

THE REPUBLIC OF PERU
MINISTRY OF ENERGY AND MINES

THE REPUBLIC OF PERU
THE MASTER PLAN FOR DEVELOPMENT
OF GEOTHERMAL ENERGY IN PERU
FINAL REPORT
(SUMMARY)

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
WEST JAPAN ENGINEERING CONSULTANTS, Inc.

ILD
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ABBREVIATIONS

Abbreviation	Description
ACRVM	Regional Conservation Area Vilacota Maure (Área de Conservación Regional Vilacota Maure)
ANA	National Water Authority (Autoridad Nacional de Agua)
ADINELSA	Enterprise for the Administration of Electric Infrastructure (Empresa de Administración de Infraestructura Eléctrica S.A.)
ANP	Protected Natural Areas (Áreas Naturales Protegidas)
a.s.l.	above sea level
COES	Committee for the Economic Operation of the System (Comité de Operación Económica del Sistema)
CENERGIA	Energy and Environment Protection Center (Centro de Conservación de Energía y del Ambiente)
CTE	Electricity Tariffs Commission (Comisión de Tarifas Eléctricas)
DEFENSORIA	Customers Protection (OSINERGMIN branch)
DGAA	General Directorate of Environmental Affairs (Dirección General de Asuntos Ambientales)
DGAAE	General Directorate of Energetic Environmental Affairs (Dirección General de Asuntos Ambientales Energéticos)
DGE	Directorate General of Electricity (Dirección General de Electricidad)
DREM	Regional Directorates of Energy and Mines (Direcciones Regionales de Energía y Minas)
EIA	Environmental Impact Assessment
FONAFE	National Fund for the Financing of State Entrepreneurial Activities (Fondo Nacional de Financiamiento de la Actividad Empresarial)
GART	Division of Tariff regulation annexed to OSINERGMIN (Gerencia Adjunta de Regulación Tarifaria)
GOP	Government of Peru
INACC	Concessions and Cadastral Institute (Instituto Nacional de Concesiones y Catastro Minero)
INDECOPI	National Institute for the Defense of Competition and Intellectual Property (Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual)
INGEMMET	Institute of Geology, Mining and Metallurgy (Instituto Geológico Minero y Metalúrgico)
INRENA	National Institute of Natural Resources (Instituto Nacional de Recursos Naturales)
IPEN	Peruvian Nuclear Institute (Instituto Peruano de Energía Nuclear)
JBIC	Japan Bank for International Cooperation (Banco del Japón para Cooperación Internacional)
JETRO	Japan External Trade Organization

JICA	Japan International Cooperation Agency (Agencia de Cooperación Internacional del Japón)
MEF	Ministry of Economy and Finance (Ministerio de Economía y Finanzas)
MEM (MINEM)	Ministry of Energy and Mines (Ministerio de Energía y Minas)
MINAG	Minister of Agriculture (Ministerio de Agricultura)
MINAM	Ministry of Environment (Ministerio del Ambiente)
MT	Magneto telluric
OGGS	Social Impact Management Office (Oficina General de Gestion Social)
OSINERGMIN	Organization of Supervising for Investments in Energy and Mines (Organismo Supervisor de la Inversión en Energía y Minería)
PPC	Citizen Participation Plan (Plan Participacion Ciudadana)
RER	Renewable Energy Resources (Recursos Energéticos Renovables)
SEIN	Electric National Interconnected System (Sistema Eléctrico Interconectado Nacional)
SERNANP	National Service of Natural Protected Areas (Servicio Natural de Áreas Naturales Protegidas)
SINANPE	National System of Protected Natural Areas State (Sistema Nacional de Áreas Naturales Protegidas por el Estado)
SNIP	National System of Public Investment (Sistema Nacional de Inversión Pública)
SRTM	Shuttle Radar Topography Mission
TOR	Terms of Reference
UTM	Universal Transverse Mercator, geographical coordinate system

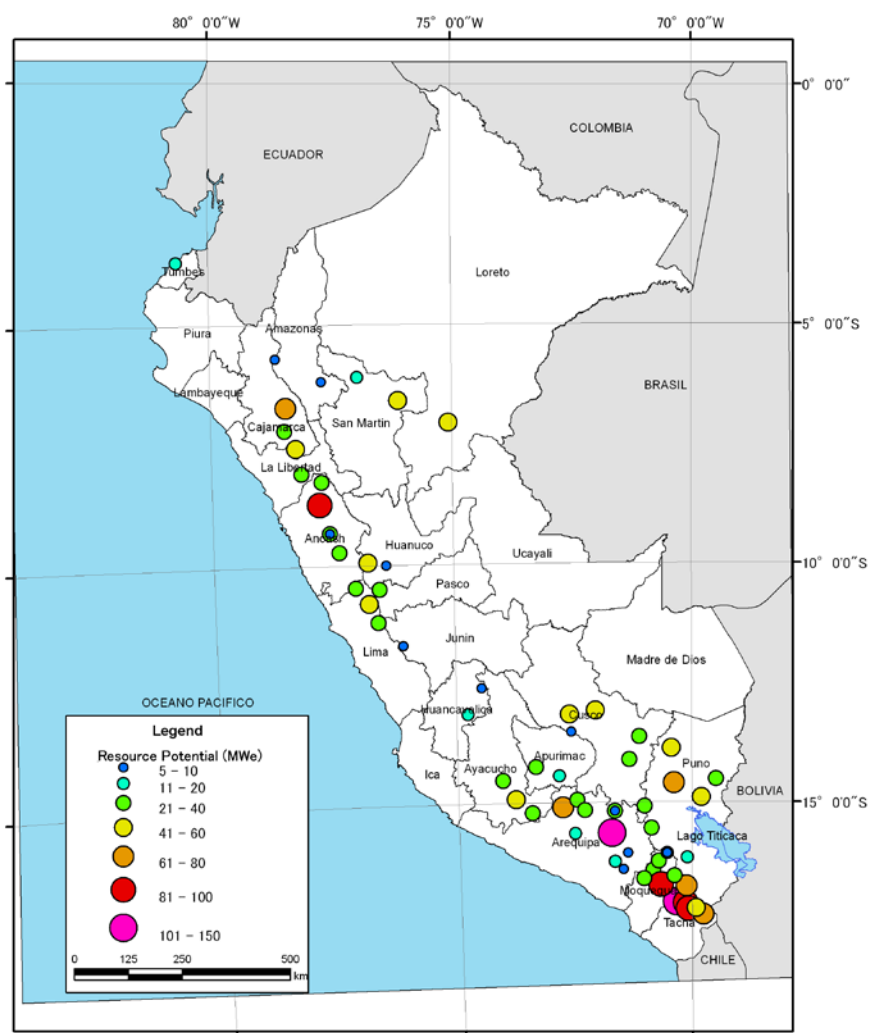
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Conclusions and Recommendations

1. Geothermal Resources in Peru

Peru has abundant geothermal resources. In the study, the total geothermal potential in Peru is estimated to be 2,860 MWe in 61 geothermal fields. The regions with abundant geothermal resources are in southern part of Peru.



2. Issues to be Solved for Promoting Geothermal Power Developments

- Although the government has set a target of 5% of the energy demand to be supplied by renewable energies, including geothermal energy, the proportion of the contribution of each energy source has not been formulated neither it is concrete plans for development.
- The risk of resource finding and the elevated initial cost, peculiar to geothermal development, might possibly prevent the progress of development by private sector. Thus it is necessary to consider options such as the improvement of the current electricity legal frame work, or to proceed to governmental participation in geothermal power generation projects.
- The only existing incentive for promoting geothermal power generation projects is currently the Feed in Tariff scheme for the renewable energy resources generators collect at least a monomic fixed

price for the energy supplied to the grid and contracted through tenders for renewable energy. The system has not been qualified as an effective measure in promoting the developments by private sector since the purchase price (the base price in the tender) has not been examined yet.

- There is not a strong base of human resources in Peru with capacity to develop geothermal energy for power generation and for the multiple use of geothermal heat. In addition, the collaborative partnership and information exchange among the related governmental institutions to be involved in the development and promotion of geothermal energy is yet not sufficient.

3. Recommendations

➤ Target of Geothermal Power Development

- ⇒ It is longed this indigenous energy resource of Peru is developed as much as possible for power generation and for other heat utilization purposes. The development will be started with resource exploration and will take rather long time. As a mid/long-term vision of energy mix strategy it would be good to develop 1,000 MW of geothermal power by 2030.

➤ Legal and Organization Framework for Geothermal Power Development

- ⇒ Any major problem does not been identified in the present legal and regulatory framework for geothermal development. However, in case of geothermal resources are only developed by the private sector to attain the goal seems to be difficult. Thus, it is recommended to review and modify accordingly the related legal framework. The possibility of participation of the government through public company in the exploration and construction stage must be evaluated in view to reduce the resource risks and lowering the investment burden of the private sector.

- ⇒ It is desirable that, while the governmental organizations such as DGE and INGEMMET streamlines their organizations and promote capacity building in order to promote geothermal energy, the others expected to be involved directly such as Electroperú S.A. should start building geothermal task team in their organizations.

➤ Assistance and incentives for promotion of geothermal development

- ⇒ To promote geothermal development through the current FIT system inducing the private investments, it is desirable to set the base price as high as possible. However, it means that the impact on electricity tariff for consumers may be significant. To avoid this effect, it is desirable to implement other means of assistance and incentives.

- ⇒ In case of geothermal development only by the private sector, it is recommended to provide assistance through Two Step concessional Loan scheme to COFIDE, for example. In addition, tax incentives such as tax holiday can also work to promote geothermal development by the private sector.
- ⇒ Another mean would be Public Private Partnership in the early stages of development utilizing ODA concessional loans for the portion of investment corresponding to the public company.
- ⇒ It is desirable that the government conducts the resource exploration as a part of fiscal assistance. This contributes to reduce the resource risk, development cost and lead time for development for the private companies.

➤ Multi-purpose Use of Geothermal Energy

⇒ Regarding the multi-use of geothermal energy, development of legal system for the geothermal resource development and exploitation regarding is required considering the combined use with power generation purpose. In addition, governmental support such as subsidy, preferential tax system, etc. for multi-use project is required. To validate the feasibility of the multi-use project, implementation of a government-led pilot project is recommended.

4. Action Plan

The action plan relating with all areas (legal framework, system/organization, supporting/assistance by the government and multipurpose use) for promoting geothermal developments in Peru is shown below.

	Short-term Target		Long-term Target							Note
	2012	2013	2014	2015	2016	2017	2018	2019	2020-	
Revision of targeted RE participation			▼						▼	present status: 5% of total energy demand
Tender for RE projects		▼		▼		▼			▼	every two years
Legal Framework										
- Enactment of policy										National Plan for RE etc.
- Revision of Geothermal Law (as necessary)			-----▶							Management of development by private sector, etc.
- Revision of RE Law (as necessary)			-----▶							
- Guideline for natural and social environmental considerations										
System/Organization										
- Capacity building to develop. management			-----▶							DGE · INGENMET
- Network for promoting geothermal										MEM Geothermal Committee
- Database updating system										
- Organization in state-owned utilities										Electroperú, etc.
- Capacity building of the public sector for their participation in geothermal			-----▶							
Support from the Government										
- Development finance system (TSL, etc.)										COFIDE etc.
- Establishment of PPP scheme										Financing at low interest, etc.
- Exploration by the public sector										
- Upgrade knowledge of geo-potential			-----▶							INGENMET
Multi-purpose Heat Use										
- Management of hot water resources										
- Legal framework for multi-purpose use										
- Establishment of subsidy system			-----▶							
- Public demonstration project			-----▶							

5. Geothermal Development Database

The geothermal development database is constructed based on the geothermal resource database by adding the other information about electric supply and demand balance, power grid, natural and social environmental issues, and so on. The geothermal development database can be utilized to search and update the necessary information regarding the geothermal development in Peru. The database is expected to assist the acceleration of geothermal development in Peru. It is preferable that related

Peruvian organization will coordinate on the management and update of the database for the purpose of effective utilization of the database.

6. Geothermal Development Plan

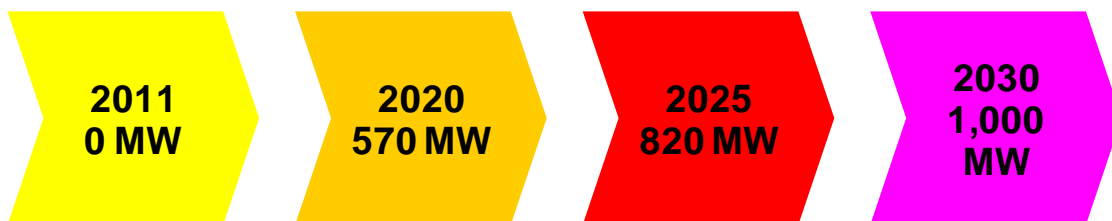
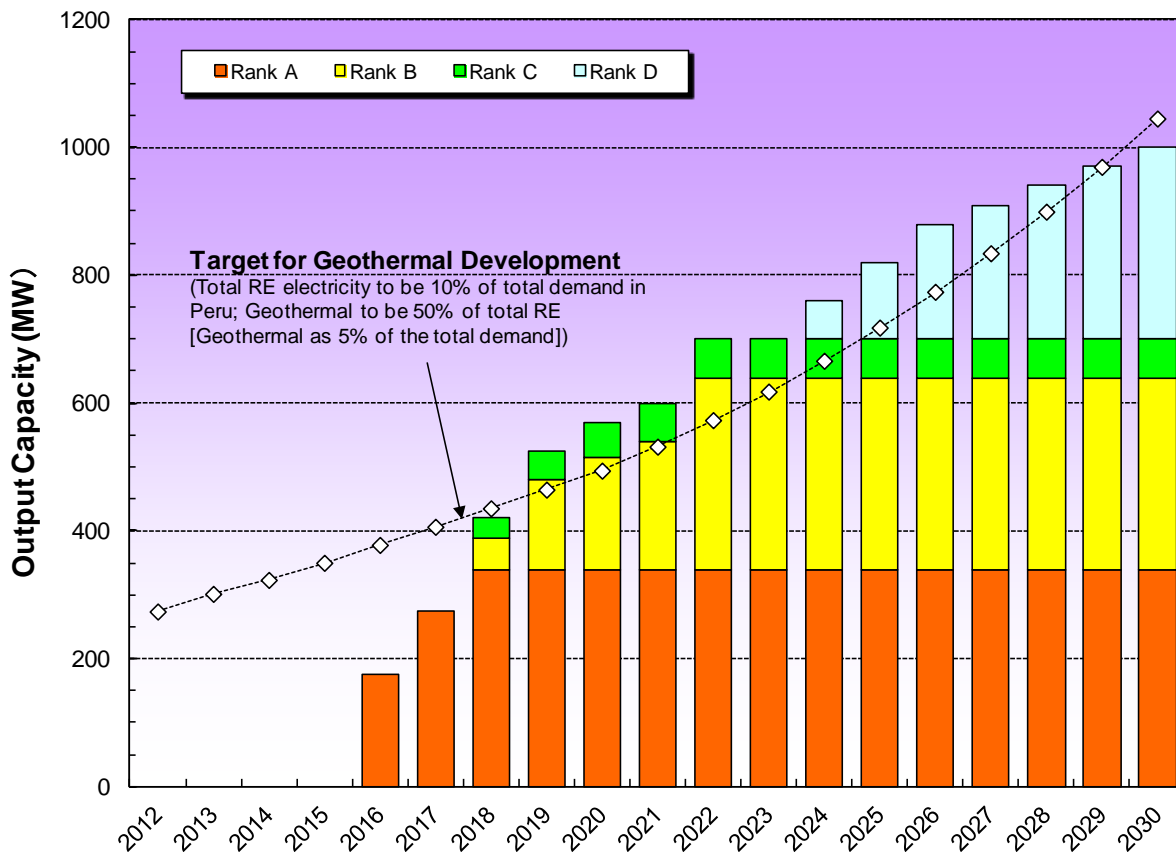
The priority evaluation results are summarized below. It can be expected that total of 640 MW power generation would be achieved from the fields categorized in relatively high priorities (Rank A and Rank B).

Rank for Priority	Description	Geothermal Field	Possible Power Output (MW)	Total Possible Power Output (MW)
Rank A	Earliest development is expected. (The development would be done even without any support from the government)	Tutupaca	105	340
		Crucero	70	
		Calacoa-Putina	100	
		Pinaya	35	
		Puquio	30	
Rank B	Followin the Rank A (The authorization for exploration is to be waited for.)	Chivay-Pinchollo	150	300
		Ancocollo	90	
		Ccollo/Titire	35	
		Ulucan	25	
Rank C	Relatively early development is expected, but the resource potential is to be confirmed.	Cailloma	5	(60)
		Huancarhuas	(30)	
		Paila del Diablo	(15)	
		Pararca	(10)	
Rank D-1	The resource potential is to be confirmed. (Based on the existing data, high potential resource can be expected.)	17 fields (including Chancos and Jesus Maria)	—	Unknown
Rank D-2	The resource potential is to be confirmed. (Based on the existing data, the existence of high potential resource cannot be expected.)	24 fields	—	Unknown
Others	Environmental impact of possible geothermal project should be evaluated. If the impact can be avoided or mitigated sufficiently, the development should be permitted.	7 fields (including Borateras, Calientes and Chungara-Kallapuma)	—	>225

Note: Number of the evaluated geothermal fields is 61 in total.

An integrated plan for geothermal power development in Peru that aims to develop 1,000MW electricity by 2030 was devised in conformity with the objectives stated in the recommendations, considering the results of ranking of geothermal fields. The yearly progress of the integrated development plan (the Road Map) is shown in the next page.

