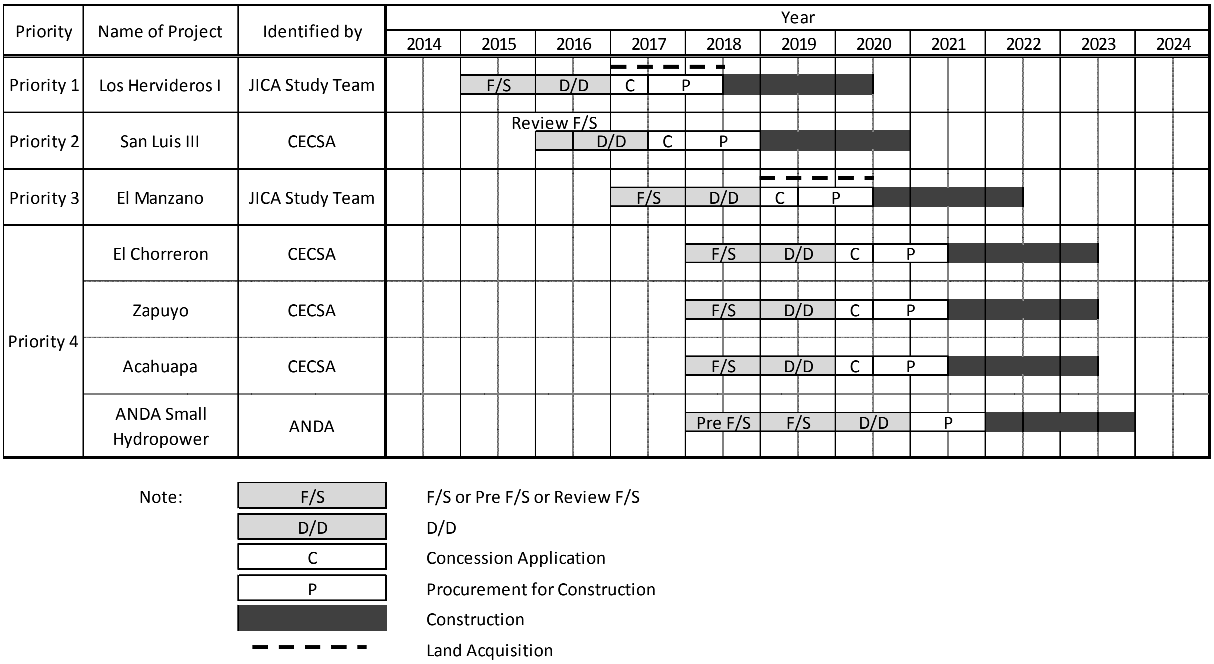
Priority 3: El Manzano

El Manzano may have geological risk for planned intake site and powerhouse site, geology of the project area should be properly assessed for the project implementation.

Priority 4: ANDA small hydropower potentials and small hydropower plan of CECSA

The small hydropower potential of ANDA (12 sites) has no concession and community issues since the projects will be located within the ANDA property land area. It is recommended to conduct pre-F/S and screening good projects for conducting F/S. The small hydropower projects of CECSA have no land acquisition issues, therefore it is recommended to review the existing F/S contents and implement the projects which have high economic feasibility.

The possible implementation plan of the above projects is as shown in Figure 4.11.1.



Source: JICA Study Team

Figure 4.11.1 Possible Implementation Plan

For formulation of the above figure, the projects were assumed to start in year 2015. The duration of F/S and D/D was assumed to one year for each. For San Luis III project, review of F/S with additional geological survey should be considered to complete the existing F/S. Land acquisition should be conducted in parallel with concession application and procurement for construction. According to the implementation plan, Los Hervideros I will commence the operation in 2020 if the project has no problem in land acquisition and concession awarding. San Luis III may start operation in 2019. For the small hydropower projects of ANDA, it is recommended to conduct pre-F/S of the potential sites and conduct screening to select the good projects for further implementing F/S and D/D.

4.11.2 Issues and Countermeasures on Development of Small Hydropower

In El Salvador, many of the small hydropower projects developed failed by encountering community disagreement. This negative reaction by the community to small hydropower development has been arisen through skepticism of the benefit to the local community. This skepticism was provoked by the experience of hydropower development in El Salvador, as the poverty level of communities near the large scale hydropower plants has not been improved.

(1) Community Involvement

In order to break the negative image of small hydropower development, it is necessary to have several good example projects that achieve the mutual understanding between project owner and community.

It is believed that finding the solution through dialogue between the project owner and the community is the key for resolution.

In order to promote small hydropower development, the following need to be considered

- ✓ Dialogue with community is important to develop mutual understanding.
- ✓ The use of third parties (consultants) is effective.
- ✓ Achieving "win-win" conditions, sharing the benefits of hydropower with local communities for sustainable development.

It is proposed that the following measures are included for project implementation.

a. <u>Development of A Model Structure of Dialogue</u>

It is necessary to build a model structure of dialogue among stakeholders. The structure should be continuous, with dialogue continuing not only during construction phase but also throughout the operation of the plant.

b. <u>Proposing Community Development Measures</u>

Through the dialogue between project owner and the local community, the issues relating to local communities and the range of contribution by the project should be defined. Afterwards, the effective measures for community development should be determined through the consent of stakeholders.

c. <u>Allocate budget for community development</u>

Through the dialogue, the project must determine a satisfactory contribution measure for the community. It is proposed to include the cost for community development at 1 - 3% of construction cost, and 3% of annual electricity sales.

With the experience gained through the implementation of several projects, the model structure of dialogue and the ratio of project cost spent for community development will be reviewed and adjusted.

(2) Example of Community Involvement

The example of the community involvement in the hydropower development is as shown below.

1) A Case of A Hydropower Project in Indonesia (Plant Capacity : 82MW)

For the case of a hydropower development 82MW of Indonesia, the project planned to take water from the main river as well as eleven tributaries to divert to another basin for hydropower generation. As the result of diversion, the project reduces the river discharge in the downstream of tributary intakes, therefore the project owner (state electricity company) and local farmers were needed for good coordination of water use.

The local farmers, who manage the irrigation facilities, and the state power company had several consultations, and the state power company requested the consultants to conduct a study to resolve the conflict. The consultant, who were in charge construction supervision for the project, recommended to improve water-use efficiency and improve the existing irrigation facilities, and conducted designing of irrigation facility. The local people were hired for the irrigation facilities construction. As the result of these efforts, the project was able to generate certain amount of electricity while securing the water for downstream irrigation.

	
Water Intake	Irrigation Weir
The river water is diverted to another basin, therefore, the discharge of downstream river decreased.	The irrigation weir is improved or newly constructed for downstream irrigators.
	
Dialogue with Irrigation Union	Improving Water Channel
The mitigation measures are discussed among the stakeholders.	A lady washing the dishes in the channel constructed for the local community.

Source: JICA（"Ex-Post Evaluation of ODA Loan Project "Renun Hydroelectric Power and Associated Transmission Line Project", 2009）, Nippon Koei Co., Ltd.

2) A Case of A Hydropower Project in Kenya (Plant Capacity : 60MW)

For the example of 60 MW hydropower development in Kenya, the project owner (power company) established a technical committee for collecting the opinion and requests of local communities, and for proposing a countermeasure recommended by the experts. Sub-committees for safety, hygiene, employment, land issues, and environment were made as the subordinates of the technical committee. The result of consultation in each of sub-committee was reported to the technical committee periodically, to formulate the countermeasures by the project owner. The project owner held the periodical stakeholders meeting to disseminate the information from the project owner and to listen to the community voices directly.

The example of fulfilment of the request of the local community was to construct a simple water supply facility and enabled the local community to use it.

	
Hydropower Intake	Waterway for Hydropower
A middle scale hydropower with capacity of 60 MW.	Water is conveyed to Hydropower Plants through Open Channel
	
Stakeholders Meeting	Irrigation Weir
The opinion of the community is collected in the stakeholders meeting.	The water supply well is constructed for local community. This system reduces works of carrying water by women.

Source: Nippon Koei Co., Ltd.

3) An Example of CECSA

CECSA has a good example of community involvement in small hydropower development. CECSA constructed a bridge for a local community and employ the local people for the construction. This activity changed the attitude of the local community to the project.

	
New Bridge for Community	Construction of Road by the Local People
A bridge was constructed for the community	Local people were employed for the construction works.

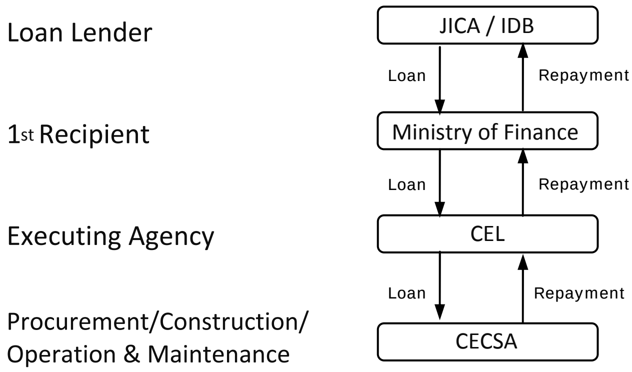
Source: CECSA

4.11.3 Implementing Small Hydropower Projects: Funding

The possible options for funding of these projects are considered below. However, the idea presented below is still conceptual level developed by the collected information during the study. The details of the funding scheme should be reviewed prior to the project implementation.

(1) Sovereign Loan to CEL

The first option for funding small hydropower development by public sector is the provision of a Sovereign Loan to CEL from JICA-IDB. The CEL would be the recipient of the loan and the design and construction work would be completed by CECSA. The repayment of the loan would be made by CEL.

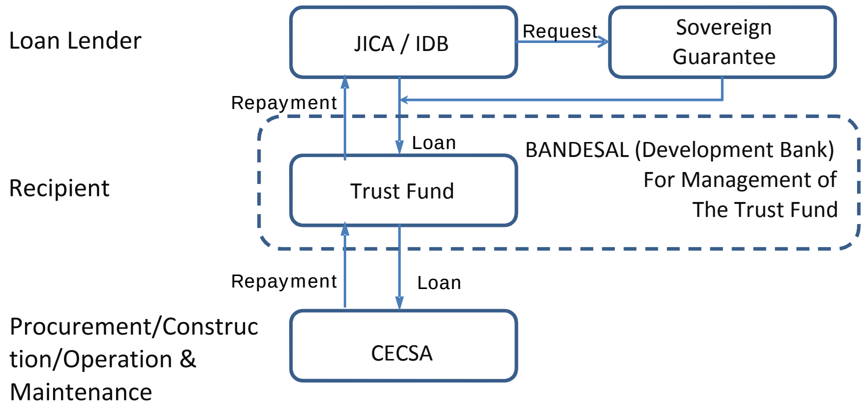


Source: JICA Study Team

Figure 4.11.2 Image of Providing Sovereign Loan to CEL

(2) Sovereign Loan to CECSA

If CEL is unable to accept a Sovereign Loan, the second option would be to provide the loan to CECSA directly. Loans to CECSA could be either Sovereign Loans or Non-Sovereign Loans. In the case of Sovereign Loans, CECSA could receive the loan from a trust fund as generally established by BANDESAL. The trust fund can be established by designation of JICA-IDB. The Sovereign guarantee can be endorsed for the trust fund by the Congress approval. If the Sovereign guarantee is not provided, CECSA cannot borrow money from the fund or banks until current debt of CECSA is cleared.



Source: JICA Study Team

Figure 4.11.3 Image of Providing Sovereign Loan to CECSA

4.11.4 Recommendation for Future Small Hydropower Development

As described in section 4.2.2, the JICA Study Team found that small hydropower development in El Salvador was stagnated due to opposition from local communities and long duration of concession awarding process. It is expected that the opposition from local community will be resolved by the experiencing good examples of community involvement during the project implementation. It is also expected that the Government of El Salvador will change the law/regulation of concession awarding procedure to shorten the process duration.

Another identified issue of small hydropower development is that the development under initiative of the private sector may results in un-organized and random development of water resources, which is not preferable for efficient resource exploitation.

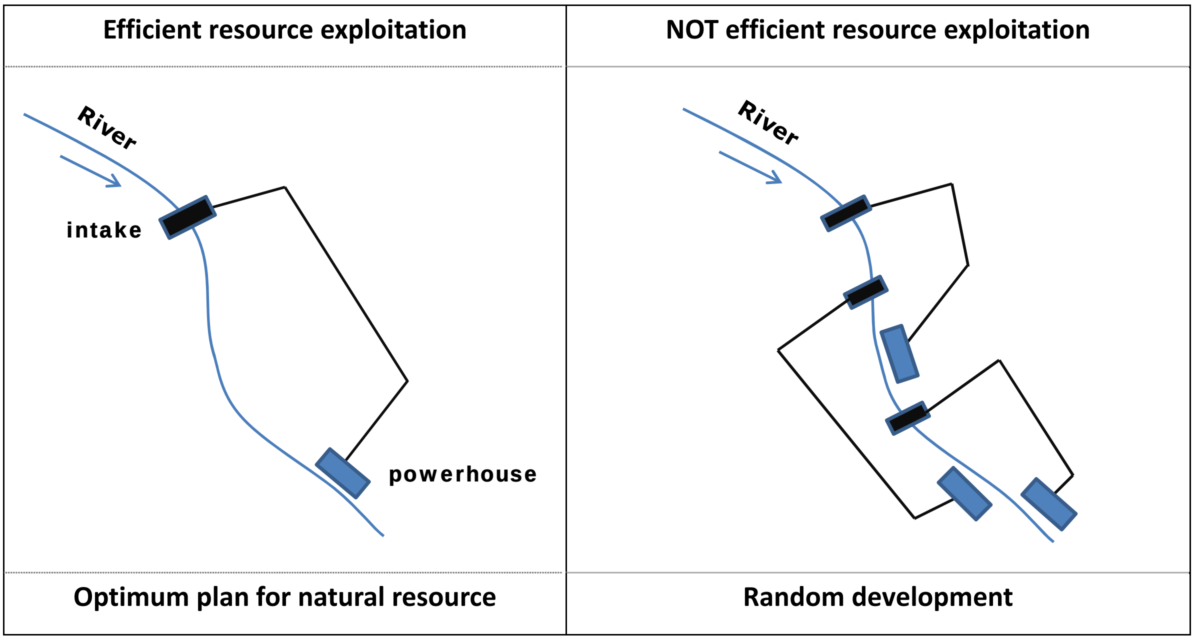
For example, a hydropower plant held by CECSA was discarded because another private company started implementing small hydropower project that was located just upstream of the CECSA's planned intake site. The project would release little water for downstream, thus CECSA's project could not withdraw planned water quantity.

Ideally, there is only one optimum development plan for alignment of hydropower plants in the river. The random development by the private sector possibly deviated from the river's optimum plan, and may result in inefficient resource exploitation.

In order to achieve the small hydropower development along the optimal water resources development, it is recommended to conduct the potential survey by the public sector, and to formulate an optimum development plan of small hydropower which fits to the hydropower potentials of the rivers. The concession should be awarded only for sites which are listed in the optimum development plan.

Specifically, it is recommended that 1) the project data list, which is presented in the renewable energy master plan, should be updated since some of them do not have enough information or some of the information are uncertain, 2) extracting major rivers which have abundant hydropower potential, 3) and to formulate small hydropower development plan for each river.

In Japan, the hydropower potential sites are thoroughly investigated and much information is disclosed to the public. It is recommended to conduct the potential survey in El Salvador and disclose the information to the public to accelerate the efficient resource development.



Source: JICA Study Team

Figure 4.11.4 Concept of Efficient Resource Exploitation and Inefficient Resource Exploitation

5. Detailed Survey for Energy Savings in Public Sectors

5.1 Detailed Energy Audit of Public Sector

Based on the discussion result among IDB headquarter in Washington, IDB El Salvador Office, JICA El Salvador Office and JICA Study Team on November 1, 2013, it was decided to conduct preliminary energy audit for 20 locations and detailed energy audit for four locations of public buildings.

JICA Study Team concluded contract agreement with S&R on November 11, 2013. S&R commenced the work from 18 November, 2013 to 29 November, 2013 after conclusion of the contract by selecting 20 facilities (public buildings) for preliminary energy audit.

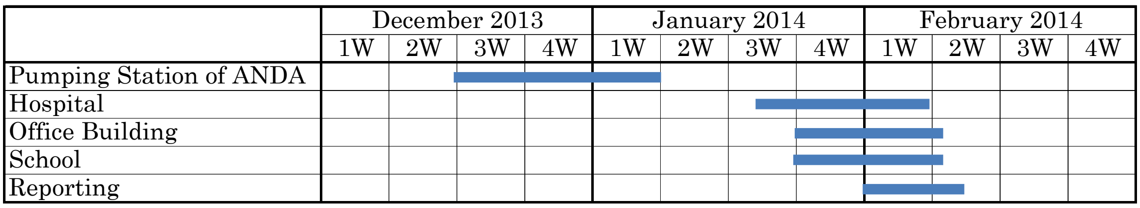
Preliminary audits of 20 locations consist of: 5 schools, 6 health care and medical units, 2 hospitals, 4 office buildings, and 3 pumping stations of ANDA.

Based on the results of 20 locations of the preliminary energy audit, four candidate locations were selected for detailed energy audit one each from ANDA pumping stations, hospitals (including health care units and medical units), schools, and government offices.