The milestones in the intended development Road Map were set as follows: 570 MW in 2020, 820 MW in 2025, and 1,000 MW in 2030. For the realization of the objectives, proper managements and instructions must be given to the exploration activities practiced by private companies, and it is desirable for the government of Peru to support or to participate in the exploration activities when the exploration studies do not work effectively. In addition, the Road Map should be revised and updated if necessary according to the progress of the exploration/development activities.



Start of Authorization 5% of Total Demand

Development Rank A Fields: 340 MW

Development Rank B Fields: 300 MW

Development Rank C Fields: 60 MW

Development Rank D Fields: total 300 MW

I INTRODUCTION

I-1 Background

The geothermal potential for power generation in the Republic of Peru (hereinafter abbreviated as “Peru”) has been estimated to be 3,000 MW or higher. However, this is only estimation and there is no any geothermal exploitation in the country. This is because the country has not established technical know-how and experience for the geothermal resource exploration, development and for the exploitation of geothermal resources as well for geothermal power facilities construction and for their operation and maintenance.

Under these circumstances, in 2008 the law for promotion of electricity generation with renewable energy was enacted. This law targets 5% of total electricity generation utilizing renewable energy resources (solar, wind, biomass, geothermal, small-hydro (< 20 MW)). According to this law, the government shall elaborate and review the national plan to develop and utilize renewable energy every two years. In the case of geothermal resources, currently there is not any development, the only concrete geothermal activities in Peru are the two Pre-Feasibility studies conducted for the Borateras and Calientes fields. A committee for the promotion of geothermal development has been created within the Peruvian government. Peru energy authorities requested technical assistance to the Japanese government to formulate a Master Plan for the development of geothermal resources of the country.

I-2 Objectives and Contents of the Study

The objective of this study project is to make the nationwide geothermal power development plan (Master Plan) for Peru in order to promote and accelerate the geothermal energy development and exploitation program in Peru.

The Master Plan will be formulated considering all factors including the geothermal resource potential in promising fields, the current and forecasted future situations of the electric power sector, and the framework established by the present policy/legal dispositions. The Master Plan will involve recommendations aimed to promoting geothermal developments in Peru through the establishment of adequate national policies. In addition, a database of information related to the Peru geothermal power development will be constructed to serve the purpose of a base upon which the Master Plan is formulated and a platform upon which the Peruvian corresponding authority can proceed to updates after this study is completed. Technology transfer to the counterpart staff of the Directorate General of Electricity (DGE), INGEMMET and other organizations in the Ministry of Energy and Mines (MEM) will be carried out all throughout the execution of the activities for this study.

The Final Report will be composed of the following chapters:

- Main Report Chapter I : Current Status of Geothermal Power Development and Issues to be Solved
- Main Report Chapter II: The Master Plan
 - Recommendations and Action Plan
 - Geothermal Development Database
 - Geothermal Development Plan
- Annex : Results of Investigations
 - Study Results for the Promising Fields (Resources/Environmental)
 - Geothermal Development Plans for the Promising Fields
 - Materials of Various Analysis

II STATUS AND TASKS FOR GEOTHERMAL DEVELOPMENT

II-1 Energy and Electric Sector

II-1.1 Energy Sector and its Policy

Peru's energy supply had significant participation of crude oil and derivatives (53%) and biomass (37%, mainly wood) in the 70's. Recently, however, there has been a strong involvement of Natural Gas (around 33%) while there has been a significant reduction in crude oil and derivatives (35%) and biomass (15%). On the other hand, the hydro, which reached its peak in 2004 with 17%, has fallen to the only 14% because of the penetration of natural gas in electricity generation. The participation of natural gas and derivatives (from the year 2004 the impact of Camisea can be clearly seen), which has helped decrease of the dependence of the crude oil and in recent years the smaller share of biomass (especially the wood) is also noticeable. On the other hand, the country's abundant water resources (about 58,000 MW) have not been sufficiently exploited.

The country's energy policy aims at securing energy self-sufficiency in a competitive environment through the promotion of private investment. Sector is expected to have a locomotive role for sustainable growth of the economy. Particularly the diversification of energy mix (through the reduction of oil dependence while increasing the use of natural gas, liquefied gas and renewables), promoting development of renewable energy resources (biomass, wind, solar, geothermal, tidal and hydropower capacity less than 20 MW), rural electrification, sustainable development of the sector with a minimum environmental impact, low carbon emissions and greater integration with the region's energy markets are a long-term vision of the Ministry of Energy and Mines for the energy sector. In Peru's National Energy Policy 2010-2040, approved by Supreme Decree (No.060-2010-EM) in November 2010, the objectives of national energy policy are:

1. Having a diversified energy mix, with emphasis on renewables and energy efficiency
2. Having a competitive energy supply
3. Universal access to energy supply
4. Having greater efficiency in the production chain and energy use
5. Achieving self-sufficiency in energy production
6. Development of energy sector with a minimal environmental impact and low carbon emissions in a sustainable development framework
7. Development of the natural gas industry, and its use in household activities, transportation, trade and industry as well as efficient power generation.
8. Strengthen energy sector institutions
9. Integration with the region's energy markets, capable of achieving long-term vision.

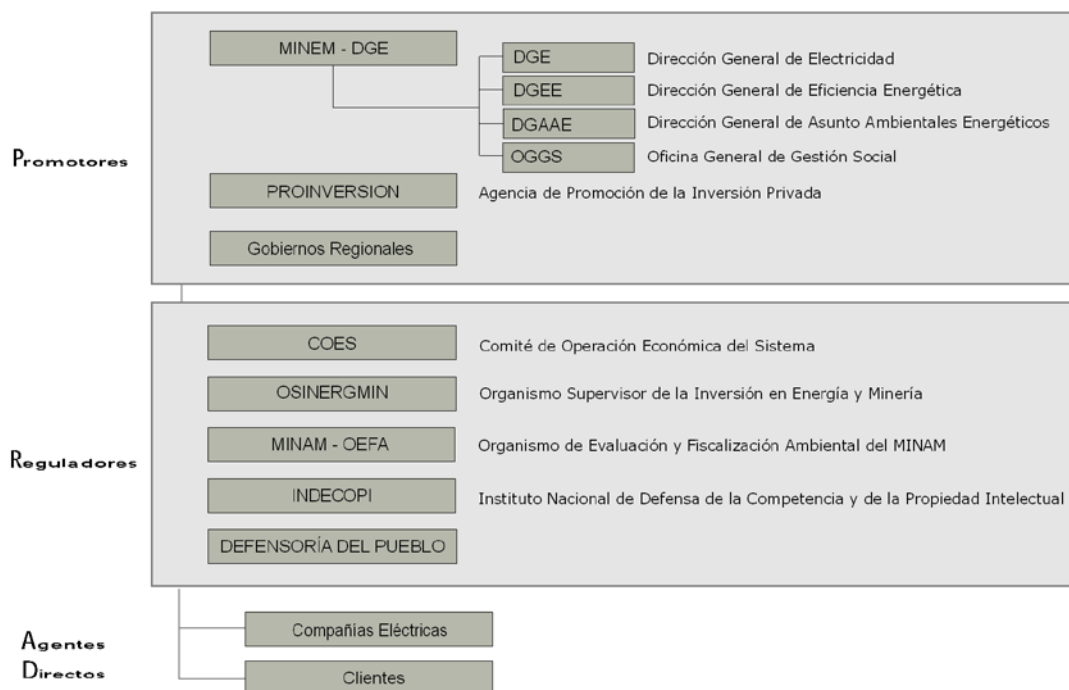
II-1.2 Legal Framework and Related Institutions

II-1.2.1 Legal Framework

The electricity subsector activities are regulated for the Electricity Concessions Law (Law No.25844) and its Regulations, which entered in force since 1992. These rules are supplemented by the Act to ensure the Efficient Development of Electricity Generation (Law No. 28832) which entered in force since 2006 for the purpose of gradual improvement and adaptation of the legal framework along the evolution of the electricity market.

II-1.2.2 Related Institutions

Figure II-1.2.1 shows the actors involved in the electricity subsector and their interaction according to current regulations.



(Source: MEM Electric Sector 2010)

Fig. II-1.2.1 Participants in the electrical subsector

II-1.3 Power Supply and Demand Situation

II-1.3.1 Generation

The installed generation capacity is 7,309MW (excluding 1,303 MW of private-owned power generation capacity) in December 2010. The power plants are owned by 45 companies.

As shown in the Table II-1.3.1, the generations are mainly consisting of, 3,345 MW (45.8%) by hydro and, 3,964 MW (54.2%) by thermal. Natural gas generation (2,479 MW) occupies about 63% of thermal power. In 2010, wind power generation has been joined in the market, while the capacity is only 0.7 MW (0.01%).

Table II-1.3.1 Installed capacity / effective / type of generation

Power Plant	Installed Capacity (MW)	%	Effective Capacity (MW)	%
Hydro	3,345	45.8%	3,237	47.1%
Thermal	3,964	54.2%	3,637	52.9%
Gas Natural	2,479	33.9%	2,306	33.5%
Dual (Gas Natural - Diesel)	544	7.4%	509	7.4%
Diesel	500	6.8%	407	5.9%
Carbon	426	5.8%	404	5.9%
Others	15	0.2%	11	0.2%
Wind	0.7	0.01%	0.7	0.01%
Total	7,309	100.0%	6,875	100.0%

Source: MEM 2010 data

II-1.3.2 Transmission Lines and Substations

In late 2010, the transmission system in Peru was mainly composed of networks of 220 kV, 138 kV and 66/30 kV. The network is interconnected in 220 kV with a length of 2,200 km from north to south. Figure II-1.3.1 shows the interconnection of transmission lines at December, 2010.

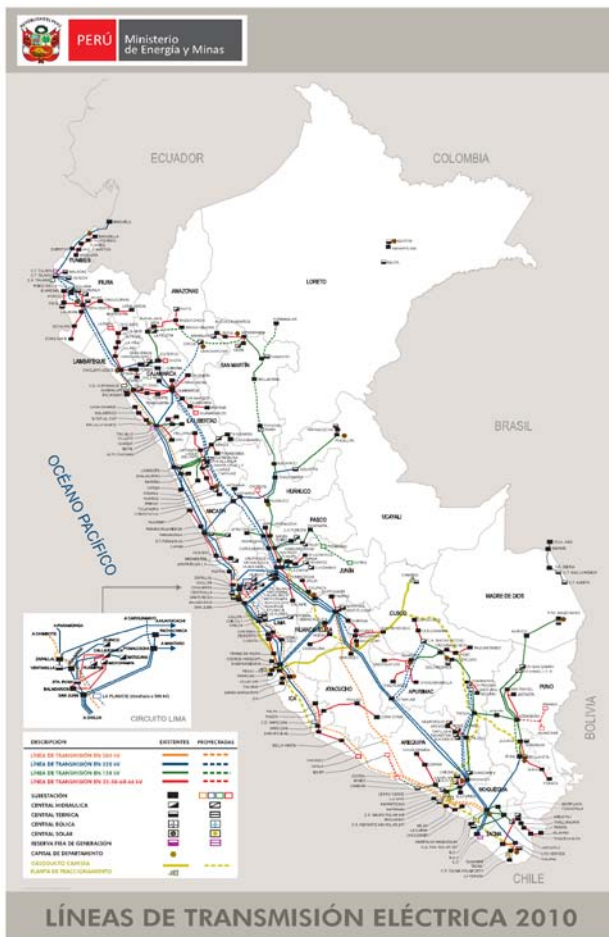


Fig. II-1.3.1 Transmission line network (MEM, 2010)

II-1.4 Power Supply Structure

II-1.4.1 Generation

The wholesale market is free and has the participation of generation companies. In the wholesale market, power generators sell power to distribution companies or directly to large users (consumers of more than 2500 kW). The dispatch center, COES-SINAC, which is an organization composed of all generation and transmission and distribution companies (for each transmission system) has the function of commercial daily dispatch. The dispatch is planned every hour in merit order in the principle of optimal economic dispatch at the minimum cost.

II-1.4.2 Transmission and Distribution

To assure the liberalized wholesale and retail markets, the law guarantees free access to transmission networks. Users of the transmission and distribution lines, transmission and distribution charges, approved by OSINERGMIN must be paid.

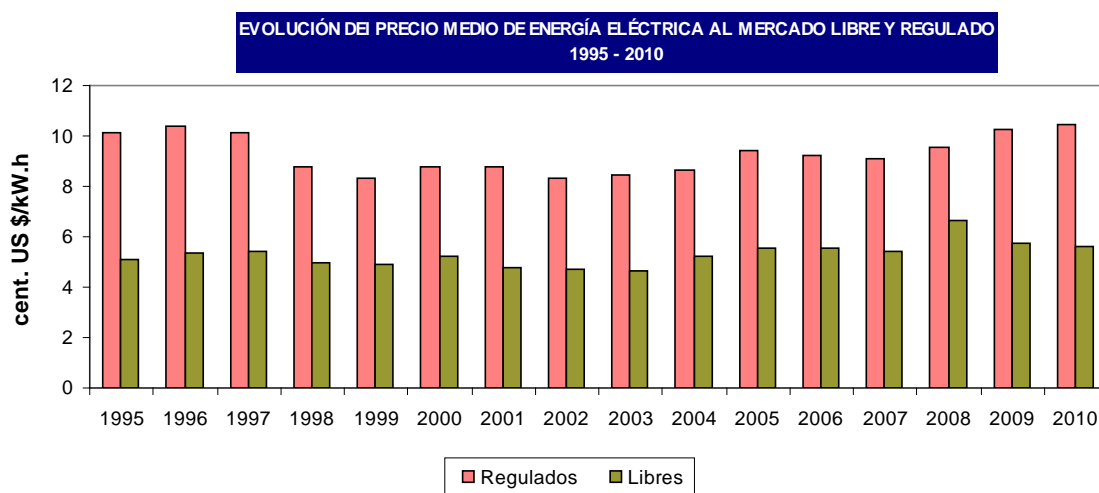
II-1.4.3 Small Users Market

To sell electricity, there are two markets. The free market for large users (consumers above 2500kW) and the regulated market for small users (consumers below 200kW). Large users can freely contract with the generation companies or distributors. There are currently 343 free contracts, occupying 46% of total energy sales in the country and representing the transaction of 11.4 GWh. In the regulated market, distribution companies are required to supply electricity to small users in their proper area.

II-1.5 Tariff Structure

Electricity tariffs in the regulated market are determined by the OSINERGMIN. In that case, the tariff for users is calculated by adding the fee at node (the generation fee and transmission fee to the node) and the distribution fee. Generation fee has two components: the capacity fee (USD/MW) and energy fee (USD/MWh). The energy fee is defined for on- and off-peak hour, respectively.

Figure II-1.5.1 shows the average electricity price in the regulated market and free market respectively from 1995 to 2010.

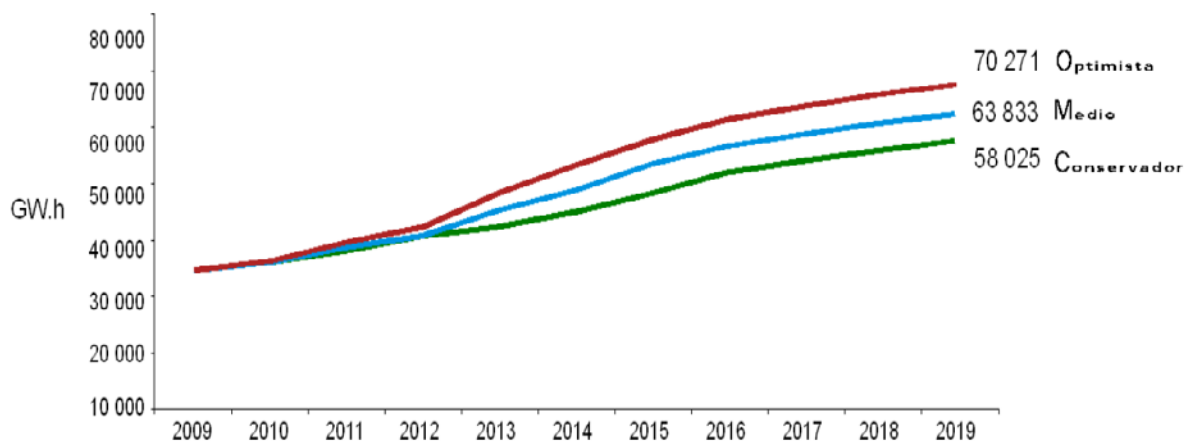


Source: MEM 2010 data

Fig. II-1.5.1 Evolution of electricity price (1995 - 2010)

II-1.6 Policies of Power Sector

In the past five years, the demand for electricity has had an average annual growth of 8% due to the strong development of mining and manufacturing. Figure II-1.6.1 shows the projected demand through 2019 in three different scenarios (Optimist: 9.0%, Medium: 8.1% Conservative: 7.0%). Although macroeconomic conditions in the country maintain this level of growth and in the last five years investment in electricity has grown at an average annual rate of 23%, the country needs to accelerate the implementation of new projects to ensure the supply of electricity.