The detailed energy audit was conducted to follow up to the preliminary energy audit. The objective of the detailed energy audit was to identify more detailed energy saving potential and to estimate the investment cost though the measurement of electrical parameters and on-site survey.

From the results of the detailed energy audit, the energy savings and investment cost was estimated at the national level in each sector (ANDA pumping stations, hospitals, schools, and government offices).

A schedule of the detailed energy audit of four locations is as shown below.



Source: JICA Study Team

Figure 5.1.1 Schedule of the Detailed Energy Audit of Four (4) Locations

5.1.1 The Outline of Detailed Energy Audit

(1) Selection of the facilities for the detailed energy audit

Four locations were selected for the detailed energy audit in consultation with CNE and ANDA in consideration of the energy saving potential, size of facility and the data availability as follows.

1) ANDA Pumping Station - Antiguo Cuscatlan

This pumping station has the greatest estimated energy savings potential in the three pumping stations evaluated. This pumping station has adequate flow meters and pressure gauges facilitating the analysis of energy savings in the detailed energy audit.

2) Regional Hospital Santiago de Maria

Their staff has shown a commitment and interest for the efficient and rational use of energy. There are many hospitals with similar size in the suburbs of San Salvador.

3) Customs Headquarters - San Bartolo

This office building represents the greatest estimated energy savings potential of the four buildings evaluated. The building includes office space, warehouse and exterior public places similar to many other buildings in the country.

4) Technical School MEGATEC of Sonsonate

This technical school has the greatest estimated energy savings potential of the five related schools evaluated. The technical school has the necessary technical conditions such as meters and gauges capable of producing data in order to conduct the detailed energy audit.

(2) Analysis of Energy Quality

The energy consumption data was obtained to study energy saving measures applicable to the facilities during the preliminary audit. In the detailed audit, some measurement devices were installed at the site to obtain more accurate data of the current situation for the analysis of energy quality. The measurements were carried out across three to five days in each site for the following electrical parameters.

- Voltage
- Current
- Active, reactive and apparent power
- Power factor
- Frequency
- Harmonics

Also, the electricity bills noting the monthly energy consumption were analyzed for the study of energy consumption indicators. With the obtained information and data, and through energy simulation, a base model was estimated. This model was used to identify measures which could be implemented to reduce energy consumption.

5.1.2 ANDA Pumping Station - Antiguo Cuscatlan

(1) General Description

The general description of the Antiguo Cuscatlan Pumping Station is as shown in Table 5.1.1

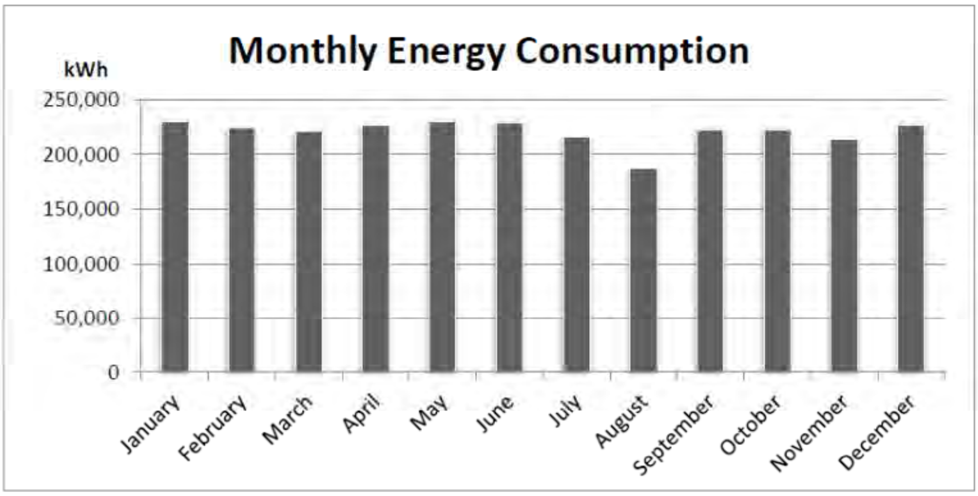
Table 5.1.1 General Description of "Pumping Station - Antiguo Cuscatlan"

Name of facility	Pumping Station Antiguo Cuscatlán		
Address of facility	Calle Mediterráneo, Avenida Antiguo Cuscatlán, Antiguo Cuscatlán, La Libertad		
Operation hours	22	hours/day	
	8,030	hours/year	
Electricity consumption	2,650,752	kWh/year	
Capacity of water supply	392.50 / 8,635.00	m^3/h, m^3/day	
Major equipment	Motor and pump 100HP		1
	Motor and pump 200HP		2
	Mercury vapor lamp 175W (Exterior light)		4
	CFL 20W (Interior light)		1

Source: JICA Study Team

(2) Current Electricity Consumption

Monthly electricity consumption from September 2011 to August 2012 is as shown in Figure 5.1.2.



Source: JICA Study Team

Figure 5.1.2 Monthly Electricity Consumption of "Pumping Station - Antiguo Cuscatlan"

The average monthly consumption is 220,896 kWh, and the total annual consumption is 2,650,752 kWh. The total annual cost for the same period is US$583,938. Almost all the electricity consumption is due to the three pumping systems as listed in Table 5.1.1.

(3) Recommended Energy Saving Measures

1) Measure 1: Replacing the existing motors with high efficiency motors

The existing electric motors have been operated over a ten year period. Therefore, their efficiency ratio (output power kW / input power kW) is lower of 0.930 estimated by the measuring data and their characteristic than that offered by the latest model of 0.960, so they must be replaced by high efficiency equipment.

2) Measure 2: Replacing the existing pumps with high efficiency pumps

As is the case of the electric motors, the existing pumps have also been operated over a ten year period. Therefore, their efficiency ratio is lower of 0.620-0.780 estimated by the measuring data and their efficiency curves than that offered by the latest model of 0.830, so they must be replaced by high efficiency equipment.

3) Measure 3: Installation of a variable speed device

The demand for water varies during the day. Even when the demand is low, the motor operates at a constant speed. Therefore, the installation of a variable speed device is needed to control the motor speed to match demand.

4) Measure 4: Replacing existing lamps with LED lamps

The current 175 Watt mercury vapor lights should be replaced with LED lamps of 60 Watts each.

(4) Energy Savings and Investment Cost

Table 5.1.2 shows the effect of energy savings by applying the four recommended measures above, and required investment costs.

Table 5.1.2 Result of the Detailed Energy Audit for "Pumping Station Antiguo Cuscatlan"

Current Consumption 2,650,752 kWh/year

	Annual Savings		Investment	IRR	NPV	B/C	Simple Payback
	kWh	US$	US$	%	US$		year
1 Replacing existing motors with high efficiency motors	39,001	7,021	45,892	8.6	-2,501	1.53	6.54
2 Replacing existing pumps with high efficiency pumps	268,786	48,390	245,073	14.8	47,511	1.97	5.06
3 Installation of a variable speed device	133,535	24,041	59,897	38.6	79,840	4.01	2.49
4 Replacing existing lamps with LED lamps	2,015	363	2,112	11.3	108	1.72	5.82
Total	443,337	79,815	352,974	18.5	124,959	2.26	4.42

Energy Savings Percent: 16.7%

Project Period: 10 years
Interest Rate: 10%

Source: JICA Study Team

(5) Energy Savings at the National Level

1) Current Electricity Consumption

Annual electricity consumption of ANDA from 2008 to 2012 is as shown in Table 5.1.3.

Table 5.1.3 Annual Electricity Consumption of ANDA

Year	Pumping Station		Purifying Plant		Administration		Others		Total	
	Consumption (MWh)	Cost (US$)	(MWh)	(US$)	(MWh)	(US$)	(MWh)	(US$)	Consumption (MWh)	Cost (US$)
2008	508,228.78	40,677,151	2.27	276,300	5.79	475,752	2.49	303,436	508,239.33	41,732,640
2009	512,476.52	51,637,090	2.19	376,083	5.84	604,550	2.41	413,020	512,486.96	53,030,744
2010	505,560.08	52,160,114	2.23	390,202	5.76	610,923	2.45	428,526	505,570.52	53,589,765
2011	508,366.29	60,039,266	2.23	456,530	5.80	703,386	2.45	501,368	508,376.77	61,700,550
2012	509,055.44	78,388,375	2.27	409,980	5.80	913,852	2.49	450,246	509,066.00	80,162,454
Average	508,737.42	56,580,399								

Source: JICA Study Team based on information from ANDA

Almost all the electricity is used for the ANDA pumping stations. The annual electricity consumption of the pumping stations alone is estimated at 508,737 MWh.

2) Energy Savings and Investment Cost

From the result of the detailed energy audit, the potential energy savings for the pumping stations can be estimated around fifteen percent (15%). The simple payback period is around four point five years.

The annual electricity consumption of the pumping stations in the country is estimated at 508,737 MWh based on the data provided by ANDA from 2008 to 2012. From the result of the detailed energy audit, the annual energy savings and the investment cost are estimated at 76,310 MWh/year and 38.2 million dollars as shown in Table 5.1.4.