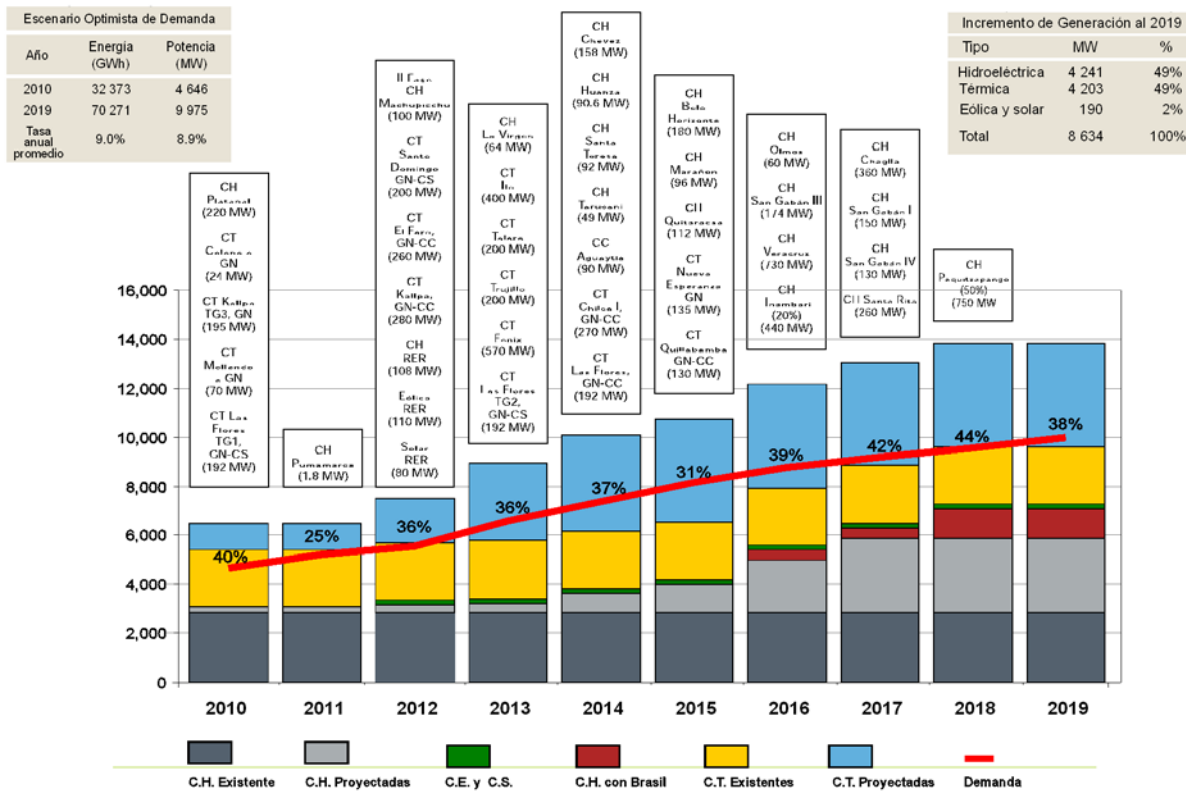
(Source: MEM 2010)

Fig. II-1.6.1 Projected demand of electric energy 2009-2019

Based on these facts, the MEM is implementing policies in the following lines:

- Diversify the energy matrix
- Mechanisms of incentive for private investment
- Perfect the regulatory and legal framework of the subsector to ensure timely and adequate supply
- Promote the development and use of renewable energy sources for electricity generation, particularly hydro
- Use efficient natural gas for power generation
- Security and coverage of electric transmission
- Regulation of tariff in the regulated market
- Continue the expansion of electricity coverage in rural, remote and border areas of the country
- Promote a culture of energy efficiency and electrical safety users
- Energy Security
- Promote investments in generation and transmission of electricity for the regional energy integration (to become an exporter of electricity in the region, considering its huge potential of hydropower)
- Promotion of energy development while preserving the environment

According to the MEM's "Electricity Sector 2010", the estimated increment of generation capacity for 2019 will be 8,634 MW. This will be given at the rate of 49% from hydropower, 49% in power plants to natural gas and 2% in renewable energy resources (excluding hydro) (Fig. II-1.6.2).



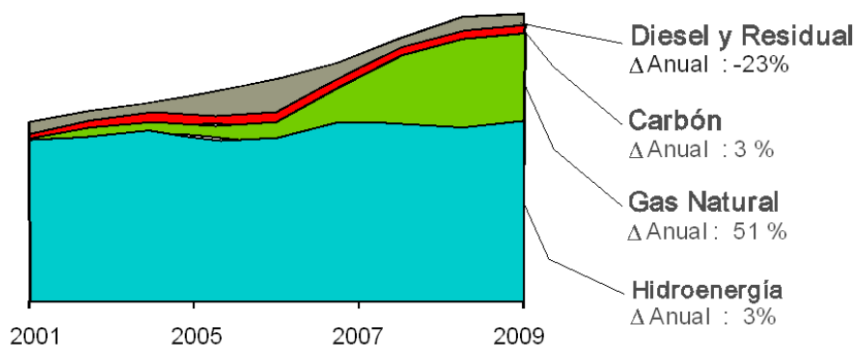
(Source: MEM 2010)

Fig. II-1.6.2 Projected supply and demand, for SEIN, 2010 - 2019

II-2 Promotion of Renewable Energy Development

II-2.1 Background

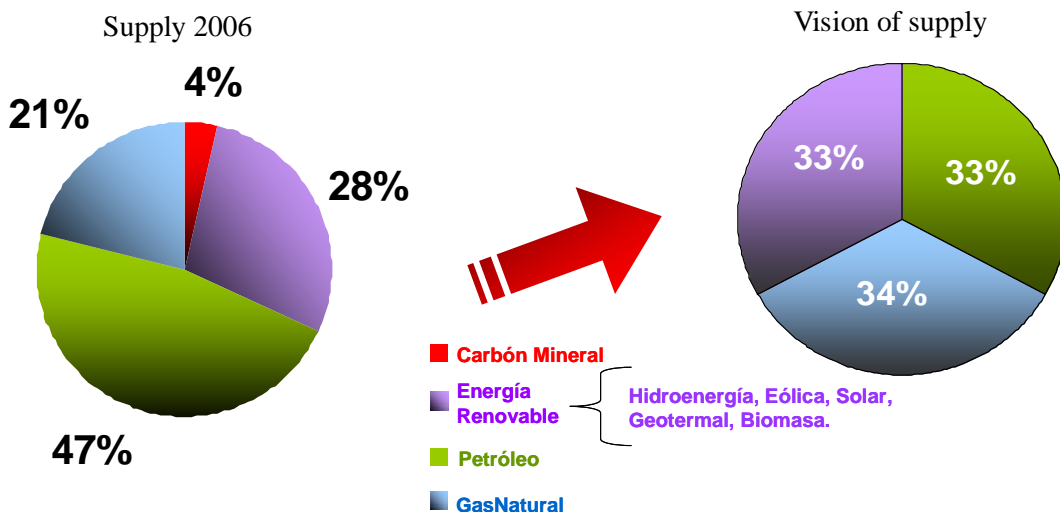
In policies for power sector, promotion of use of renewable energy resources is one of the pillars and the government is implementing concrete measures. For the country it is a requirement not only from the standpoint of view of the environment, but in order to meet the growing demand for electricity in the medium term it will be essential to use renewable energy resources. However, as shown in Fig II-2.1.1, the country is highly dependent on the production of electricity from hydro resources and on the other hand, the generation of electricity by burning natural gas has also increased recently. In this sense, the importance of the introduction of renewable resources of the country's energy mix will be increasing from the point of view of the country's energy security.



(Source : MEM, 2010)

Fig. II-2.1.1 Generation by Resource 2001 - 2009

The Peruvian government has the vision for the change of the energy matrix in the future, in which about one-third of the energy supply (including power generation) should be met with renewable energy sources (Figure II-2.1.2). In June 2010, the government presented officially the national actions for mitigation of climate change in accordance with the international agreement in COP 15 under the framework convention on climate change (Copenhaguen Agreement). Among the activities which the government compromised to realize voluntarily, the modification of the actual energy matrix in the way that at least 33% of the energy matrix should be represented with “non-conventional energy, hydroenergy, biomass” in 2020 is included.



(Source : MEM“ Norms and facilities to develop Renewable Energy” 10/2008)

Fig. II-2.1.2 Vision for a change in the energy matrix

II-2.2 Laws for Promotion of Electricity Generation with Renewable Resources

The government established an obligation of 5% of energy consumption in the next five years should be covered with renewable energy resources (RER: biomass, wind, solar, geothermal, tidal and hydropower up to 20 MW). The government is implementing rules and incentives to promote the use of renewable energy resources and within the promulgation of the Law to Promote Electricity Generation with Renewable Energy (Law No.1002) in May 2008 and its Regulation (Supreme Decree No.050-2008-EM) enacted in October of the same year are the most important.

Under the Law and Regulations, the government carried out the first and second auctions of electricity supply with renewable energy resources in SEIN for the period of 20-30 years in the awarded price. The auction was conducted in the following manner:

- The country guarantees that the 5% of annual energy consumption should be covered by energy generated from renewable energy resources during the next 5 years. This percentage of participation of renewable energy resources may be increased by the MEM.
- To meet the requirement, the country guarantees the payment of the awarded price in the auction for a period between twenty and thirty years (renewable energy resources generator receives the guaranteed income from the sale of energy produced at the awarded price. In case of that the awarded price exceeds the marginal cost of the spot market, that difference will be covered as premium).
- The composition of energy by type of technology is defined accordingly to the National Renewable Energy Plan, projects with requested for concession. The bidding documents are prepared by MEM.

- The bidding process is conducted by OSINERGMIN at the request of MEM:
- For the determination of the Base Price, MEM considers a return of not less than 12% as defined in Article 79 of the Electricity Concessions Law. Base Price will be calculated by OSINERGMIN by type of generation technology with renewable energy resources (See Fig. II-2.2.1)

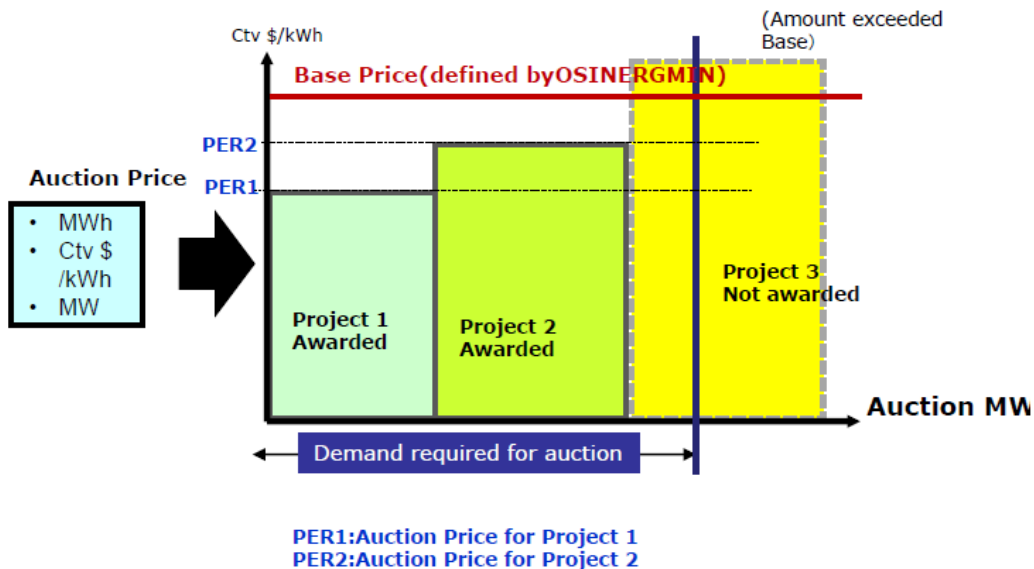


Fig. II-2.2.1 Auction scheme for generation with renewable energy resources

- The Award Price shall be guaranteed to each successful bidders for the sale of its energy production, expressed in USD/MWh.
- The evaluation of bidders is independently done by technology type of renewable energy resources.
- The award is determined in merit order within the Base Price up to complete the share of each technology defined in the bid document to cover the total energy required.
- The term of validity is established in the Rules, within not less than twenty years nor more than thirty years.
- The call to auction will take place with intervals of 2 years.
- The sale of power generated with renewable energy resources in the short term market at marginal cost plus a premium is guaranteed, in cases where the marginal cost is less than the corresponding award price (See Fig. II-2.2.2). The premium will be reflected in the price of electricity for end users.

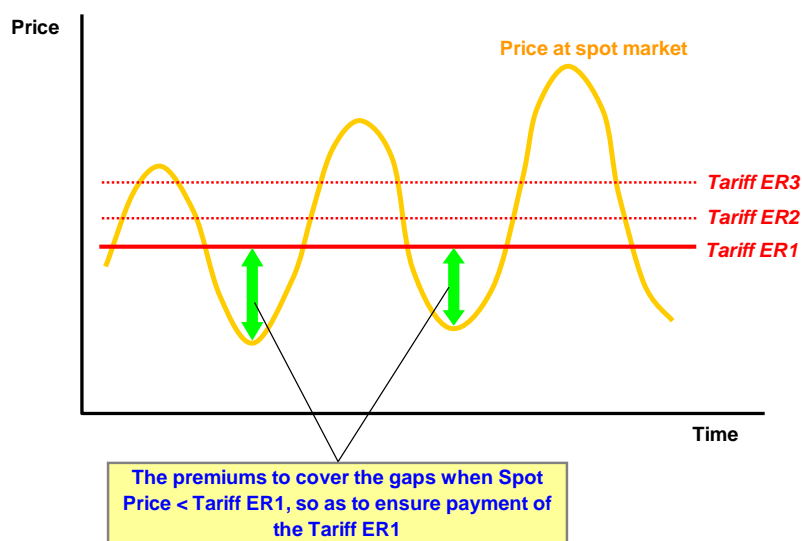


Fig. II-2.2.2 Selling price of power generated by renewable energy resources

- Be owner of a temporary concession is not a requirement for bidders.
- Preferential dispatch and free access to connection networks.

In October 2009, the government conducted the first auction of renewable energy resources electricity supply in order to have an installed capacity of 500 MW (converted from required energy 1,134 GWh/year at the capacity factor of 30%) with renewable energy resources other than hydro. The award was determined in February 2010 among 20 qualified bidders with 31 projects: 17 hydroelectric, 6 wind, 2 solar and 6 biomass. Finally, 26 projects have been awarded. The maximum prices set by OSINERGMIN previously were: hydro 74 USD/MWh, wind 110 USD/MWh, biomass 120 USD/MWh and solar 269 USD/MWh. These prices were calculated by OSINERGMIN according to its own methodology, and were kept in reserve until the public act of opening of bids.

The term of the award price is 20 years and the projects awarded will enter into commercial operation no later than December 31, 2012. Auction to complement the missing portion of 500 MW was announced in March 2010 and 25 projects (5 biomass, 17 solar and 3 hydroelectric) participated. However, most projects had a price above the base price and only two hydroelectric projects were awarded. The second auction was announced in April, 2011 and awarded for one biomass project, one wind project and one solar project in July, 2011. The base price was revealed after the auction only for the biomass project, which was 65 USD/MWh. Table II-2.2.1 shows the awarded biomass, wind and solar projects up to now.

Table II-2.2.1 Awarded renewable energy resources projects

Project Name	Capacity (MW)	Price (centUSD/kWh)	Capacity Factor (%)	Tender Year	Generation Start Year
Biomass	29.4				
Generación Ingenio Azucarero Paramonga	23.0	5.20	57.10	2009	2010
CTB Huaycoloro	4.4	11.00	73.40	2009	2011
La Gringa V	2.0	9.999	80.00	2011	2014
Wind	232.0				
Marcona	32.0	6.55	52.93	2009	2012
Central Eolica Talara	30.0	8.70	46.00	2009	2012
Central Eolica Cupishnique	80.0	8.50	43.00	2009	2012
Central Consorcio Tres Hermanas	90.0	6.90	52.73	2011	2014
Solar	96.0				
Panamericana Solar 20TS	20.0	21.50	28.90	2009	2012
Majes Solar	20.0	22.25	21.50	2009	2012
Tacna Solar	20.0	22.50	26.90	2009	2012
Reparticion Solar 20T	20.0	22.30	21.40	2009	2012
Solarpack Corporación Tecnológica S.L.	16.0	11.99	30.50	2011	2014
Total	357.4				

The renewable energy resources generator connected to the SEIN may sell part or all of their energy in the spot market. Additionally they get a premium if the amount awarded is higher than a marginal cost in the spot market. The renewable energy resources generator connected to an isolated system will sell its distributor at the awarded price. The renewable energy resources generator not awarded may sell part or all of their energy freely in the contract with third parties or in the spot market.

Additionally, laws that grant tax benefits to investment on renewable energy have been adopted, a) Decree Law No.1058, which has the benefit of accelerated depreciation of assets, up 20% each year for purposes of payment of income tax for investments hydroelectric and other renewables (June, 2008) and b) No.28896 Act provides that the generation of electricity with renewable hydro resources and/or other, is eligible for Early Recovery System of General Sales Tax (GST) (June 2006).

II-3 Legal Framework for Development of Geothermal Resource

II-3.1 Organic Law of Geothermal Resources

To promote development of geothermal resources, the Organic Law on Geothermal Resources (Law No.26848) was promulgated in July 1997 and its Regulations in 2006. Later in April 2010, the new Regulation of Law No.26848 was approved with the objective of introducing private investment in developing this energy source and reduce the risk to them. Also, Ministerial Resolution No.191-2007-PCM established a Multisectoral Technical Commission.

II-3.2 Organizations Related to Geothermal Development

Relevant entities related to geothermal development in the country are;

Vice Ministry of Energy, Ministry of Energy and Mines

Ministry of Energy and Mines shall resolve as a second and final administrative entity those challenges against decisions of the Directorate General of Electricity.

General Directorate of Electricity (DGE)

The functions of DGE, in accordance with the provisions of the Geothermal Resources Law and its Regulation, are to process and settle in the first instance, as appropriate, all administrative procedures.

General Directorate of Energy Environmental Affairs (DGAAE)

The functions of the DGAAE, conforming to the Geothermal Resources Law and its Regulation, are to process and settle in the first instance, as appropriate, all administrative procedures relating to environmental studies of geothermal activities.

Supervisor of Investment in Energy and Mining (OSINERGMIN)

OSINERGMIN is in charge of supervision and monitoring of geothermal activity. Establish the scale of fines and penalties for geothermal rights holders who violate the law and regulations, under the legal provisions established for this purpose. Forward the case of disqualification of geothermal rights which may cause revocation, to DGE.