Table 5.1.4 Energy Savings and Investment Cost at the National Level

Electricity Consumption	MWh/year	508,737
Electricity Payment	US$/year	56,580,399
Energy Savings Rate		15.0%
Energy Savings	MWh/year	76,310
Cost Savings	US$/year	8,487,060
Payback Period	year	4.5
Investment Cost	US$	38,191,769

Source: JICA Study Team

5.1.3 Regional Hospital of Santiago de Maria

(1) General Description

The general description of Regional Hospital Santiago de Maria is as shown in Table 5.1.5.

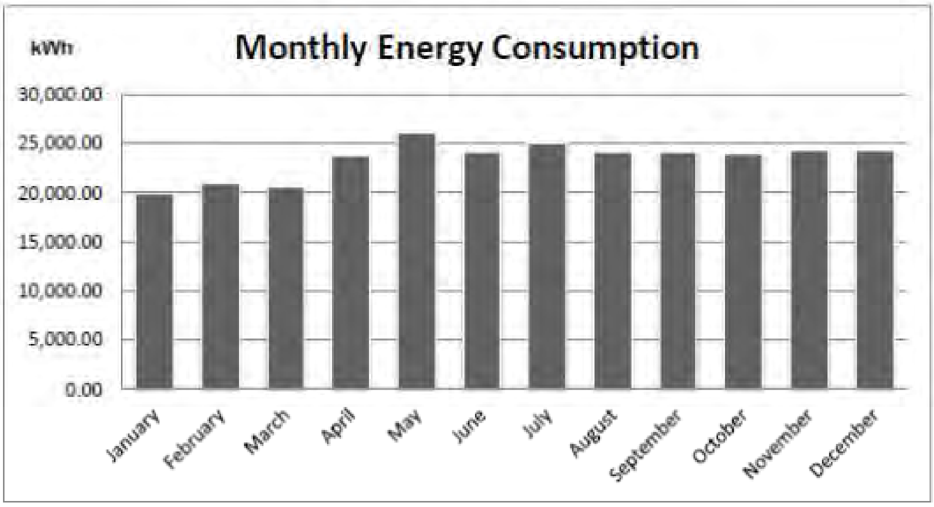
Table 5.1.5 General Description of "Regional Hospital of Santiago de Maria"

Name of facility	National Hospital "Dr. Jorge Arturo Mena"	
Address of facility	3ª. Calle poniente No. 15, Barrio Concepción, Santiago de María, Usulután	
Type of facility	Service (for health and care)	
Operation hours	24	hours/day
	8,760	hours/year
Electricity consumption	85,403	kWh/year
Total floor area	4,237.12	m^2
Number of Beds	75/100	Current / future
Number of Patients	350/55	External/internal
Number of Staff	205	
Major equipment	T12x2 prismatic diffuser (Interior light)	210
	Incandescent lamp 60W (Interior light)	14
	CFL 20W (Interior light)	3
	CFL 75W (Interior light)	1
	T12x4 prismatic diffuser (Interior light)	12
	Mercury vapor lamp 175W (Exterior light)	10
	Mini split type A/C 24,000 BTU/h	1
	Window type A/C 12,000 BTU/h	5
	Window type A/C 24,000 BTU/h	6
	Window type A/C 36,000 BTU/h	6
	Central type A/C 24,000 BTU/h	1
	Central type A/C 48,000 BTU/h	3
	Central type A/C 60,000 BTU/h	3
	Motor and Pump 10HP	2

Source: JICA Study Team

(2) Current Electricity Consumption

Monthly electricity consumption from December 2012 to November 2013 is as shown in Figure 5.1.3.

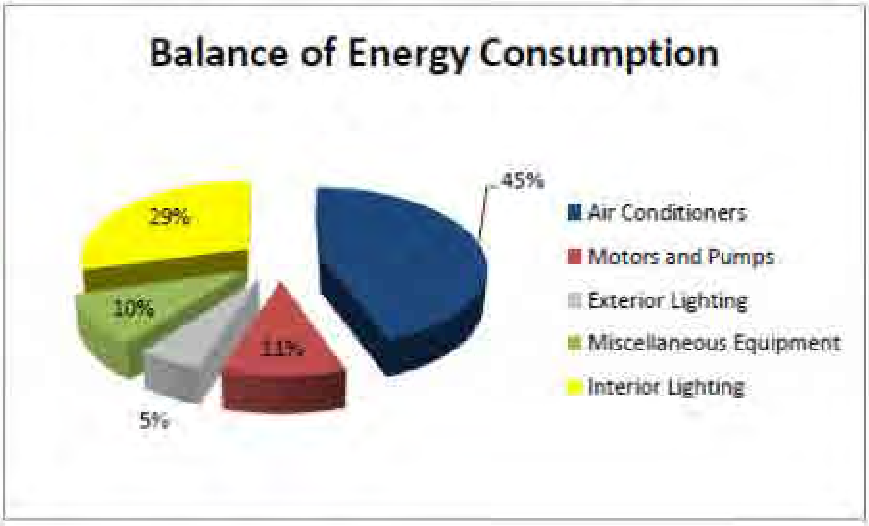


Source: JICA Study Team

Figure 5.1.3 Monthly Electricity Consumption of "Regional Hospital of Santiago de Maria"

The average monthly consumption is 23,480 kWh, and the total annual consumption is 281,762 kWh. The total annual cost for the same period is US$52,225.

The balance of electricity consumption is as shown in Figure 5.1.4.

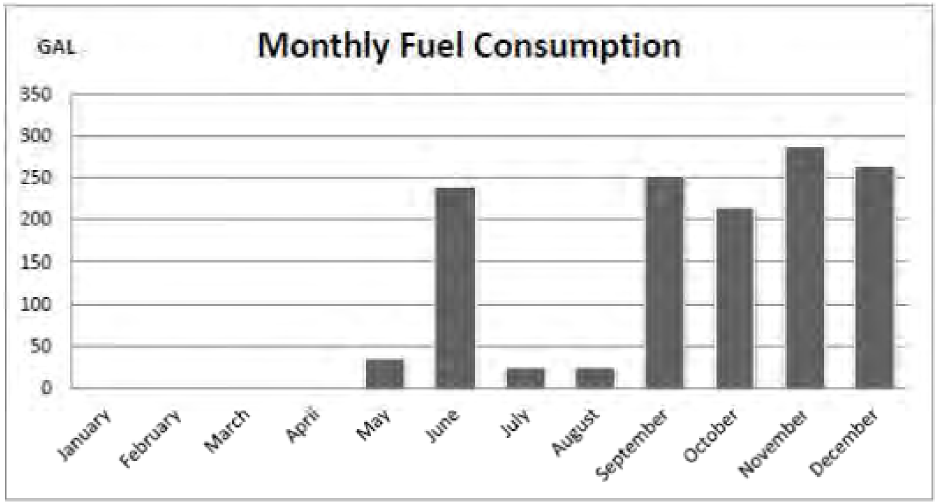


Source: JICA Study Team

Figure 5.1.4 Balance of Electricity Consumption of "Regional Hospital Santiago de Maria"

The highest percentage of consumption (45%) is due to the air conditioners.

In addition to the electricity consumption, diesel fuel is used for the operation of a steam generating system. The fuel consumption of the system is as shown in Figure 5.1.5.



Source: JICA Study Team

Figure 5.1.5 Monthly Fuel Consumption of "Regional Hospital of Santiago de Maria"

There was no consumption of diesel fuel from January to April, because the hospital could not secure a sufficient budget for the purchase of fuel. Across the months of May, July and August, fuel was consumed only for equipment maintenance operations. The total annual consumption of fuel was 3,072 gallons.

(3) Recommended Energy Saving Measures

1) Measure 1: Replacing existing lighting system with high efficiency LED lamps.

It is an effective measure to replace the existing lighting system consisting of F40T12 type and incandescent 60W lamps (internal) and 175W mercury vapor lamps (external) with high efficiency model LED lamps of 18W, 6W and 60W.

2) Measure 2: Lighting Control through the use of Occupancy Sensors

The occupancy sensors are installed for the automatic shut-down of respective lamps when no-one is using the area. It is recommended to install these sensors in office spaces, meeting rooms, bathrooms and kitchens.

3) Measure 3: Replacing Existing Air-conditioners with High Efficiency Models

The current air conditioners are old and of a low efficiency type. The energy efficiency ratios (cooling capacity BTU / power consumption W) of the existing air-conditioners are estimated at 7.0-8.5 and that offered by the latest model is specified at 13.0-14.0. It is an effective measure to replace the existing air conditioners with high efficiency models to ensure long-term operation.