II-3.3 Definition of Geothermal Activities

According to the Organic Law on Geothermal Resources and its Regulations, geothermal activities are divided into the following;

Table II-3.3.1 Development phase of geothermal resources and geothermal rights

Development phase	Activities	Geothermal rights	Terms
(i) Identification	Activity to determine whether the area has geothermal resources or not by means of observation of terrain, geology and geo chemical studies.	None.	-
(ii) Exploration phase 1: realization of studies prior to the drilling of exploratory wells with a depth less than 1000 m. phase 2: realization of drilling of minimum of 3 exploratory wells	Activity to determine the dimensions, position, characteristics and extent of geothermal resources, including drilling of thermal gradient.	Requires Authorization	3 years phase 1: 2 years phase 2: 1 year, possible to be extended one time for 2 years
(iii) development (exploitation) to power generation	Activity to exploit the geothermal energy with the commercial aims by means of steam, heat and fluid of high and low temperature and others	Requires Concession. In the event of power generation, the concession contract shall be extend automatically for the same period of the concession for electricity generation.	30 years Possible to be extended for 10 years each time.

Development of geothermal resources should be done under the Organic Law of Geothermal Resources.

However, for the electricity generation, it requires to obtain the concession for electricity generation under the Electricity Concession Law, and the concession for geothermal exploitation can be automatically extended for the years of the concession for electricity generation.

Meanwhile, other renewable resources, the development and electricity generation are reigned by the Electricity Concession Law, according to which, the required rights are classified into the following three;

- Concession (Definitive Concession) : Required for electricity generation with hydro power (> 20MW) and renewable energy resources (RER, including hydro less than 20 MW)
- Temporary Concession: Required for generation projects with any capacity, including the renewable energy resources, to conduct the F/S within the period of 2 years.
- Authorization: Required for thermoelectric plants over 0.5 MW

Table II-3.3.2 shows the rights required for resource development and generation with geothermal and other renewable energy resources.

Table II-3.3.2 Required right for resource development and electricity generation

		Thermoelectric (more than 500kW)	Hydroelectric (more than 20MW)	RER except geothermal energy (biomass, wind, sun, tidal power, hidro less than 20 MW)	Geothermal Energy
		Electricity Concessions Law			
Rights	Pre F/S	None	None	None	Authorization (for exploration)
	F/S	Temporary Concession	Temporary Concession	Temporary Concession	Concession (for exploitation)
	Generation	Authorization	Definitive Concession	Definitive Concession	For electricity generation, the definitive concession is required under the Electricity Concession Law (concession for geothermal exploitation can be extended automatically for years of definitive concession).

For applications and approval of authorization and concession for geothermal development, the submission of the Environmental Impact Assessment (EIA) is not a requirement. However, before beginning the exploration and exploitation activities, the EIA should be submitted to the DGAAE for their approval.

Documents required for application of definitive concession for electricity generation with renewable energy resources including geothermal energy are defined in the Electricity Concession Law and its Regulation, in which the requirements are stipulated, depending on the generation capacity (< 10 MW, 10 MW – 20 MW, > 20 MW).

II-3.4 Request of Authorization

II-3.4.1 Procedure for Request of Authorization

Authorization is required to run exclusive exploration of a particular area of geothermal resources. For the request for authorization the following will be required:

1. Request to the Directorate General of electricity, signed by the legal representative, (mentioning identification and legal domicile).
2. Proof of payment for processing in accordance with the TUPA.
3. Simple copy of the public deed of Constitution of the company if the applicant is a legal person. Must also prove registration in the corresponding public registry.
4. (a) identification of the grid and the closed land polygon requested, the coordinates in UTM (PSAD56), specifying the name of the Chart and the zone where the area is located. (b) drawing on the respective area (scale 1: 100,000) according to the grid system adopted with RM No. 320-91-Ma-DGE, signed by the legal representative and the engineer responsible for its development.
5. (a) descriptive report, signed by the legal representative. (b) plans for exploration project, signed by the engineer responsible for elaboration.

6. Timetable and budget by major headings with precise indication of the number of wells and milestones of the critical path and for each of the phases, signed by the legal representative.
7. Sworn statement through which have an environmental study approved by DGAAE, before the start of the exploration work commitment is set. The type of study environment will be depending on the nature of the activity, signed by the legal representative.
8. Certificate of ability or capacity of engineer responsible for the drawings.

When two or more applications of geothermal rights on a same area, the DGE shall evaluate them according to the order of presentation. Where the request for geothermal right over an area of geothermal resources with different legal nature such as derivatives law rights registered prior rights hydrocarbons, mining or electricity, the previous owner will have a single preferential option to replace the request for geothermal right on its concession area. The holder of an authorization will have preference for the granting of geothermal resources up to 2 years beyond the duration of its authorization.

II-3.4.2 Request of Concession for Geothermal Resources

It is required to obtain a concession for geothermal resources to run geothermal resources exploitation activities. To apply a concession, the following will be required:

1. Request addressed to the Directorate General of electricity, signed by the legal representative, mentioning identification and legal domicile.
2. Proof of payment for processing in accordance with the TUPA.
3. Simple copy of the public deed of Constitution of the company if the applicant is a legal person. Must also prove registration in the corresponding public registry.
4. Simple copy of the resolution of granting of the authorization, in case of exercising the right of preference.
5. (a) identification of the grid and the closed land polygon requested, the coordinates in UTM (PSAD56), specifying the name of the Chart and the zone where the area is located. (b) drawing on the respective area (in scale 1: 100,000), according to the grid system adopted with RM No. 320-91-Ma-DGE, signed by the legal representative, and the engineer responsible for its development.
6. Technical report on the possibilities of production and proposal of the applicant for them.
7. Estimated date for start of production.
8. (a) Descriptive report, signed by the legal representative. (b) drawing project of exploitation, signed by the engineer responsible for elaboration.
9. Projected production capacity and scale of operations.
10. Work program and timetable for implementation of the same, signed by the legal representative. Project budget and investment program, signed by the legal representative.
11. Sworn declaration from which sets the commitment for elaborating and obtaining the EIA approved by DGAAE, before the start of work on the construction of the project. The environmental impact assessment will be granted depending on the nature of the activity, signed by the legal representative
12. Guarantee for an amount equal to one percent (1%) of the budget, until the subscription of the corresponding concession contract.
13. Certificate of ability and capacity of engineer responsible for the drawings.

In the event that the concession holders for geothermal resource exploitation generates electricity, the definitive concession for power generation is required. In that case, the concession period for geothermal resource exploitation can be extended automatically for the period of definitive concession for power generation.

II-3.5 Legal Framework on Natural and Social Environmental Concerns

II-3.5.1 Environmental Impact Assessment System

(1) Agencies to Implement EIA for Power Development Projects

No governmental department or agency in Peru has the comprehensive authority over the environmental impact assessment (EIA). Currently, different ministries take charge of EIA according to the nature of projects. The Ministry of Environment (MINAM; Ministerio del Ambiente) was established in May 2008 to take charge of formulating environmental management rules to ensure sustainable and strategic development of natural resources, managing protected natural areas and conducting research of the indigenous people in the Amazon river basin.

With examination of the EIA survey contents not included in its responsibility, the MINAM is not involved with the EIA procedures for power development projects. The National Protected Nature Areas Service (SERNANP: Servicio Natural de Áreas Naturales Protegidas) is an organ under MINAM with the authority to grant permission for development within protected natural areas and gives technical opinions on EIA submitted.

EIA for power development projects is reviewed and approved by the Directorate General of Energy-related Environmental Affairs (DGAAE; Dirección General de Asuntos Ambientales Energéticos) of the Ministry of Energy and Mines (MEM; Ministerio de Energía y Minas), while environmental rules and regulations are managed by the Directorate General of Electricity (DGE; Dirección General de Electricidad).

(2) EIA for Power Development Projects

Implementation of EIA in Peru is stipulated in Law No. 27446 promulgated on April 23, 2001. EIA implementation for power development projects is provided for in Decree Law No. 25844, Law of Electricity Concessions and Regulations, promulgated in 1993, and the details of EIA implementation are set forth in D.S. No. 29-94-EM, Environmental Protection Regulations for Electrical Activities that came into effect in 1994.

The Law No. 25844 stipulates that the requirement for EIA for a power development project depends on the energy output capacity of power plant. An EIA is required for a project of 20 MW or greater capacity. For a project of 500 kW or greater output capacity, the MEM's concession and approval (for the thermal power plant) are required.

In the meantime, Peru has Law of Geothermal Resources (Ley Orgánica de Recursos Geotérmicos), Law No. 26848 promulgated on July 29, 1997. Under Articles 30 and 49 of that law, EIA survey documents are required to be attached to the application for geothermal development concession, and EIA is essential for geothermal resources development.

The relationship between EIA and concessions required for power development projects are presented in Table II-3.5.1.

Table II-3.5.1 Relationship between EIA and concessions required for power development projects

Project		Requirement		
		Concessions	Authorization	EIA
Renewable Power projects ¹⁾	500 kW to 20 MW	O	-	-
	> 20 MW	O	-	O
Thermal Power ²⁾	500 kW to 20 MW		O	-
	> 20 MW		O	O

Note) O : It is required - : No required

Source: JICA study team, 2010

1) Hydropower, solar, wind, geothermal and biomass

2) By-products of petroleum, gas and mineral coal.

EIA is a requisite for approval for a project. It takes approximately one year from EIA survey to completion of EIA statement preparation. After the EIA statement is submitted, processing of the EIA takes 60 days before approval, including 20 days set as the period for holding public hearings after publication of the EIA statement.

II-3.5.2 Protected Areas

(1) Categories of Protected Areas

Under Peruvian Law No. 26834, Protected Natural Areas Law (Ley de Áreas Naturales Protegidas), and D.S. No. 038-2001-AG, Regulation of the Law on Protected Natural Areas (Reglamento de la Ley de Áreas Naturales Protegidas), the protected natural areas (ANP: Áreas Naturales Protegidas) are classified into ten categories according to the protection level, and buffer zones are designated outside the protected natural areas. As of 2010, 67 protected areas are designated.

The distribution of the protected natural areas in Peru is shown in Fig. II-3.5.1.



Fig. II-3-5-1 Protected natural areas in Peru (SERNANP)

(2) Protected Area Administration Agency

The agency administering the protected natural areas is the National Service of Natural Protected Areas (SERNANP) of the MINAM. The SERNANP is the organ in charge of operation of the National System of Protected Natural Areas (SINANPE: Sistema Nacional de Áreas Naturales Protegidas por el Estado), and responsible for establishing technical management criteria and procedures for management of the protected natural areas. The SERNANP also has the authority to give permission for and technical opinions on resource development within protected natural areas, and takes an active role in zoning of protected areas and implementation of the master plan.

(3) Use Restrictions of Protected Areas

In accordance with the management and operation objectives of the protected natural areas, indirect or direct use is allowed on the condition of compliance with the rules under Law No. 27117.

a) Indirect Use Protected Areas

Indirect use is allowed for the following protected natural areas. In these areas extraction and development of natural resources are not allowed, but scientific research and survey, tourism and recreation conducted under proper management and control are allowed.

- National park (Paque Nacional)
- National sanctuary (Santuario Nacional)
- Historical sanctuary (Santuario Historico)

b) Direct Use Protected Areas

Direct use is allowed for the following protected natural areas. In these areas natural resources can be utilized and developed with permission of the SERNANP and in accordance with the management plan.

- National reserve (RN: Reservas Nacionales)
- Wildlife refuge (RVS: Refugio de Vida Silvestre)
- Protected forest (BP: Bosque de Protección)
- Hunting refuge (CC: Coto de Caza)
- Communal reserve (CR: Reserva Comunales)
- Landscape reserve (RP: Reservas Paisajísticas)
- Reserved zone (ZR: Zona Reservadas)

c) Restrictions at Buffer Zones

The master plan has been formulated for buffer zones. Activities and development within a buffer zone are approved with the permission given by the agency in charge in accordance with the master plan.

For a power development project, the EIA submitted by the project proponent is sent to the SERNANP by the DGAAE. The DGAAE decides whether or not to approve the project within a buffer zone based on the SERNANP's opinions on the EIA.

d) Regional Reserve

In addition to national reserves, regional reserves are stipulated by law in Peru. As with the areas surrounding the national reserves, buffer zones are designated outside the regional reserves.

Development and use of natural resources are possible in the regional reserves and buffer zones around them as the same use restrictions on the protected national areas categorized as direct use areas and their buffer zones described above are applied. Likewise, approval of EIA for a project within a regional reserve is granted by the SERNANP and that for a project within a buffer zone by the DGAAE based on the SERNANP's opinions.

e) Permission Activities and Approvals EIA of ANP

Permission activities and approval EIA of the ANP in electric power development projects are summarized in Table II-3.5.2.

Table II-3.5.2 Permission activities and approval EIA of the ANP in electric power development projects

Category of ANP	Activities restrictions	Permission of EIA
Indirect use protected areas	Other than scientific research activities, etc. are not allowed.	—
Direct use protected areas	Development Activities are allowed.	SERNANP (DGAAE approves the permission of SERNANP)
Restrictions at buffer zones	Development Activities are allowed	DGAAE (based on the SERNANP's opinions)
Outside the ANP	No restriction on development activities	DGAAE

Source: by JICA Study Team

II-4 Status of Geothermal Development

II-4.1 Geothermal Resource Assessment

From 1970's, reconnaissance and preliminary surveys/studies of the geothermal resource in Peru have been conducted by several Peruvian institutions including Electroperú, INGEMMET, the Proyecto Especial Tacna (PET), and the Instituto Peruano de Energía Nuclear (IPEN), with the cooperation of various international organizations (Battocletti et al., 1999). One of the most important studies is the inventory survey conducted by INGEMMET from 1997 to 2003, in which geological/geochemical samplings and analyses had been carried out for more than 500 springs with temperatures higher than 20 °C almost all over the Peru. At present, most of the data and information obtained through the reconnaissance and surveys/studies have been collected and compiled by INGEMMET.

In order to help the management decisions to be taken on possible investments in geothermal exploration/exploitation, geoscientists in INGEMMET (Vargas and Cruz, 2010) updated the Geothermal Map of Peru (Fig. II-4.1.1) based on the previous works (Cossio and Vargas, 1979; Huamaní and Valenzuela, 2003; Fidel et. al., 1997; etc.).

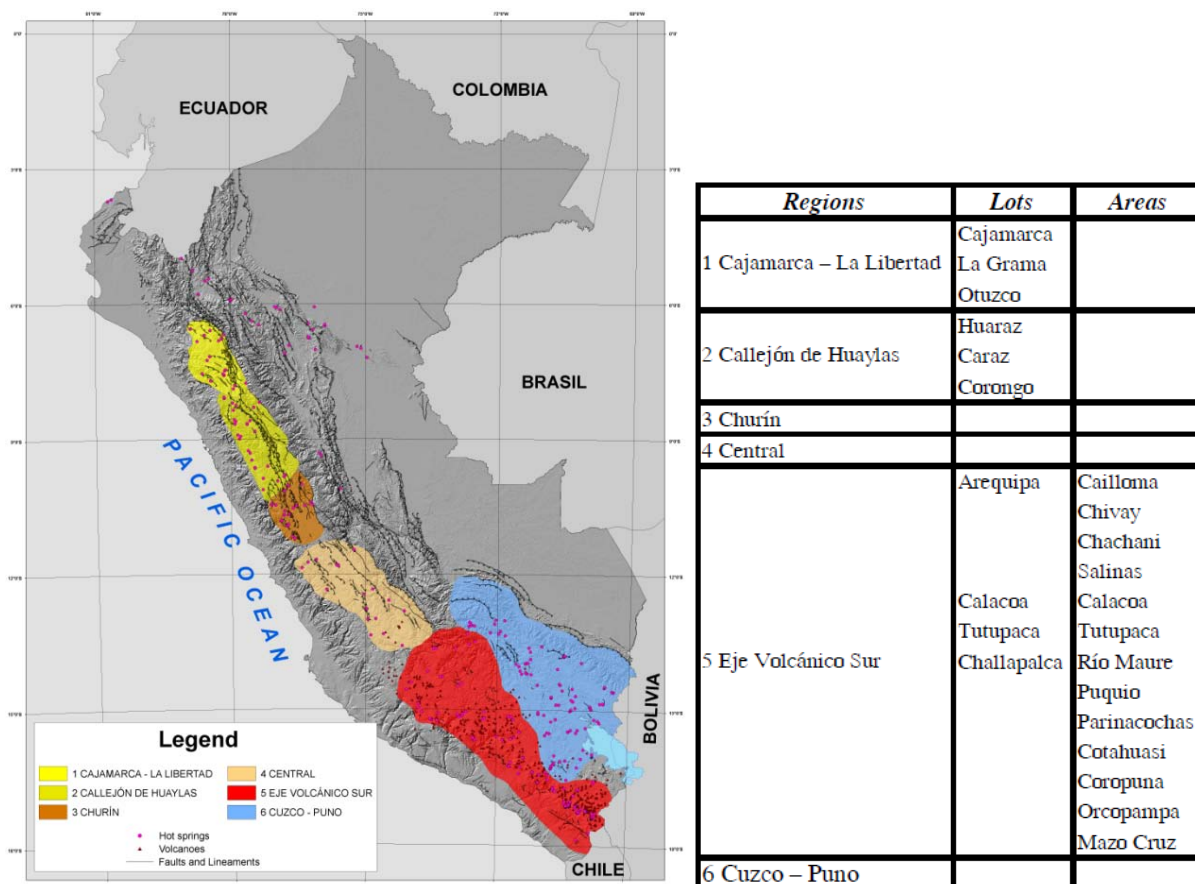


Fig. II-4.1.1 Updated geothermal map of Peru (Vargas and Cruz, 2010)

The main tool to update the Geothermal Map has been the locations of hot springs and mineral springs all over the country. The boundaries of six geothermal regions have been re-defined in the updated map. The hot springs located in the northern and central Peru (Region 1, Region 2, Region 3, and Region 4) have a meteoric origin and are product of the geothermal gradients. In the southern Peru (Region 5 and Region 6), geothermal manifestations are related to active volcanism and in some cases are of mixed origin, the water from precipitations infiltrates and it is heated by a heat source at depth (Vargas and Cruz, 2010).