4) Measure 4: Reduction of Heat Loss from Steam Line

The thermal insulators for the steam lines are damaged due to long-term use. It is recommended to insulate steam lines, valves and condensate return lines for heat-loss reduction. The implementation of this measure will lead to reduced fuel consumption.

(4) Energy Savings and Investment Cost

Table 5.1.6 shows the effect of energy savings by applying the three recommended measures of "measures 1) to 3)" above for electricity consumption, and required investment costs.

Table 5.1.6 Result of the Detailed Energy Audit for "Regional Hospital of Santiago de Maria" (1)

Current Consumption 281,762 kWh/year

	Annual Savings		Investment	IRR	NPV	B/C	Simple Payback
	kWh	US$	US$	%	US$		year
1 Replacing existing lamps with LED lamps	41,670	10,406	34,867	27.1	26,430	2.98	3.35
2 Lighting control using with occupancy sensors	1,490	368	1,296	25.5	877	2.84	3.52
3 Replacing existing air-conditioners with high efficiency models	48,630	13,563	59,170	18.8	21,972	2.29	4.36
Total	91,790	24,337	95,333	22.1	49,279	2.55	3.92

Energy Savings Percent: 32.6% (Total)

Project Period: 10 years
Interest Rate: 10%

Source: JICA Study Team

Table 5.1.7 shows the effect of fuel savings by applying "measure 4)."

Table 5.1.7 Result of the Detailed Energy Audit for "Regional Hospital of Santiago de Maria" (2)

Current Consumption 3,072 GAL

	Annual Savings		Investment	IRR	NPV	B/C	Simple Payback
	GAL	US$	US$	%	US$		year
4 Steam line heat loss reduction	345	1,413	2,079	67.6	6,003	6.80	1.47

Energy Savings Percent: 11.2% (Total)

Project Period: 10 years
Interest Rate: 10%

Source: JICA Study Team

(5) Energy Savings at the National Level

1) Current electricity consumption

The number of hospitals and their overall annual electricity consumption from November 2012 to October 2013 is as shown in Table 5.1.8. The data is estimated based on the data from AES and DELSUR (the distribution companies in El Salvador).

Table 5.1.8 Number and Annual Electricity Consumption of Hospitals in the Country

	AES	DELSUR	Total
Number (Service)	29	145	174
Electricity Consumption (MWh/year)	1,026	7,720	8,746
Electricity Payment (US$/year)	249,263	1,825,805	2,075,068

Source: JICA Study Team based on information from AES and DELSUR

The annual electricity consumption of all the hospitals in El Salvador is estimated at 8.75 GWh.

AES has 74% sales coverage in the country while DELSUR has 26%, so AES and DELSUR cover most of the distribution areas of the country. The mentioned figures mostly represent the entire country.

2) Energy Savings and Investment Cost

From the result of the detailed energy audit, the potential of energy savings for each hospital can be estimated around thirty percent (30%). The simple payback period is around four years.

Based on the annual electricity consumption of all the hospitals in the country assumed at 8,746 MWh, the energy savings and the investment cost are estimated at 2,624MWh/year and 2.5 million dollars from the result of detailed energy audit, as shown in Table 5.1.9.

Table 5.1.9 Energy Savings and Investment Cost at the National Level

Number (Service)		174
Electricity Consumption	MWh/year	8,746
Electricity Payment	US$/year	2,075,068
Energy Savings Rate		30.0%
Energy Savings	MWh/year	2,624
Cost Savings	US$/year	622,520
Payback Period	year	4.0
Investment Cost	US$	2,490,082

Source: JICA Study Team

5.1.4 Customs Headquarters San Bartolo

(1) General Description

The general description of Customs Headquarters - San Bartolo is as shown in Table 5.1.10.

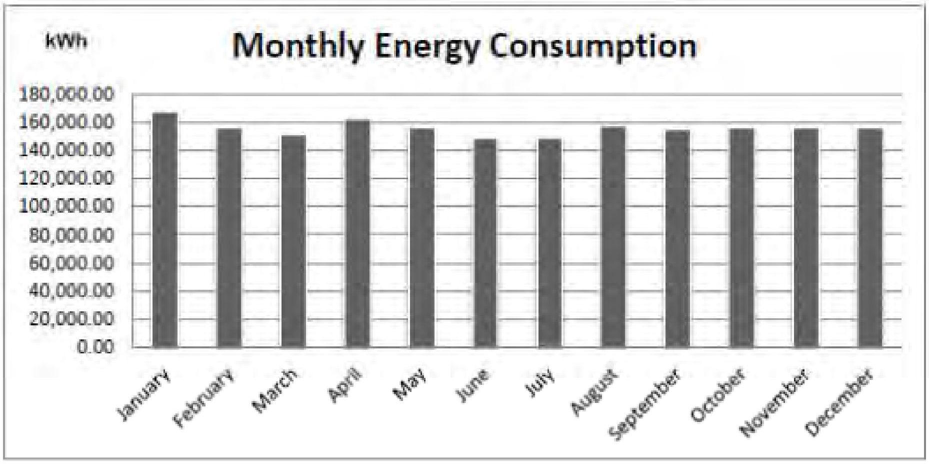
Table 5.1.10 General Description of "Customs Headquarters - San Bartolo"

Name of facility	Customs Headquarters - San Bartolo	
Address of facility	Panamerican Highway Km 17 1/2, San Bartolo, Ilopango, San Salvador	
Type of facility	Service (Customs for exports and imports)	
Operation hours	8	hours/day
	2,112	hours/year
Electricity consumption	1,866,690	kWh/year
Total floor area	36,980	m^2
Number of floors	3	
Number of users	300	
Major equipment	F75T12 x4 Open Diffuser	432
	F40T12 x4 Prismatic Diffuser	66
	F20T12 x4 Prismatic Diffuser	586
	F75T12 x2 Open Diffuser	37
	F40T12 x2 Prismatic Diffuser	93
	F40T12 x2 Prismatic Diffuser	192
	F40T12 x1 Open Diffuser	31
	F32T8 x1 Open Diffuser	4
	F32T8 x4 Prismatic Diffuser	1
	175W Mercury Vapor lamps	96
	PC	264
	Water Dispensers	34
	Coffee Makers	24
	Mini Split Air Conditioners 24,000 BTU/h	29
	Mini Split Air Conditioners 60,000 BTU/h	41
	Window Air Conditioners 12,000 BTU/h	12
	Central Air Conditioners 90,000 BTU/h	1
	Pump (1.5 HP)	8
	Pump (1.5 HP)	2

Source: JICA Study Team

(2) Current Electricity Consumption

Monthly electricity consumption from January 2013 to December 2013 is as shown in Figure 5.1.6.

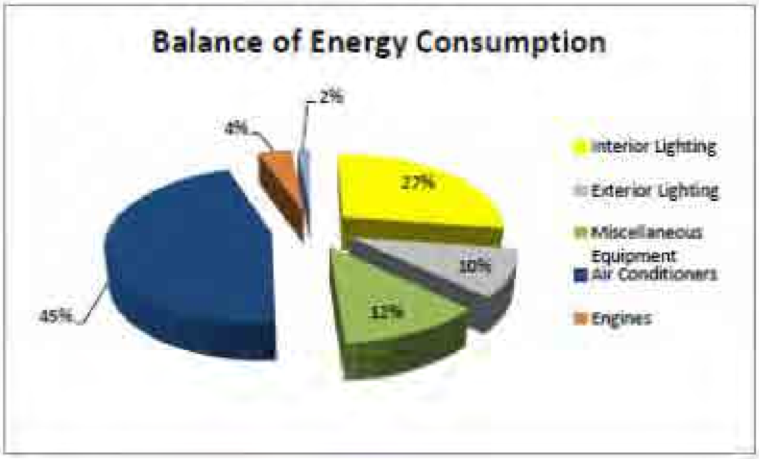


Source: JICA Study Team

Figure 5.1.6 Monthly Electricity Consumption of "Customs Headquarters - San Bartolo"

The average monthly consumption is 155,558 kWh, and the total annual consumption is 1,866,690 kWh. The total annual cost for the same period is US$383,911.

The balance of electricity consumption is as shown in Figure 5.1.7.



Source: JICA Study Team

Figure 5.1.7 Balance of Energy Consumption of "Customs Headquarters - San Bartolo"

The highest percentage (45%) of overall consumption is due to the air conditioners.

(3) Recommended Energy Saving Measures

1) Measure 1: Replacing the existing lighting system with high efficiency LED lamps

It is effective measure to replace both the existing F20T12 and F40T12 type lamps (interior) and 175W mercury vapor lamps (exterior) with high efficiency model LED lamps of 9W, 18W and 60W.

2) Measure 2: Lighting Control through the use of Occupancy Sensors

The occupancy sensors are installed for the automatic shut-down of respective lamps when no-one is using the area. It is recommended to install these sensors in the office spaces of both administrative buildings.

3) Measure 3: Replacing Existing Air-conditioners with High Efficiency Models

The current air conditioners are old and of a low efficiency type. The energy efficiency ratios of the existing air-conditioners are estimated at 7.0-8.5 and that offered by the latest model is specified at 13.0-14.0. It is an effective measure to replace the existing air conditioners with high efficiency models to ensure long time operation.

4) Measure 4: Installation of Thermal Insulation in Ceilings

Thermal insulation materials should be installed in the ceilings of both administrative buildings. Their air conditioners are operating almost throughout each working day.

(4) Energy Savings and Investment Cost

Table 5.1.11 shows the effect of energy savings by applying the four recommended measures above, and required investment costs.

Table 5.1.11 Result of the Detailed Energy Audit for "Customs Headquarters - San Bartolo"

Current Consumption 1,866,690 kWh/year

		Annual Savings		Investment	IRR	NPV	B/C	Simple Payback
		kWh	US$	US$	%	US$		year
1	Replacing existing lamps with LED lamps	303,000	63,488	228,752	24.7	146,686	2.78	3.60
2	Lighting control using with occupancy sensors	19,200	4,292	15,211	25.3	10,147	2.82	3.54
3	Replacing existing air-conditioners with high efficiency models	228,700	55,518	241,779	18.9	90,323	2.30	4.35
4	Installation of thermal insulation in Ceilings	45,744	10,101	22,905	42.9	35,601	4.41	2.27
	Total	596,644	133,399	508,647	22.9	282,756	2.62	3.81

Energy Savings Percent: 32.0% (Total)

Project Period: 10 years
Interest Rate: 10%

Source: JICA Study Team

(5) Energy Savings at the National Level

1) Current Electricity Consumption

The number of government office buildings and their annual electricity consumption from November 2012 to October 2013 is as shown in Table 5.1.12. The data is estimated based on the data from AES and DELSUR (the distribution companies in El Salvador).

Table 5.1.12 Number and Annual Electricity Consumption of Office Buildings in the Country

	AES	DELSUR	Total
Number (Service)	9,658	1,419	11,077
Electricity Consumption (MWh/year)	45,027	52,040	95,067
Electricity Payment (US$/year)	8,233,574	12,816,650	21,050,224

Source: JICA Study Team based on information from AES and DELSUR

The annual electricity consumption of government office buildings is estimated at 95.0 GWh.

2) Energy Savings and Investment Cost

Based on the results of the detailed energy audit, the potential energy savings for the office buildings can be estimated around thirty percent (30%). The simple payback period is around four years.

Based on the annual electricity consumption of all the office buildings in the country assumed at 95,067 MWh, the energy savings and the investment cost are estimated at 28,520 MWh/year and 25.3 million dollars from the result of detailed energy audit as shown in Table 5.1.13.

Table 5.1.13 Energy Savings and Investment Cost at the National Level

Number (Service)		11,077
Electricity Consumption	MWh/year	95,067
Electricity Payment	US$/year	21,050,224
Energy Savings Rate		30.0%
Energy Savings	MWh/year	28,520
Cost Savings	US$/year	6,315,067
Payback Period	year	4.0
Investment Cost	US$	25,260,269

Source: JICA Study Team

5.1.5 Technical School MEGATEC of Sonsonate

(1) General Description

The general description of Technical School MEGATEC of Sonsonate is as shown in Table 5.1.14.

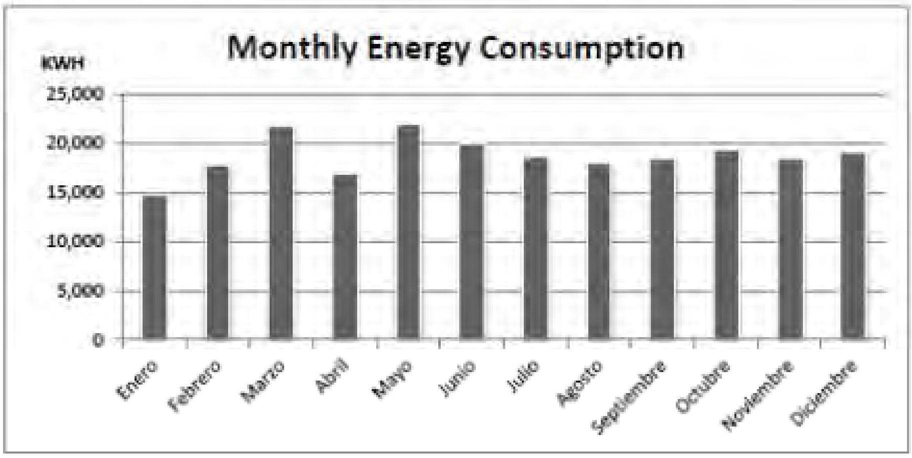
Table 5.1.14 General Description of "Technical School MEGATEC of Sonsonate"

Name of facility	Educational Complex ESFE / ÁGAPE, Technical School Megatec		
Address of facility	Km 63 Highway San Salvador to Sonsonate		
Type of facility	Education (technical high school level)		
Operation hours	13.25	hours/day	
	4,134	hours/year	
Electricity Consumption	224,874	kWh/year	
Total floor Area	17,809 / 568.64	Total/constructed m^2	
Number of Classrooms	16	7 classrooms, 3 workshops & 6 laboratories	
Number of Students	700 / 200 / 125	General / speciality / computers	
Number of Staffs	70		
Major equipment	F32T8 x2 Prismatic Diffuser		30
	F32T8 x3 Prismatic Diffuser		91
	F32T8 x4 Prismatic Diffuser		4
	15W CFL		62
	F40T12x2 Open Diffuser		20
	175W Mercury Vapor		14
	400W Metal Halide		20
	PC		75
	Mini Split 60,000 -90,000 BTU/h		27
	Window 36,000 BTU/h		1

Source: JICA Study Team

(2) Current electricity consumption

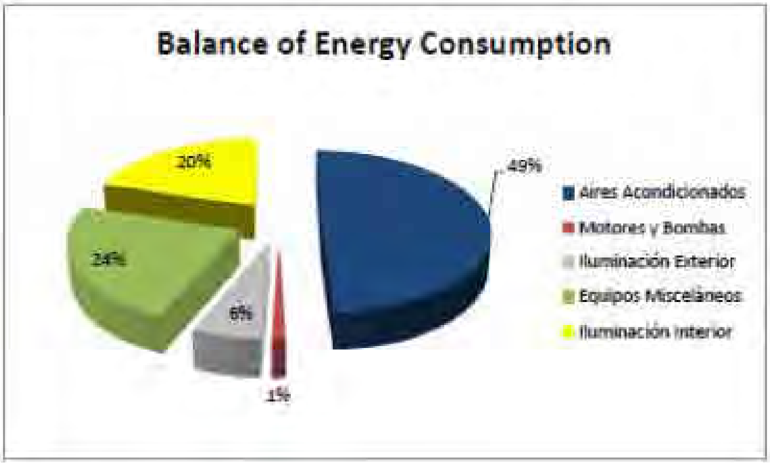
Monthly electricity consumption from December 2012 to November 2013 is as shown in Figure 5.1.8.



Source: JICA Study Team

Figure 5.1.8 Monthly Electricity Consumption of "Technical School MEGATEC of Sonsonate"

The average monthly consumption is 18,740 kWh, and the total annual consumption is 224,874 kWh. The total annual cost for the same period is US$39,978. Due to long holidays, electricity consumption in January and April is low in relation to the other months. The balance of electricity consumption is as shown in Figure 5.1.9.



Source: JICA Study Team

Figure 5.1.9 Balance of Energy Consumption of "Technical School MEGATEC of Sonsonate"

(3) Recommended Energy Saving Measure

1) Measure 1: Replacing existing lighting system with high efficiency LED lamps

It is effective measure to replace both the existing F32T8 and F40T12 type lamps (interior) and 175W mercury vapour/400W metal halide lamps (exterior) with high efficiency model LED lamps18W, 60W and 120W.

2) Measure 2: Lighting Control using by Occupancy Sensors

The occupancy sensors are installed for the automatic shut-down of respective lamps when no-one is using the area. It is recommended to install these sensors in office spaces, class rooms, the computer center, and in meeting rooms.

3) Measure 3: Replacing Existing Air-conditionings with High Efficiency Models

The current air conditioners are old and of a low efficiency type. The energy efficiency ratios of the existing air-conditioners are estimated at 7.0-8.5 and that offered by the latest model is specified at 13.0-14.0. It is an effective measure to replace the existing air conditioners in the computer center and office spaces with high efficiency models to ensure long time operation.

4) Measure 4: Insulation of Thermal Insulation in Ceilings

Thermal insulation materials should be installed in the ceilings of both administrative buildings. Their air conditioners are operating almost throughout each working day.

(4) Energy savings and Investment cost

Table 5.1.15 shows the effect of energy savings by applying the four recommended measures above, and required investment costs.