The geothermal studies, which have been conducted so far in Peru, are regarded to be of reconnaissance and prefeasibility level. Drilling of exploratory well for geothermal exploration has never been conducted. Therefore, present data and information of any geothermal fields in Peru are not sufficient to make development program.

Only in the two fields, Calientes and Borateras, in Tacna Region, pre-feasibility study including the resource assessment with adopting MT resistivity survey was conducted for planning of geothermal power development (JBIC, 2008; JETRO, 2008).

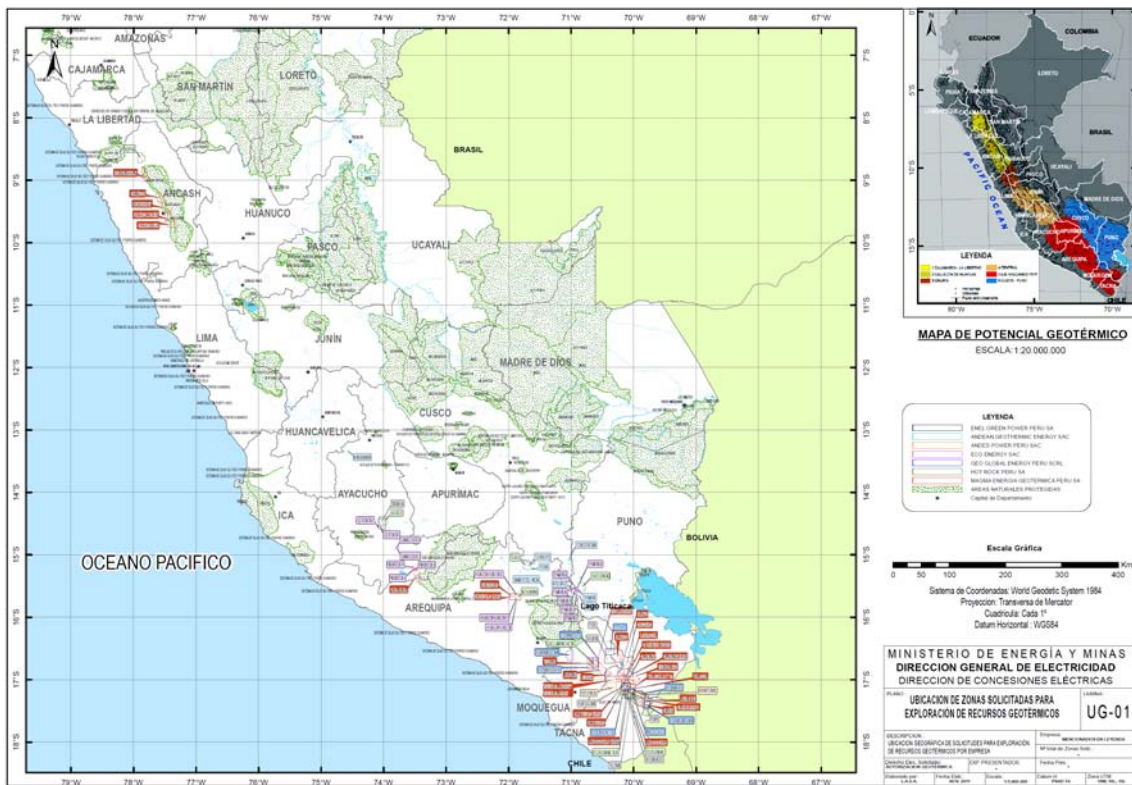
II-4.2 Current Status of Geothermal Rights Applications

After implementation of new Regulation of the Organic Law of Geothermal Resources in April 2010, the multiple requests for authorization of geothermal rights have been presented to the MEM. Table II-4.2.1 shows the 98 projects whose applications were notified in the official newspaper up to December 2011. To date, the MEM gave authorization of 20 projects to four companies (Canadian, Australian, Peruvian and American). Although the authorizations have been given since February 2011, no application for concession has been officially made to date. Figure II-4.2.1 shows the location map of the requested project for authorization.

Table II-4.2.1 Status of applications for an authorization request up to December 2011

No.	No. for each company	Name of applied field	Field name in the JICA Master Plan Study (Promissing field)	Company Name	No.	No. for each company	Name of applied field	Field name in the JICA Master Plan Study (Promissing field)	Company Name
1	1	Casiri	Chungara-Kallapuma	Magma Energía Geotérmica S.A.	55	1	Hualca Hualca	Chivay-Pinchollo	Eco Energy S.A.C.
2	2	Ticsani	Calacoa-Putina		56	2	Pinaya I	Pinaya	
3	3	San Pedro			57	3	Pinaya II	Pinaya	
4	4	Vilacota			58	4	Hualca Hualca I	Chivay-Pinchollo	
5	5	Ancocollo	Ancocollo		59	5	Hualca Hualca II	Chivay-Pinchollo	
6	6	Crucero	Crucero		60	6	Umacusiri I		
7	7	Pinchollo	Chivay-Pinchollo		61	7	Umacusiri II		
8	8	Tutupaca Norte			62	8	Geronta I	Puquio	
9	9	Suche			63	9	Geronta II	Puquio	
10	10	Cancave			64	10	Pinaya III	Pinaya	
11	11	Calientes Norte			65	11	Pinaya IV	Pinaya	
12	12	San Pedro Libre			66	12	Pinaya V	Pinaya	
13	13	Ancocollo Libre	Ancocollo		67	13	Pinaya VI	Pinaya	
14	14	Sara Sara			68	14	Rio Pararca I		
15	15	Pasto			69	15	Rio Pararca II		
16	16	Panejo			70	16	Rio Pararca III		
17	17	Loriscota			71	1	Tutupaca	Tutupaca	Andes Power Peru
18	18	Huayllatiri			72	2	Borateras	Borateras	
19	19	Antajave			73	1	No.3	Calientes	Murahuay S.A.C
20	20	Atarani			74	2	Rio Calientes	Calientes	
21	21	Chancos	Chancos		75	3	Rio Calientes III	Calientes	
22	22	Olleros Sur			76	1	Pusa		Andean Geothermic Energy S.A.C
23	23	Yungay			77	2	Pinaya	Pinaya	
24	24	Monterrey			78	3	Censuyo	Cailloma	
25	25	Huancarhuaz			79	4	Baños del Inca		
26	26	Olleros Norte			80	5	Paclla		
27	27	Crucero Libre			81	6	Occollo		
28	28	Tutupaca Libre			82	7	Baños del Inca		
29	29	Casiri Libre 1			83	8	Coline		
30	30	Pinchollo Libre	Chivay-Pinchollo		84	9	Condorama		
31	31	Cancave Libre			85	10	Atecata		
32	32	Vilacota 21			86	11	Niñobamba		
33	33	Vilacota 22			87	12	Condorama South		
34	34	Ticsani Libre	Calacoa-Putina		88	13	Condorama		
35	1	Achumani	Chivay-Pinchollo	89	14	Atecata		Enel Green Power Perú S.A.	
36	2	Ocururane	Ancocollo	90	15	Niñobambnba			
37	3	Quellaapacheta	Calacoa-Putina	91	16	Baños del Inca			
38	4	Turu	Cailloma	92	1	Carmen	(Puquio)		
39	5	Achuco	Chungara-Kallapuma	93	2	Chilata			
40	6	Rupha		94	3	Titiri	Ccollo/Titire		
41	7	Huarajayoc		95	4	Huaylluma	Calientes		
42	8	Chocopata	(Pinaya)	96	5	Pilar	Chungara-Kallapuma		
43	9	Huisco		97	6	Río Salado	Ancocollo		
44	10	Ocururane Sur	Ancocollo	98	7	Putina			
45	1	Rio Calientes	Calientes						
46	2	Rio Maure	Borateras						
47	3	Rio Kallapuma	Chungara-Kallapuma						
48	4	Ancocollo	Ancocollo						
49	5	Tutupaca	Tutupaca						
50	6	Ticsani Oeste							
51	7	Ticsani Este	Calacoa-Putina						
52	8	Huaynaputina	Ulucan						
53	9	Ubinas							
54	10	Ccollo	Ccollo/Titire						

Authorized by MEM for exploration
 In evaluation by MEM (or rejected)



(Source: DGE, 2011)

Fig. II-4.2.1 Location map of requested project for authorization

II-4.3 Current status of geothermal development system and organization

II-4.3.1 Development history and organizations involved

First serious geothermal study in Peru was said to be launched in 1975 when Mimero Peru conducted geochemical study on Calacoa region of the Moquegua state. In 1978, INGEMMET made an inventory of the thermal activities known in the nation and clustered them geographically in six regions. From 1979 to 1980, with the financial support from OLADE, INGEMMET collaborated with Aquater of Italy for conducting the geothermal resource study in the region 5 and identified prospective geothermal fields such as Tutupaca, Calacoa, Challapalca, Laguna Salinas, Chachani and Chivay. In accordance with a technical assistance agreement with the British geological survey, INGEMMET launched a preliminary study in Cuzco-Puno, area of the Region VI and showed some reservoir in the area might have temperatures of 160°C.

On the other hand, Electroperú S.A. dispatched their engineers to geothermal specialization courses in Italy, Japan and other countries for their efforts to establish a Geothermal Investigations Unit in order to acquire a permission to explore the areas of Calacoa, Tutupaca and Challapalca, possibly with international technical cooperation. As a result, they reached an agreement of Technical and Economical Cooperation with the Centro Studi Renzo Tasselli (CESEN) of Italy and implemented a geothermal study including shallow well boring in the zones covering Callejon de Huaylas, Oturco, La Grama, and Cajamarca in an approximate area of 100,000 km² during 1982 to 1986. The study concluded the area of interest exhibited reservoir with medium to low temperature. Also in 1986, with help from IAEA, they conducted geochemical investigations in the Region V and found prospective resources in Calacoa and Calientes.

Later in 1997, Cenergia, with Mexican assistance, collected data from the past studies and made assessment on them. INGEMMET conducted nationwide survey on the hot spring inventory.

Furthermore, in 2007, JBIC launched detail geothermal study in Calientes and Borateras area.

As it is described above, certain provisions were made on the expert training when implementing the series of initial geothermal studies during 1970s and 1980s. Since then, after a long absence of large scale geothermal projects, coupled with the fact that the organizations which lead the earlier studies have been restructured, the expertise on this technology has not been well maintained. Though some of the engineers who were engaged in the past projects are still active as consultants, most of them are aged. Consequently data available for the geothermal study have not been renewed for long time. In this situation, as to the group of experts in the geothermal technology, we can not expect the other than those in INGEMMET. Speaking about their resources, however, it is far from enough both in terms of personnel and equipment.

Table II-4.3.1 Experts in geothermal related technologies available in Peru (September 2011)

Area	DGE	INGEMMET	Petroperú	University	Private	Total
Geologist	0	1	0	5	100	106
Geochemist	0	1	0	1	30	32
Geophysicist	0	1	0	1	15	17
Reservoir Engineer	0	0	0	0	5	5
Drilling Engineer	0	0	0	0	10	10
Power Engineer	0	0	0	0	60	60
Environmental Scientist	0	0	0	1	100	101
Financial Analyst	0	0	0	0	100	100
GIS Scientist	1	2	0	10	200	213
Drillers	0	0	0	0	50	50
Technicians	0	0	0	0	1000	1000
Total	1	5	0	18	1670	

II-4.3.2 Implementing organization and system for the geothermal development

The authentic bodies in the government organization in Peru which are responsible for the geothermal development were described in II-3.2. Other than those mentioned, a geothermal committee (Comision Multisectorial de Geotermia) is established within the MEM, whose members consists of the academics (earth science experts) and INGMMET engineers. But, since the committee allocated small portion for the geothermal experts, its contribution to the geothermal development will be limited. Furthermore, little technical experts are present in the governmental organization in the area of resource development technologies including geothermal well drilling and geothermal power plant technology, while the capacity building program in this area is barely existent.

II-4.3.3 Human resource and system in the oil and gas development in Peru

The industry infrastructure concerning oil and gas development in Peru including regulatory bodies, development companies, service contractors, equipemnt stock, facilities and the man power seems to be well established. Generally speaking, building a geothermal development infrustructure has many things in common with those of oil and gas. Therefore it should not pose much obstacle to build one for geothermal in case of Peru. Especially regarding the drilling related services which always pose problems when developing geothermal fields, Petrex under Italian ENI and SAXON under Schlumberger, although they are under foreign capitals, together own more than 20 drilling rigs, operating for oil and gas fields under service contracts. Since thier working fields are located in the

Amazonian low lands, they need to acquire drilling knowhow and equipment pertaining to the highlands geothermal application such as air rated drilling for tackling lost circulation or cooling tower for cooling high temperature mud. None of them is anticipated to create serious obstacles either.

II-5 Status of Multi-purpose Use of Geothermal Energy

II-5.1 Worldwide Direct Use of Geothermal Energy

The direct use of geothermal heat in the world as reported in the 2010 international Geothermal Congress was 438,071 TJ/Yr (50,583 MWt) of which space conditioning (heat pumps, space heating and green house heating) represents the largest share followed by aquaculture (pond heating), agriculture/drying, industrial uses, bathing and swimming and cooling/snow melting.

As for Latin America alone, it is reported that 15,301.40 TJ/Yr (862.50 MWt) of utilization (Table II -5.1.1).

Table II-5.1.1 Direct utilization of geothermal heat in Latin-American

Country	Capacita MWt	Anual Use TJ/yr	Anualice GWh/yr	Capacita Factor
Argentina	307.47	3,906.74	1,085.30	40.00%
Brazil	360.10	6,622.40	1,839.70	58.00%
Caribbean Islands	0.10	2.78	0.80	85.00%
Chile	9.11	131.82	36.60	46.00%
Columbia	14.40	287.00	79.70	63.00%
Costa Rica	1.00	21.00	5.80	67.00%
Ecuador	5.16	102.40	28.40	63.00%
El Salvador	2.00	40.00	11.10	63.00%
Guatemala	2.31	56.46	15.70	78.00%
Honduras	1.93	45.00	12.50	74.00%
Mexico	155.82	4,022.80	1,117.50	82.00%
Peru	2.40	49.00	13.60	65.00%
Venezuela	0.70	14.00	3.90	63.00%
Total Latin America	862.50	15,301.40	4,250.60	60.50%
Percentage respect world total	1.71%	3.49%	3.49%	---
World Total	50,583.00	438,071.00	121,696.00	27.00%

II-5.2 Multi-Utilization of Geothermal Resources in Peru

The figures given for Peru in Table II-5.1.1 were those reported by Lund et al. (2005) for seven spas in the central-north part of Peru.

From the perspective and knowledge gained through this Master Plan study it is believed that in Peru the application of geothermal resource in uses other than power generation is possible and that can contribute to local social-economic development of communities as well as to the mitigation of the world's climate change. Only for reference, the direct use of geothermal energy in the world as reported in the 2010 World geothermal congress contributed to energy savings amounted to 307.8 million barrels (46.2 million tonnes) of equivalent oil annually, preventing 46.6 million tonnes of carbon and 148.2 million tonnes of CO₂ being release to the atmosphere which includes savings in geothermal heat pump cooling (compared to using fuel oil to generate electricity)

II-6 Issues to be Solved for Promoting Geothermal Power Developments

As mentioned in the previous sections, the legal framework for geothermal resource development in Peru has been established with a system that postulates that the developments will be basically carried out by private sector. The application of the legal framework, however, has been just started from 2010. Thus for the developments to be actually enhanced, it is necessary for the Peruvian government to proclaim the policy and strategy for the promotion of geothermal developments. The aggressive governmental activities for the promotion are also necessary, and it is expected that flexible applications or revisions of the framework will be required according to actual situations.

The current issues to be solved for promoting the geothermal resource development in Peru can be enumerated as follows.

- Although the target for power generation by renewable energies including geothermal is set to be 5 % of the total electricity demand, the proportions to be supplied by each renewable energy sources, or a concrete development plans have not been formulated yet.
- The resource risk and risk in high initial cost, which are peculiar to geothermal, possibly prevent the progress of development by private sector. Thus it is necessary to consider options such as the improvement of the current legal system, or governmental participation to geothermal power generation project.
- The only existing incentive for promoting geothermal power generation projects is currently the fixed-price purchase system of generated electric power through the tender for renewable energy projects. The system has not been qualified as an effective measure in promoting the developments by private sector since the purchase price (the base price in the tender) has not been examined yet.
- There are not many experts on geothermal power generation and utilization in governmental institutions. Besides, collaborative partnership and information exchange for development promotion among the related institutions are not sufficient.

The Master Plan is necessary to cope with the issues enumerated above. In this project, the Master Plan was formulated, that consists of the recommendations and action plans, the geothermal development database, and the geothermal development plans, as shown in the following chapter.

III MASTER PLAN

III-1 Recommendations and Action Plan

III-1.1 Target for Geothermal Power Development

III-1.1.1 Development Potential based on Geothermal Resource

(1) Overview of Geothermal Resource in Peru

Main land of Peru is located in the fire belt near the zone of subduction of the Nazca plate below the South American plate, which have generated tectonic movements and an intense volcanic activity that extends by million years and is still present in very recent years. The Andes, where most of geothermal fields and hot springs in Peru are situated, is a mountain belt resulting from the underthrusting of oceanic lithosphere adjacent to a continental margin. The Andes in Peru comprise two subparallel folds belts (Fig. III-1.1.1). The Western Cordillera is of Mesozoic-Tertiary age and the Eastern Cordillera of Late Paleozoic age. In southern Peru, where the fold belts diverge, they are separated by the Altiplano, which consists of a thick sequence of Tertiary molasse. The Andean Cordilleras are flanked to the east by the sub-Andean zone, which consist of continental sediments deposited on the Brazilian Shield, and to the west by the Precambrian Arequipa Massif, which may make up a large part of the Peruvian continental shelf (Kearey and Vine, 1996).