Table 5.1.15 Energy Savings and Investment Cost at the National Level

Current Consumption 224,874 kWh/year

	Annual Savings		Investment	IRR	NPV	B/C	Simple Payback
	kWh	US$	US$	%	US$		year
1 Replacing existing lamps with LED lamps	35,360	7,431	30,010	21.1	14,228	2.48	4.04
2 Lighting control using with occupancy sensors	2,290	509	1,879	23.9	1,135	2.71	3.69
3 Replacing existing air-conditioners with high efficiency models	25,320	5,984	65,807	-1.7	-26,398	0.91	11.00
4 Installation of thermal insulation in Ceilings	10,037	2,330	7,946	26.5	6,368	2.93	3.41
Total-1	73,007	16,254	105,642	8.7	-5,244	1.54	6.5
Total-2 of excluding No.3	47,687	10,270	39,835	22.4	21,254	2.58	3.88

Energy Savings Percent: 32.5% (Total)
21.2% (Total of Excluding No.3)

Project Period: 10 years
Interest Rate: 10%

Source: JICA Study Team

Measure 3 is not effective from the results of detailed energy audit. Three measures excluding Measure 3 are recommended for the school.

(5) Energy Savings at the National Level

1) Current electricity consumption

The number and the annual electricity consumption of government office buildings from November 2012 to October 2013 are shown in Table 5.1.16. The data is estimated based on the data from AES and DELSUR (the distribution companies in El Salvador).

Table 5.1.16 Number and Annual Electricity Consumption of Schools in the Country

	AES	DELSUR	Total
Number (Service)	3,614	991	4,605
Electricity Consumption (MWh/year)	2,516	7,200	9,716
Electricity Payment (US$/year)	742,221	2,013,509	2,755,730

Source: JICA Study Team based on information from AES and DELSUR

The annual electricity consumption of government office buildings is estimated 9,716MWh.

2) Energy Savings and Investment Cost

From the result of detailed energy audit, the potential of energy savings for the school can be estimated around twenty percent (20%). The simple payback period is around four years.

Based on the annual electricity consumption of all the schools in the country assumed at 9,716 MWh, the energy savings and the investment cost are estimated 1,943 MWh/year and 2.2million dollars from the result of detailed energy audit, as shown in Table 5.1.17.

Table 5.1.17 Energy Savings and Investment Cost at the National Level

Number (Service)		4,605
Electricity Consumption	MWh/year	9,716
Electricity Payment	US$/year	2,755,730
Energy Savings Rate		20.0%
Energy Savings	MWh/year	1,943
Cost Savings	US$/year	551,146
Payback Period	year	4.0
Investment Cost	US$	2,204,584

Source: JICA Study Team

5.2 Public Lighting

5.2.1 Current Situation

According to a census conducted in 2012, there are 262 municipalities with 187,000 lamps in use for public lighting. Almost 80% or 150,000 of these lamps use High Pressure Mercury Vapour (HPMV) at 175W.

With the intention of determining the energy savings potential, a variety of more efficient alternatives are compared to replace the existing lamps. The 175W HPMV lamp has been identified as the most common in use throughout the public lighting systems in El Salvador. Besides efficiency, the highest technical savings value can be achieved through the use of either 60W LED lamps or 70W EMI (Magnetic Induction) lamps.

5.2.2 Energy Savings and Investment Cost

The study for the replacement of HPMV with 60W LED lamps is as shown in Table 5.2.1.

Table 5.2.1 Energy Savings and Investment Cost of Public Lighting at the National Level

Lamp type		Current Lamp Mercury	Replaced Lamp LED
Power	W	175	60
Number of replace		149,578	
Monthly consumption	kWh	9,423,414	3,230,885
Monthly savings	kWh		6,192,529
	%		65.71%
	US$		1,238,506
Yearly savings	kWh		74,310,350
	US$		14,862,070
Lamp cost	US$		500
Investment	US$		74,789,000
Life hours of lamp	hour		50,000
Payback period	years		5.0

Source: JICA Study Team based on information from CNE

Replacing approximately 150,000 mercury lamps with 60W LED lamps will lead to savings of about 74.3 GWh/year. The investment cost would be about 75 million US$.

5.3 Conclusion

5.3.1 Summary

Table 5.3.1 summarizes the energy savings, investment cost and feasibility of replacement based on the results of both the detailed energy audit and the study of replacement of public light.

Table 5.3.1 Summary of the Results of Energy Savings for Government Sector

	Number of facility	Current	Saving			Investment	Payback	IRR	NPV
		MWh/year	Potential	MWh/year	Cost (Mil US$)	Mil US$	years		Mil US$
Pumping Station (ANDA)	450	508,734	15%	76,310	8.487	38.2	4.5	17.96%	12.7
Hospital	174	8,746	30%	2,624	0.623	2.5	4.0	21.31%	1.21
Office Building	11,077	95,067	30%	28,520	6.315	25.3	4.0	21.36%	12.3
School	4,605	9,716	20%	1,943	0.551	2.2	4.0	21.46%	1.08
Public Lighting	150,000	113,076	65%	73,499	14.862	74.5	5.0	15.03%	15.3
Total		735,339	25%	182,897	30.838	142.7	4.6	17.19%	42.5

Project Period 10 years
Interest Rate 10%

Source: JICA Study Team

The implementation of energy savings in the five sectors will translate to a total electricity savings of 180GWh. 180GWh represents three percent (3.0%) of total electricity consumption in the country.

5.3.2 Recommendation

Based on the survey results, the following order of implementation is recommended

Priority 1: ANDA Pumping Stations and Public Lighting

These two sectors are heavy electricity users. The implementation of energy savings in each sector will lead to a substantial saving of electricity. The potential energy savings in these two sectors is 150 GWh in total. 150 GWh represents 2.5% of total electricity consumption in the country.

Priority 2: Office Buildings and Schools

The potential energy savings in these sectors is 20-30% against current values. Further, energy savings programs implemented in these areas will lead to general education in energy conservation.

In the hospitals, there is a 30% savings potential. However, it will be important to consider the needs of the patients first while considering methods of implementation.

The above mentioned priorities were presented by the JICA Study Team during the 2nd workshop on February 18, 2014, and there were no particular objections on the priority.

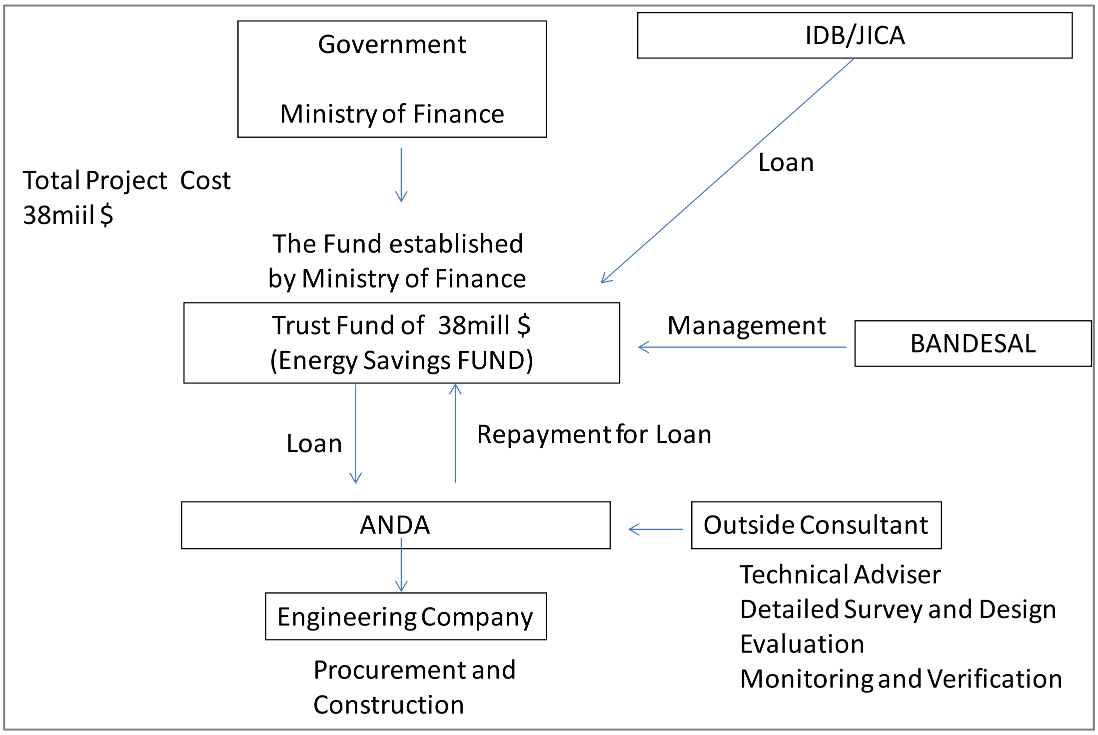
5.3.3 Implementation Plan

The implementation schemes of three cases for ANDA pumping station and public lighting of municipalities were considered with core scheme of IDB and JICA. The schemes mentioned in below are just preliminary ideas, it is necessary to study more on the possibility of the schemes.

(1) ANDA

The maximum project cost is estimated 38.2 mill dollars. If ANDA take a loan to implement the project, it is a big loan for ANDA. It is necessary to support ANDA on the financing management and the technical coordination of the project. The tentative implementation scheme is as shown in Figure 5.3.1.

1) Ministry of Finance establish the trust fund for energy saving project for ANDA
2) IDB and JICA provide a loan of 30 million dollars to the trust fund.
3) BANDESAL makes a financial management for the trust fund.
4) The trust fund provide loan to ANDA.
5) ANDA consign a technical management to an outside consultant.
6) ANDA make repayment for the loan to the trust fund.



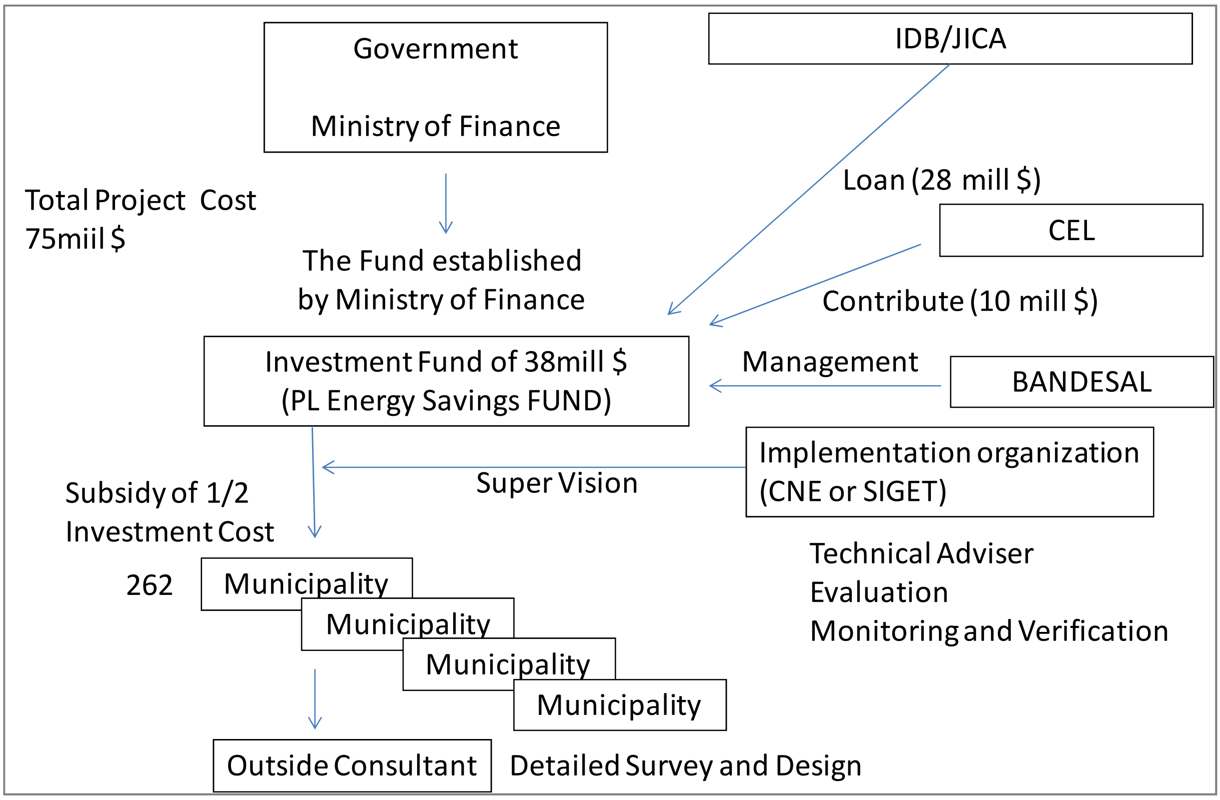
Source: JICA Study Team

Figure 5.3.1 Implementation Scheme of Energy Savings PJT for ANDA

(2) Public Lighting (Subsidy Scheme)

It is necessary to establish any support systems for promotion of the energy saving project in the municipality. It is recommended the support system by subsidy to investment cost of the energy saving project. The tentative implementation scheme is as shown in Figure 5.3.2.

1) Ministry of Finance establish the investment fund for public lighting energy saving project for municipalities
2) The maximum capacity of the fund is 37.5 million dollars of 50% in total project cost.
3) IDB and JICA provide a loan of 28 million dollars to the trust fund.
4) CEL contributes 10 million from their subsidy.
5) BANDESAL makes a financial management of the fund.
6) The fund provides subsidy of 50% in the investment cost to Municipality.
7) CNE or SIGET is a technical consultant for the project.
8) The Municipality consigns an outside consultant for the detailed survey.
9) The Municipality takes incentives of the replacement of lamps with half cost and the energy cost of 50% in the current.



Source: JICA Study Team

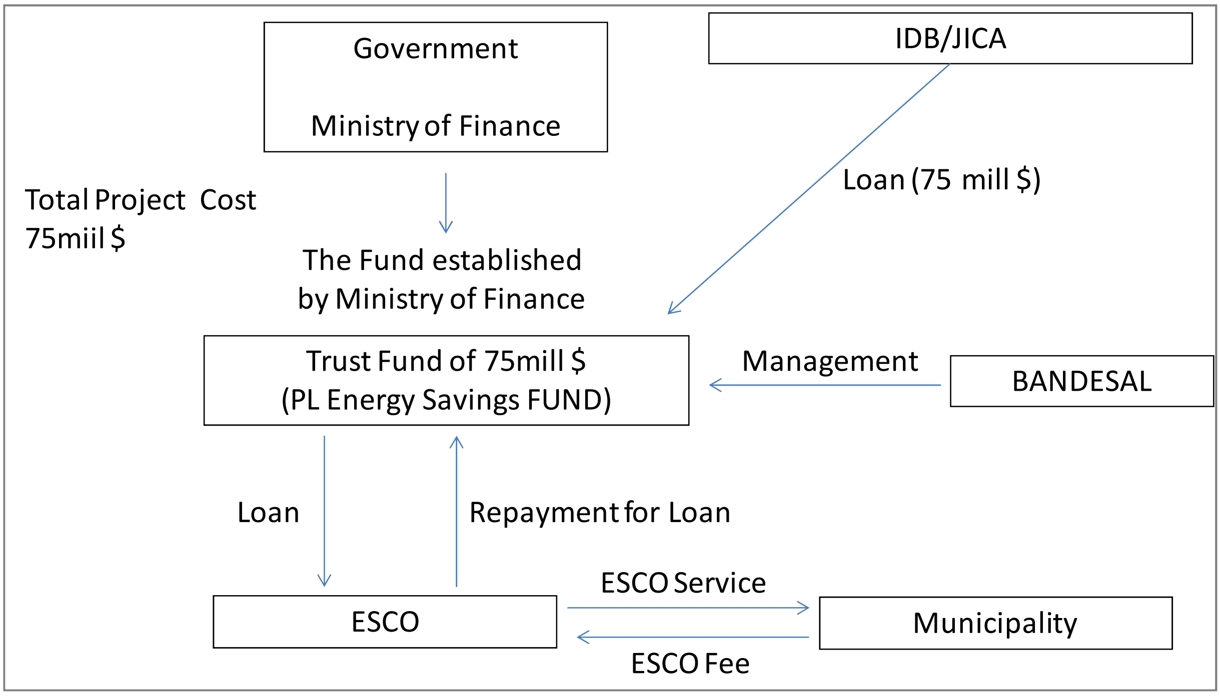
Figure 5.3.2 Implementation Scheme of Energy Savings Project for Public Lighting

(3) Public Lighting (ESCO Scheme)

ESCO business is one of the effective tools to promote energy savings. If the low interest rate loan for ESCO is realizable, ESCO business may be successful for energy savings of public lighting. However, there are no experiences of ESCO business in El Salvador. It is a need to develop a business environment in ESCO market such as the development of ESCO companies.

The tentative implementation scheme is as shown in Figure 5.3.3.

1) Ministry of Finance establish the trust fund for public lighting energy saving project for municipalities
2) The maximum capacity of the trust fund is 75 million dollars of total project cost.
3) IDB and JICA provide a loan of 75 million dollars to the trust fund.
4) BANDESAL makes a financial management of the trust fund.
5) The trust fund provides loan to ESCO company for the investment cost.
6) Municipality will pay ESCO service fee to ESCO company in saving cost reduced by the energy saving project.



Source: JICA Study Team

Figure 5.3.3 Implementation Scheme of Energy Savings Project for Public Lighting by ESCO