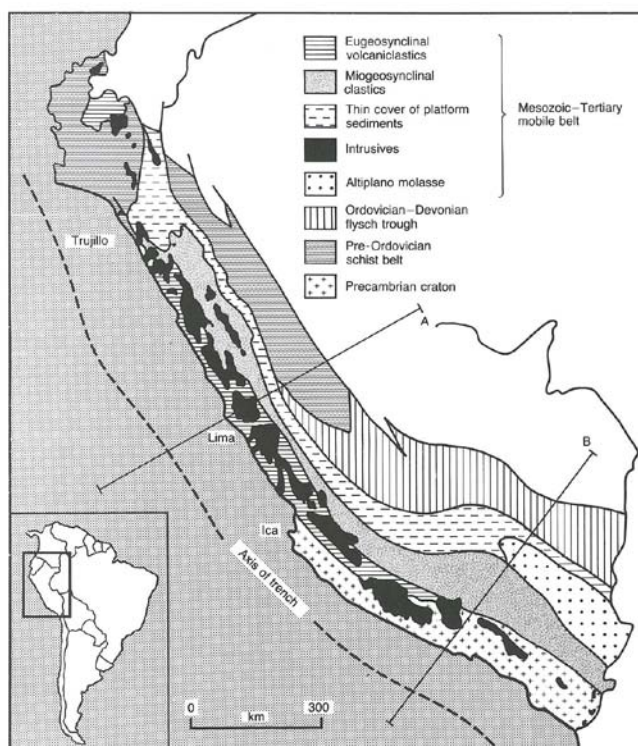


Fig. III-1.1.1 Geology of the Andes in Peru (Kearey and Vine, 1996)

Figure III-1.1.2 shows the distribution of active volcanoes and volcanic centers younger than Miocene (Kono et al., 1989). Active volcanoes align in a single line forming a distinct volcanic front in southern Peru and northern Chile. However, in entire Neogene period, the volcanic centers are distributed almost all over the Altiplano. A wide distribution of volcanism is also consistent with high heat flow values observed not only near the Western Cordillera but in most part of the Altiplano. These imply that a much wider region has been under the influence of the volcanic activity, and a considerable amount of magmatic material should have been supplied to the crust beneath the Western Cordillera as well as the Altiplano (Kono et al., 1989). Kono et al. (1989) suggests that the

volcanic activity in the Andes of southern Peru is perhaps distributed over a wide geographical extent covering most of Altiplano, and that the Altiplano corresponds roughly to the area of magma generation associated with the subduction of the Nazca plate beneath the South American plate (Fig. III-1.1.3). Presence of volcanic activity in Neogene in wide area of southern Peru implies that the occurrence of geothermal fields with high potential is expected.

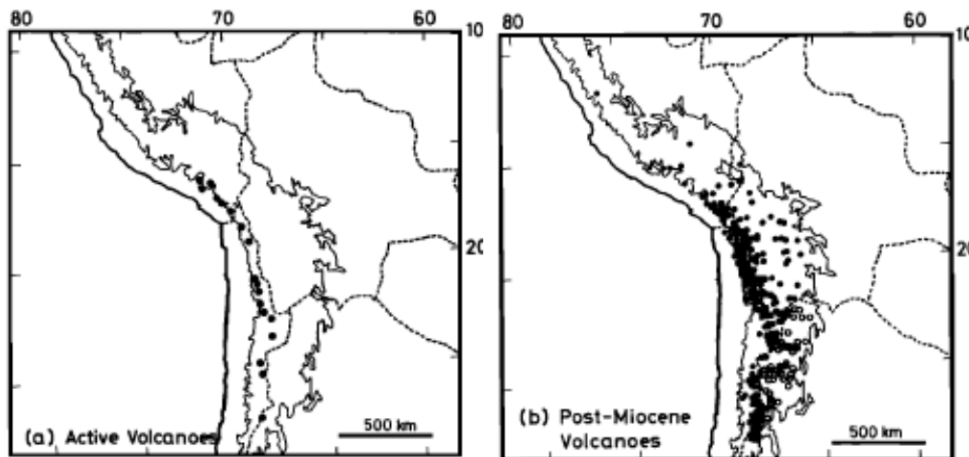


Fig. III-1.1.2 Distributions of active volcanoes and post-Miocene volcanoes in Central Andes (Kono et al, 1989)

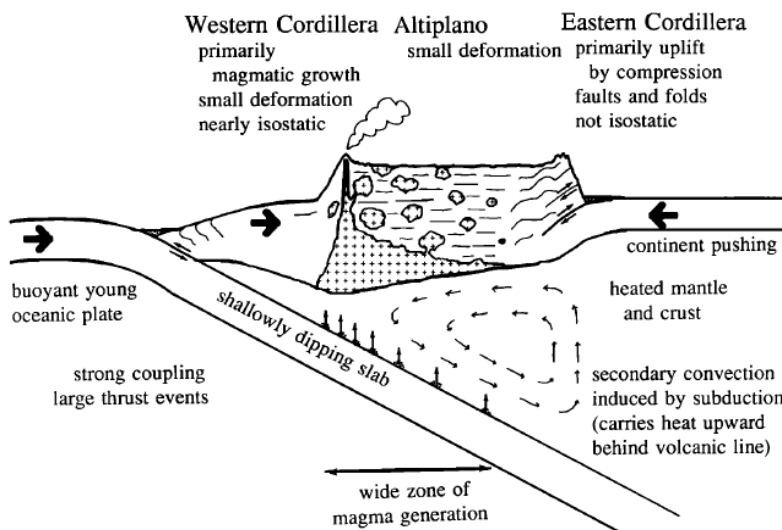


Fig. III-1.1.3 A cartoon showing the processes in the formation of the Central Andes (Kono et al., 1989)

(2) Geothermal Resource Potential in Peru

a) Delineation of Geothermal Fields

In the Geothermal Map of Peru updated by INGEMMET, several important geothermal areas were defined. However, the geothermal (or hydrothermal) systems having the individual hydrological systems have not been delineated. In order to evaluate each geothermal field, the geothermal systems were delineated based on the spatial distribution of hot or mineral springs and topography (Fig. III-1.1.4).

In the delineation work, the isolated mineral and cold springs were ignored. Sixty-one (61) geothermal fields were delineated in the whole country, but the fields more than half of them

(38 fields) are within the Region 5 and Region 6. Among the 61 fields, 34 fields have one or more hot spring(s) with a discharge temperature higher than 60°C.

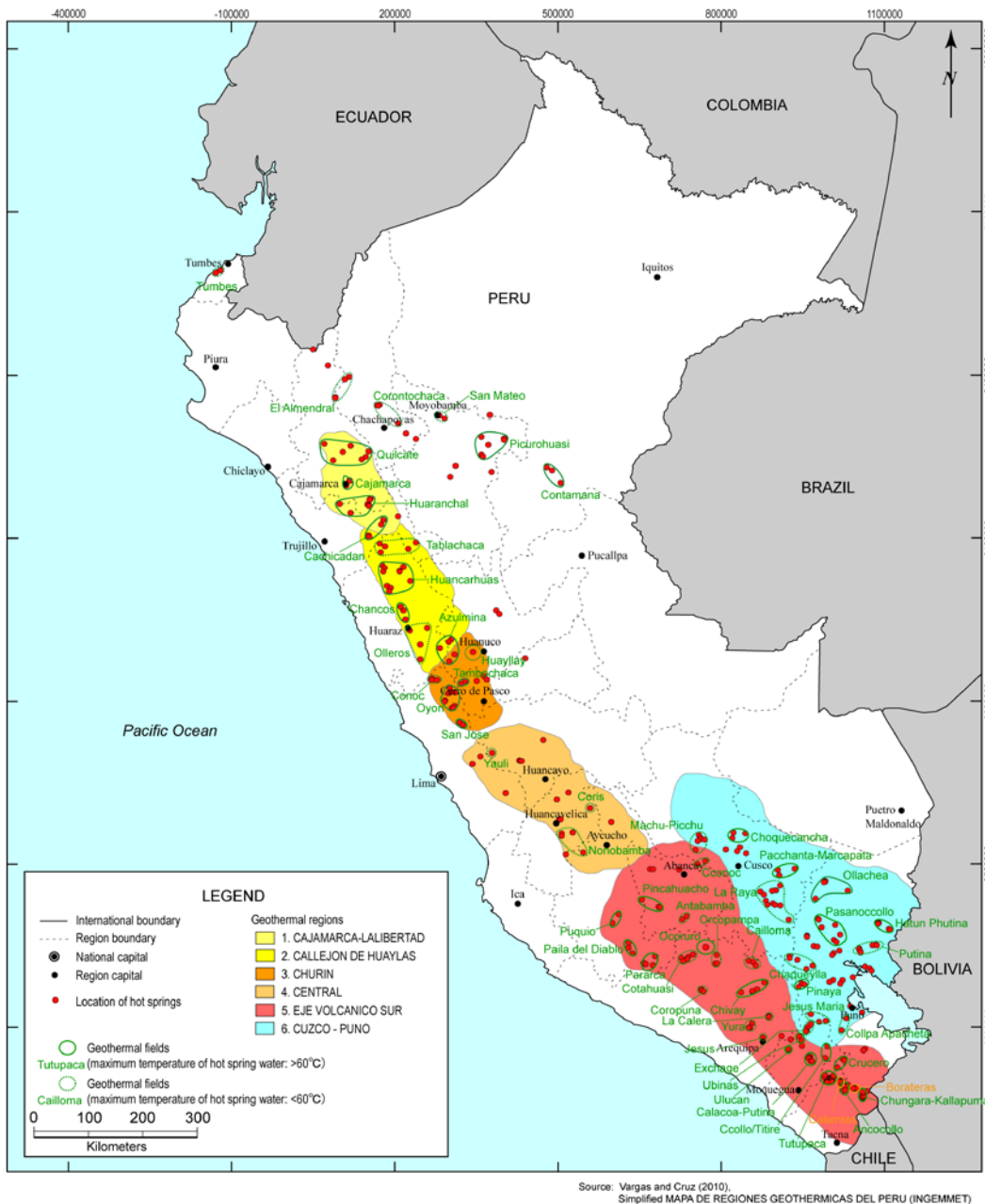


Fig. III-1.1.4 Location map of the delineated geothermal fields

b) Estimation of Resource Potential in Peru

The resource potential of 61 geothermal fields are calculated by stored-heat method to estimate roughly the whole geothermal resource potential in Peru. The resource potential calculation is carried out with classifying the 61 fields into four categories as below.

- Calientes and Borateras: According to the study reports of JBIC (2008) and JETRO (2008), in which the conceptual model of geothermal systems for resource potential estimation is based on detailed surface surveys including MT survey.

- Ancocollo and Tutupaca: Those two fields are selected as the most promising fields in this study, and the conceptual model for the fields for resource potential estimation is based on detailed surface surveys including MT survey.
- Eleven promising fields: The eleven fields are selected as the promising fields in this study, and the conceptual model for the fields for resource potential estimation is based on geological and geochemical surveys conducted in this study.
- Other fields (46 fields): The fields are delineated only by the special distribution of hot or mineral springs and topography. The resource potential is estimated with stored-heat method based on the rough assumption of temperature and volume of possible geothermal reservoir.

The result of resource estimation is summarized in Table III-1.1.1. The total geothermal potential in Peru is estimated to be 2,860 MWe.

Table III-1.1.1 Summary of geothermal power generation potential in Peru

Geothermal Region	No.	Region	Field Name	Resource Potential (MWe)		No. of Sector **
				Promising Fields*	Other Fields	
(Northern Peru)	1	Tumbes	Tumbes		15	2
	2	Amazonas	El Almendral		10	2
	3	Amazonas	Corontochaca		7	5
	4	San Martin	San Mateo		14	3
	5	San Martin	Picurohuasi		58	6
	6	Loreto	Contamana		48	3
1. Cajamarca-La Libertad	7	Cajamarca	Quilcate		70	7
	8	Cajamarca	Cajamarca		29	2
	9	Cajamarca-La Libertad	Huaranchal		54	5
	10	La Libertad	Cachicadan		40	3
2. Callejon de Huaylas	11	Ancash-La Libertad	Tablachaca		29	5
	12	Ancash	Huancarhuas		89	10
	13	Ancash	Chancos	15.3	21	3
	14	Ancash	Olleros		29	4
	15	Huanuco-Ancash	Azulmina		53	5
3. Churin	16	Lima	Conoc		21	3
	17	Pasco	Huayllay		10	1
	18	Pasco	Tambochaca		24	2
	19	Lima	Oyon		45	5
	20	Lima	San Jose		25	2
4. Central	21	Junin	Yauli		7	1
	22	Huancavelica	Coris		10	1
	23	Huancavelica	Nonobamba		15	3
5. Eje Volcanico Sur	24	Cusco-Apurimac	Cconoc		9	2
	25	Apurimac	Pincahuacho		25	2
	26	Apurimac	Antabamba		15	2
	27	Ayacucho	Puquio	34.3	10	1
	28	Ayacucho	Paifa del Diablo		54	4
	29	Ayacucho	Pararca		31	3
	30	Arequipa	Ocoruro		23	1
	31	Arequipa	Cotahuasi		65	7
	32	Arequipa	Orcopampa		29	4
	33	Arequipa	Cailloma	9.1	26	2
	34	Arequipa	Coropuna		15	3
	35	Arequipa	Chivay	162.9	136	9
	36	Arequipa	La Calera		9	2
	37	Arequipa	Yura		15	4
	38	Arequipa	Jesus		7	2
	39	Moquegua	Ubinas		24	3
	40	Moquegua	Ulucan	27.4	0	0
	41	Moquegua	Calacoa-Putina	108.2	45	4
	42	Moquegua	Ccollo/Titire	39.7	27	3
	43	Moquegua-Tacna	Crucero	79.4	3	1
	44	Tacna	Tutupaca	113.8	29	5
	45	Tacna	Calientes	100.0	0	0
	46	Tacna	Ancocollo	98.2	55	4
	47	Tacna	Borateras	40.0	31	3
48	Tacna	Chungara-Kallapuma	84.0	17	3	
6. Cuzco-Puno	49	Cusco	Machu-Picchu		49	6
	50	Cusco	Choquecancha		43	3
	51	Cusco	Pacchanta-Marcapata		40	3
	52	Cusco	La Raya		26	5
	53	Puno	Ollachea		45	3
	54	Puno	Pasanocollo		65	6
	55	Puno	Hatun Phutina		39	4
	56	Puno	Putina		53	6
	57	Puno	Chaqueylla		26	3
	58	Puno	Pinaya	36.8	27	2
	59	Moquegua	Jesus Maria	17.3	17	2
	60	Moquegua	Exchage		27	5
	61	Puno	Collpa Apacheta		13	2
Total				966.4	1,894	207
Grand Total				2,860		

* at 80% Confidence Level

** Excluding Borateras, Calientes and Selected 13 Fields.

In the previous studies, the geothermal power potential in Peru was estimated to be 2,990 MWe by Battocletti et al. (1999) and 3,002.7 MWe by JICA (2008 internal report). The resource potential estimated in this study is 2,860 MWe, and this result is very close to the previous estimations even though the estimation approach is different. This fact confirms the validity and the mutual complementarities of the estimations.

The distribution of calculated geothermal power potential in Peru is shown in Fig. III-1.1.5, and other statistical graphs are shown in Figs. III-1.1.6 and III-1.1.7. More than half of the total resource potential exists in the Region 5.

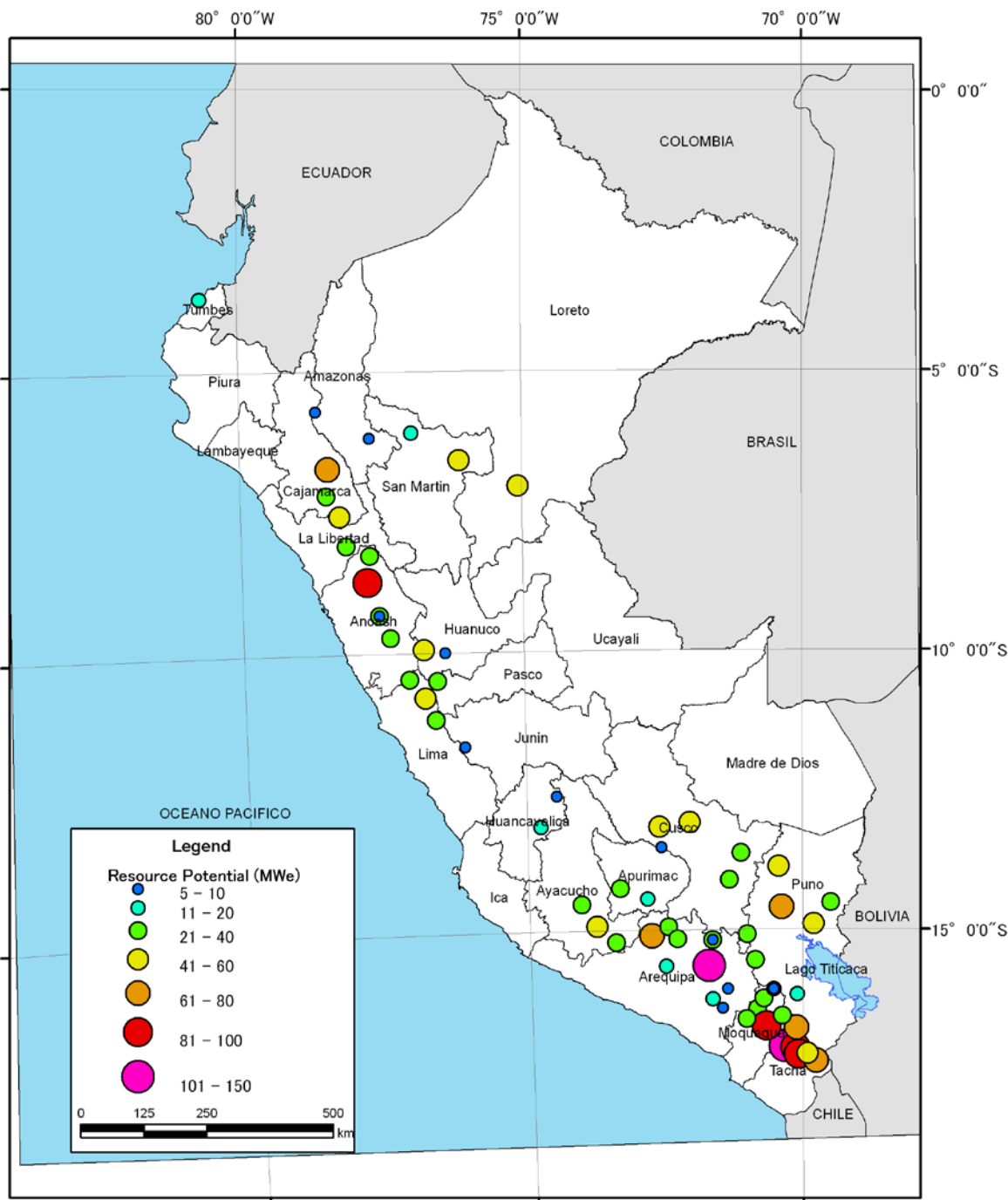


Fig. III-1.1.5 Map of geothermal power potential in Peru

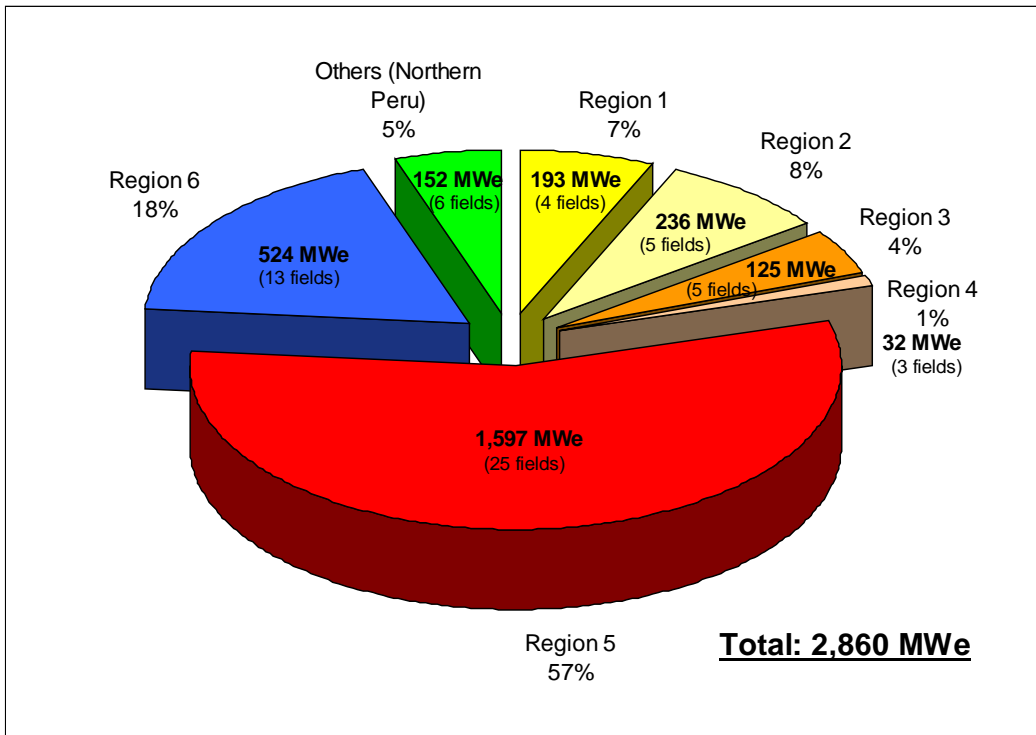


Fig. III-1.1.6 Geothermal power potential in each geothermal region

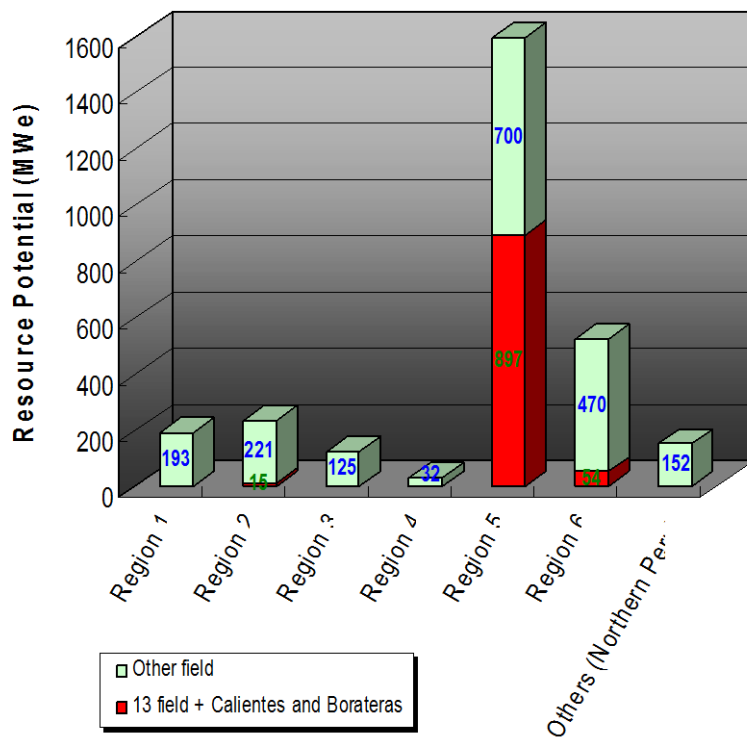


Fig. III-1.1.7 Geothermal power potential in the promising fields and the other fields

Although the significant amounts of cumulative resource potential of the other fields are presented, the potential of each sector is probably not enough for the single large-scale development. Figure III-1.1.8 shows the number of sectors against the estimated resource potential in histogram. The potential is lower than 10 MWe in most of the sectors as shown in the figure. If the geothermal system in each sector is separated, only small-scale power development is possible at the respective sector. In general, the small power development is costly for power generation compared with the large development. Since the connection and the extent of the geothermal system in the other fields are still unknown, it is necessary to conduct further resource assessment to update the estimation of resource potential.

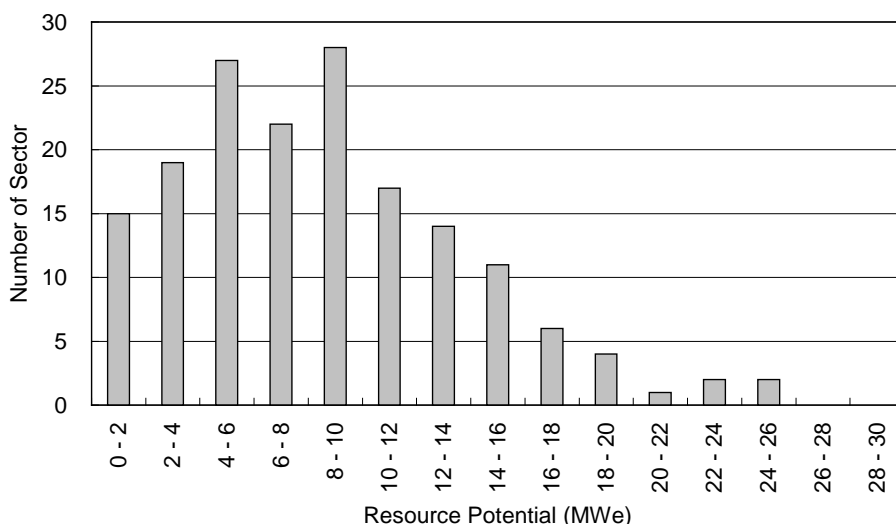


Fig. III-1.1.8 Number of sectors by estimated resource potential (excluding the promising fields)

One of the major characteristics of geothermal resource in Peru is that the high-potential fields tend to be located in high elevation areas. Figure III-3.1.1.9 shows histograms of site elevation vs. number of field and estimated resource potential. As shown in the figures, 82% of geothermal fields and 85% of estimated resource potential exist at high elevation areas of 2,500-5,000m a.s.l. Moreover, more than half (58%) of estimated resource potential is recognized at very high elevation areas of 3,500-5,000m.

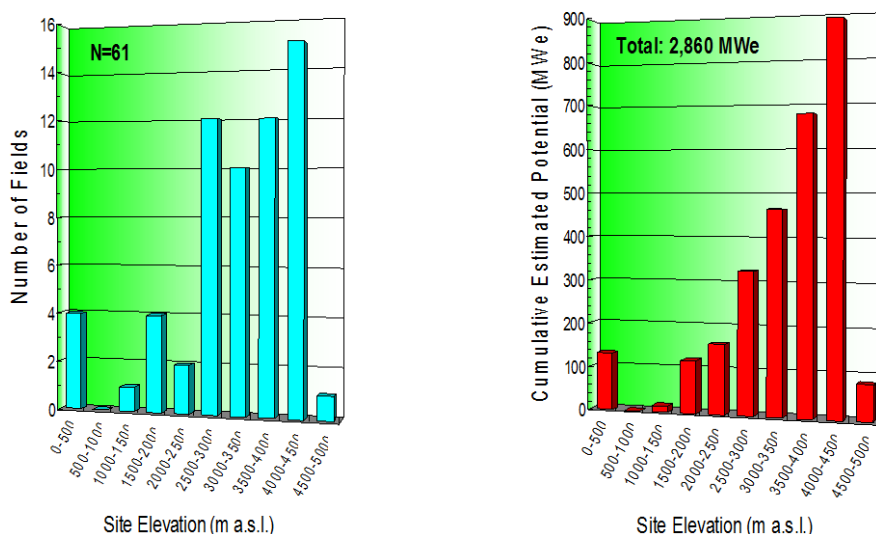


Fig. III-1.1.9 Histograms of site elevation vs. number of field and estimated resource potential

III-1.1.2 Superiority of Geothermal Energy as an Electricity Power Source

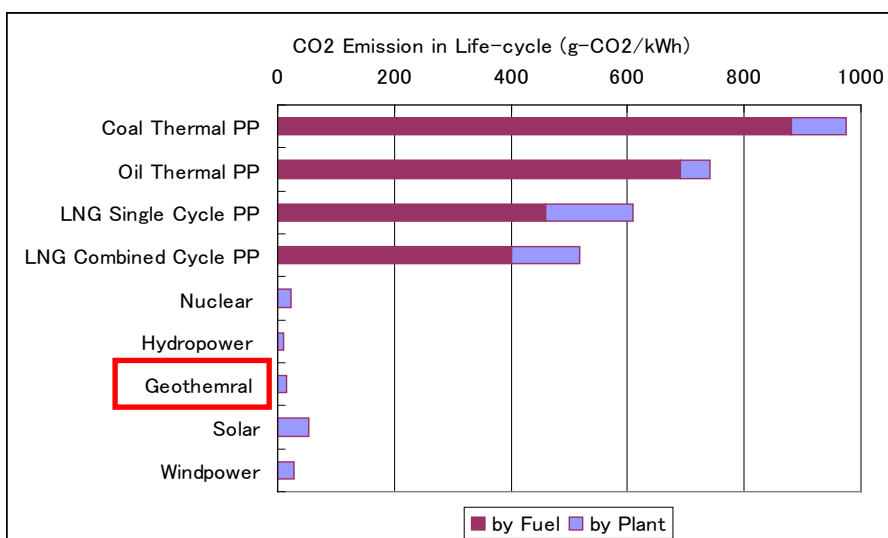
(1) Superiority of Geothermal Energy

In general, geothermal energy is a clean reliable source of renewable energy which offers significant benefits when compared to other sources of energy:

- Environment friendly energy
- Reliable source of energy
- Indigenous source of energy
- Power generation business is economically viable to some extent
- Multi-purpose use of heat is available

Environment-friendly energy

Geothermal power generation does not emit air pollutant such as sulfur oxide, nitrogen oxide, and dusts, since no combustion process is included. Furthermore, the amount of carbon dioxide emission is much smaller comparing with other kind of power generation. Therefore, geothermal power generation is an environment-friendly energy source, and it contributes to a country development without deteriorating the global warming (Fig. III-1.1.10).



(Source: Central Research Institute of Electric Power Industry, Japan; CRIEPI Review No.45, 2001 Nov.)

Fig.III-1.1.10 Life cycle CO₂ emission of various power sources

Reliable source of energy

Among other renewable resources, the points that best characterize the geothermal resource are high capacity factor and its stability, that is, it can be used throughout the year regardless to climate conditions. Thus the geothermal energy is an energy source of high supply reliability (Fig. III-1.1.11).

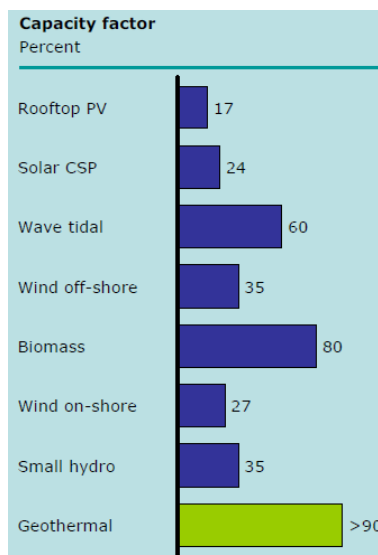


Fig.III-1.1.11 Plant capacity factors of various kinds of renewable energy

Indigenous energy source

Geothermal energy is a purely domestic source of energy. The countries without reserves of fossil fuels can reduce the amount of import of fossil fuels. Even for the countries with fossil fuels reserves and have ability of exportation, geothermal energy can replace the domestic consumption of fossil fuels. The saved amount can be displaced to export, or it can be reserved for future use.

Power generation business has economically viable to some extent

Geothermal energy development requires high initial investment at its exploitation stage. On the contrary, geothermal energy will save the operational cost since it does not consume fuel expenses. Consequently, the long-term power generation cost of geothermal energy is not expensive as that of solar power generation (Fig. III-1.1.12), and neither it is not affected by the fluctuation of the international petroleum price or exchange rate. Thus geothermal energy can be supplied at stable supply cost and the utilization of geothermal resources would contribute to stabilize national economic balance.

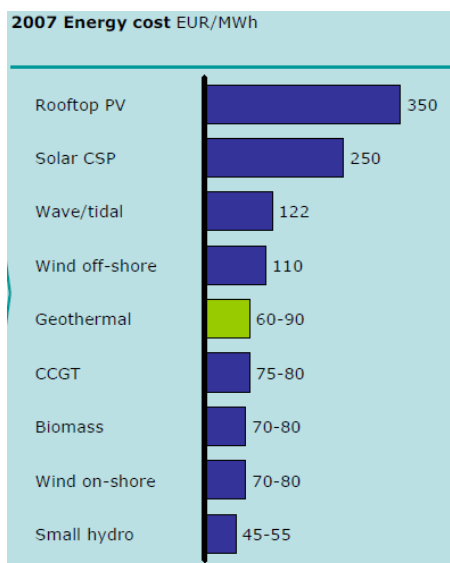


Fig.III-1.1.12 Power generation cost of renewable energies (Bertani, 2009)

Multi-purpose use of heat is available

Hot waters originate from heat source or produced as the by-product of power generation can be utilized for agriculture, fish farming, and the heat source for regional industry. Such multi-purpose use is efficient especially in the region of cold climate, and can be utilized for desiccation of woods or cereals. The steam originate from geothermal power generation can be utilized for agricultural, ranching, and drinking purposes after condensation by cooling. Geothermal energy is an energy source that can unite energy developments and regional developments.

Comparisons between geothermal energy and other renewable energies are shown in Table III-1.1.2. The benefit of geothermal resource development is not only limited to the above mentioned merits, but it also contribute to growth of regional economy.

Table III-1.1.2 Comparison between geothermal and other renewable energy sources

Power Source	Environment	Availability	Energy Independence	Commercial Balance	Multiple Utilization
Geothermal	Yes	Yes	Yes	Yes	Yes
Hydro	-	-	Yes	Yes	Yes
Wind	Yes	-	Yes	Yes	-
Solar	Yes	-	Yes	Yes	-
Biomass	-	-	Yes	Yes	-

(2) Advantage and Necessity of Geothermal Energy Development in Peru

Geothermal development in Peru is desirable especially because of the following reasons.

- Electricity power development with various kinds of energy source is necessary to cope with growing energy demand. Among various renewable energies, geothermal energy is highly expected as a promising power source since it can achieve stable supply. Fig. III-1.1.13 shows the capacity factors of power plants that had been offered in the tenders of renewable energy projects. Only a few of small-scale hydraulic power plants and biomass plants could achieve the capacity factor over 80%. In general, geothermal power plants can achieve a capacity factor of 80-95%.

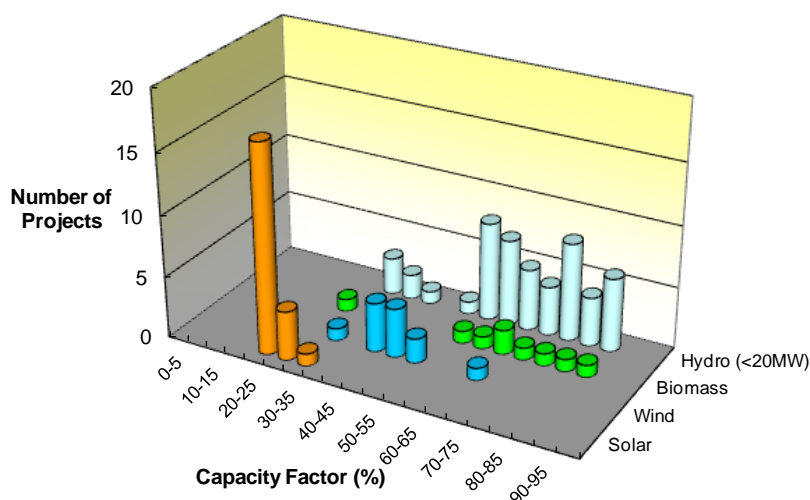


Fig. III-1.1.13 Capacity factors of renewable energy power projects offered in the tenders in Peru

- At present, natural gas fired power generations are carried out at low costs in Peru, and the power output is getting increased. Natural gases are demanded not only for power generation use but also for other purposes. Thus its domestic consumption is increasing. When geothermal power generation is realized, the consumption of natural gases for power generation use will be reduced, and the saved amount can be supplied to other purposes such as town gas demand. As natural gases are international merchandise, the saved amount can be sold to international market as LNG and the sales will bring foreign currency to Peru.
- Geothermal power generation will emit much smaller amount of CO₂ comparing with that of gas fired power generation that power supply is getting increased recently in Peru (refer to Fig. III-1.1.10). Replacement of gas fired power plants with geothermal power plants will greatly contribute to the reduction of CO₂ emission.
- There exist abundant geothermal resources in southern part of Peru. On the other hand, there are poor amount of water resources in southern part of Peru since arid region widely spread over the southern part. In addition, solar resources are relatively rich in southern part of Peru, but wind power is not available except limited area in mountainous region (Fig. III-1.1.14).

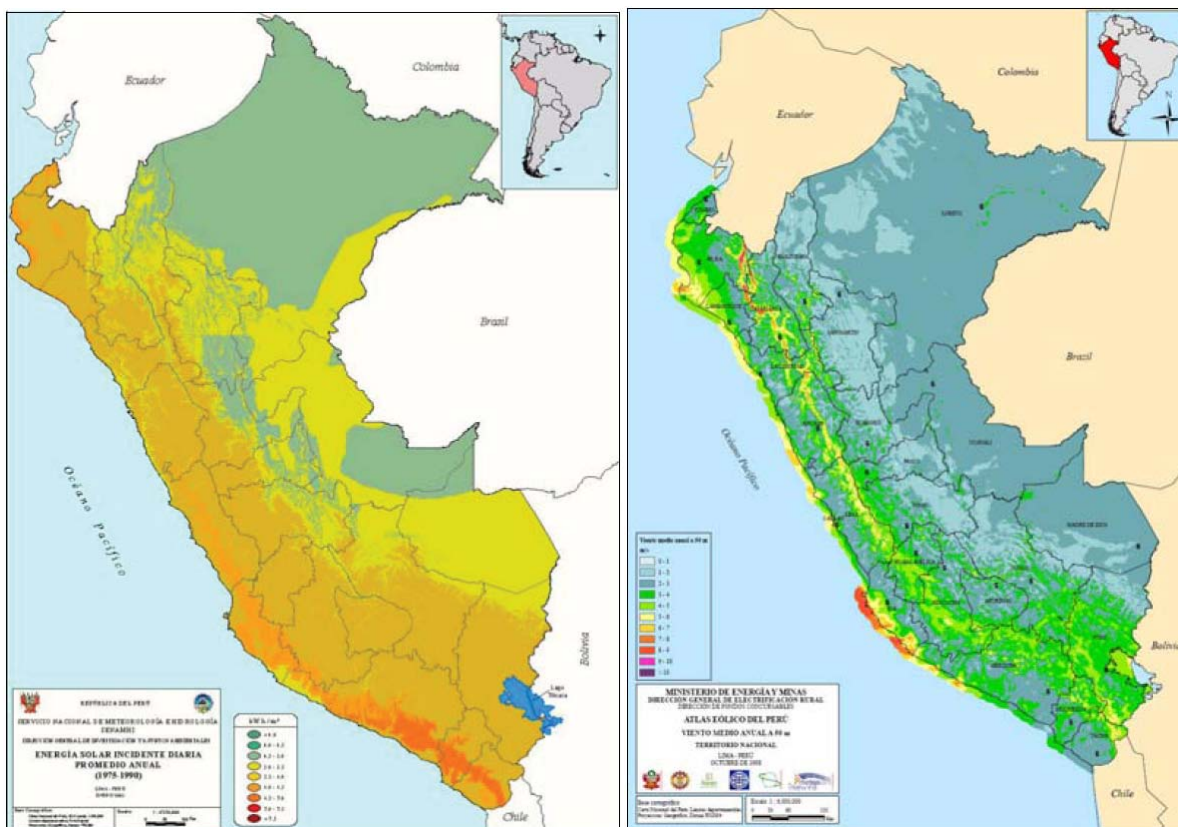
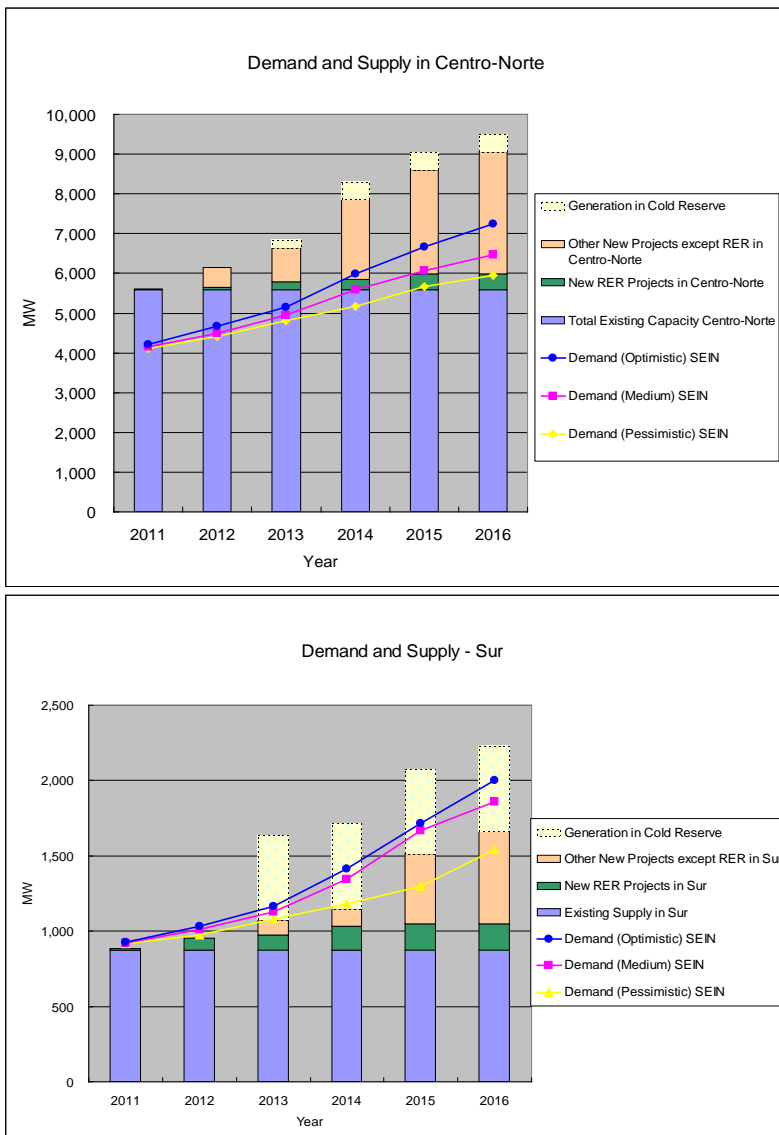


Fig. III-1.1.14 Distribution map of solar (left) and wind (right) resources in Peru

- Projections of demand and supply of electric power (up to 2016) for south area and other area (north and central) are shown in Fig. III-1.1.15. In north and central area, there will be enough supply than even optimistic demand. On the other hand, the margin of the supply in south area will be only by “cold reserve (reserva fria)” power plant, which is the lowest priority of operation among power plants, in case of optimistic and medium demand projection. In this case, power with cheaper cost may be dispatched from central area to south. Consequently, geothermal power at promising geothermal fields in south area will make southern grid (Zona Sur: Apurimac, Cusco, Arequipa, Puno, Moquegua and Tacna) stable and contribute to improvement of the transmission losses and overall system stability, as well.



(Source: MEM and COES Website)

Fig. III-1.1.15 Demand and Supply Projection (up to 2016)

- The regions with abundant geothermal resources in Peru are cold districts at high-altitudes. Multi-purpose use of geothermal energy including room heating can be highly expected.

III-1.1.3 Quantitative Evaluation of Benefit of Geothermal Development in Peru

(1) Economic Evaluation of Geothermal Power Project

In this study, the economy of the possible geothermal power projects is evaluated for the 13 promising fields selected in this study and for Calientes and Borateras fields where the detailed studies had been conducted previously. In the economic evaluation, the selling price of electricity that can attain 12% of the Financial Internal Rate of Return (FIRR) for the geothermal plant investors during 30-year operation period is calculated. As a result, the highest project economy is estimated for the “Field-A” with the lowest selling price of 10.5 US cent/kWh.

(2) Comparison with Alternative Power Sources (Benefit of Natural Gas Saving)

In this section, the cost competitiveness of the geothermal power project against alternative sources is studied. Natural gas (combined cycle power plant; NGCC), coal and diesel are selected as alternative sources.

Firstly, the power plant specification of alternative sources is assumed as shown in Table III-1.1.3. Oil price is assumed as 120 USD/bbl while coal price is 110 USD/ton and natural gas price is 12 USD/MMBTU (Table III-1.1.4). These prices are referred to the IEA's "World Energy Outlook 2010", and are considered as constant during the evaluation period for the simplicity. The current price of the natural gas for power generation use in Peru is around 1.58 USD/MMBTU. However, this is a domestic price, and it is necessary to evaluate natural gas value in terms of the international price since the fuel is the internationally traded commodity. According to a report of IEA, the LNG price for 2015-2035 is forecast to be 12-17 USD/MMBTU in Asia, 7-11 USD/MMBTU in the United States and 11-14 USD/MMBTU in Europe. Therefore, 12 USD/MMBTU is taken as an average price of the three markets, and the price of 3-15 USD/MMBTU is used in the sensitivity analysis.

Table II-1.1.3 Power plant specification of alternative sources

Plant Type	Natural Gas-fired (Combined-Cycle)	Coal-fired Plant	Diesel Plant
Fuel	Natural Gas	Coal	Heavy Oil
Capacity	300 MW	300 MW	50 MW
Construction Cost (w/o IDC)	1,200 USD/kW	1,600 USD/kW	1,000 USD/kW
Construction Period	3 years	4 years	3 years
Plant Efficiency	45%	38%	38%
In-house use	3.5%	7%	4%
Capacity Factor	82.8%	85.9%	83.2%
O&M Costs	0.5 US cent/kWh	0.65 US cent/kWh	0.5 US cent/kWh
Fuel Price	12 USD/MMBTU	110 USD/ton	120 USD/bbl
Heat Value of Fuel	9,140 kcal/m ³	6,000 kcal/kg	9,800 kcal/L
Operation Period	30 years	30 years	30 years

Table II-1.1.4 Forecasted price of fossil fuels by IEA (2009 prices)

Energy	Unit	Current Policies Case					
		2009	2015	2020	2025	2030	2035
Natural Gas							
United States	USD/MMBTU	4.1	7.0	8.2	9.3	10.4	11.2
Europe	USD/MMBTU	7.4	10.7	12.1	12.9	13.9	14.4
Japan	USD/MMBTU	9.4	12.4	13.9	14.9	15.9	16.5
Crude Oil	USD/bbl	60.4	94.0	110.0	120.0	130.0	135.0
Steam Coal	USD/ton	97.3	97.8	105.8	109.5	112.5	115.0

Source: IEA, "World Energy Outlook 2010"

Based on these assumptions, the cost competitiveness against alternative thermal plants of the geothermal plants is calculated. The comparison is done to calculate the total cost difference between the case in which a geothermal plant is built and operated for 30 years and the case in which an alternative thermal power plant with the same capacity is built and operated in the same period. The comparison is expressed in terms of Economic Internal Rate of Return (EIRR). If the EIRR is larger than 12%, which is the social cost of the capital, the geothermal plant has cost competitiveness against an alternative plant.

According to the above-mentioned results;

- Cost competitiveness of geothermal project against natural gas power project depends on the price of the natural gas. If the price of the gas is within a range of 10-15 USD/MMBTU, the geothermal plant in certain fields has cost competitiveness.
- Geothermal project in any fields has less cost competitiveness against coal power project. It is because the price of coal is comparatively cheap. However, it should be noted that coal power plant exhausts large amounts of CO₂ and has an impact on the global environment to some extent.
- Geothermal project in many fields has cost competitive against diesel power project. This shows the possibility that the geothermal plants can alternate diesel power plants as the power sources in the remote independent system.

This calculation shows the benefits of geothermal energy. The cost difference between the case where a 150 MW geothermal power plant is built in Filed-A and the case where a natural gas power plant with same capacity is to be built in some area instead of the geothermal plant is studied. According to this comparison, it is understood that the society can obtain the cost saving of USD 2,281 million by the geothermal plant through the construction and the 30 year-operation period. This cost saving turns to be USD 151 million in terms of net present value when converted by the social discount rate of 12%. This amount can be expressed as 3.53 US cent/kWh when divided by the total amount of the electricity produced by the geothermal plant¹.

(3) Increase of Tax Income

Geothermal projects need a large up-front investment and a long development time period. This characteristic greatly influences the amount of the tax payment from the geothermal generation business. Fig. III-1.1.16 show the composition of the selling price of the electricity supplied by geothermal plant and natural gas power plant (NGCC). The geothermal is the case of project in Field-A and the natural gas is the case with a gas price of 12 USD/MMBTU. According to this calculations, the tax payment and royalty from geothermal project is 1.6 US cent/kWh and accounts for 15.2% of the selling price of 10.5 US cent/kWh. On the other hand, the tax payment from natural gas power project is 0.5 US cent/kWh and accounts for only 3.9% of the selling price of 12.9 US cent/kWh. There is the great difference in the tax payment of 1.1 US cent/kWh between the two projects.

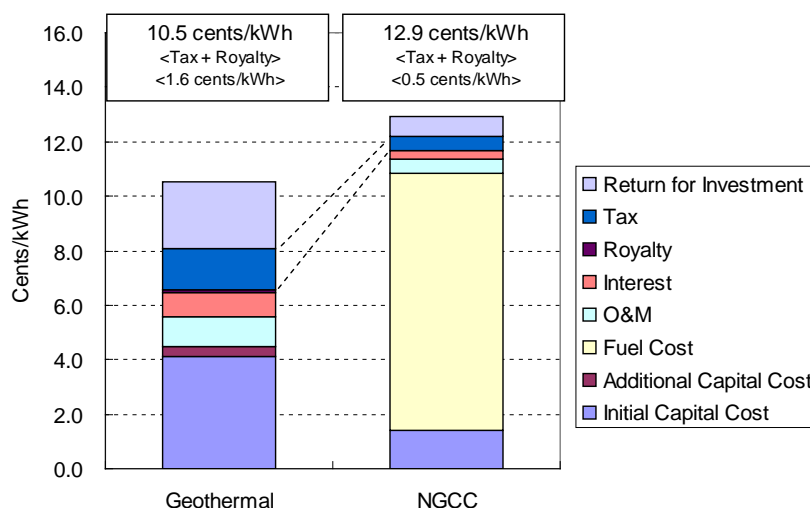


Fig. III-1.1.16 Composition of the selling price of geothermal and natural gas power projects

¹ The electricity production is also converted to the net present value using 12% discount rate.

The less tax load of natural gas power project is due to the fact that the fuel expense which is the main cost factor of natural gas generation can be treated as a cost and can be subtracted from the sales profit. On the other hand, the investment return of geothermal project, which corresponds to the fuel cost of natural gas generation and is the main cost factor, is treated as profit in business operation. Therefore it is taxed and the tax amount becomes large in geothermal project compared with a same sale natural gas project. In this respect, California Energy Commission (1996) also reports that the tax load of geothermal projects is 2.8 times heavier than that of the alternative thermal power projects.

The phenomenon that the tax load of geothermal project is higher than that of alternative natural gas project means that geothermal project can bring benefit of tax increase for the government. If geothermal plant were constructed instead of natural gas power plant, the government would be able to obtain more tax income. Although the government can use this tax income for any fiscal expenditure, it is highly desired that the government should decrease the tax ratio from geothermal business or use this tax benefit for the various incentives to promote geothermal energy development in Peru.

The incentives to promote geothermal energy development need their costs. However, if these incentive costs are less than the tax income increase, the net government benefit remains plus. Even if the net governmental benefit becomes minus when incentive costs become large, the incentives might be justified when the other social benefits of geothermal energy, including the benefit of fuel saving and environmental quality improvement, is taken into the consideration.

III-1.1.4 Target of Geothermal Power Development

As described in previous sections, the total resource potential in Peru can be approximately estimated to be 2,860 MW reserved in 61 geothermal fields, according to the results of the Master Plan study. In addition, a development of 735 MW electric power in total could be possible in the 13 geothermal fields that were selected as promising fields in this study. The evaluation results of national resource potential and development strategies proved that Peru is endowed with abundant geothermal resources. Moreover, since the geothermal developments in Peru will bring plenty national benefits including natural gas saving and others as described above, successful utilizations of geothermal energy as a renewable energy source is strongly desired.

The expectation to the growth of geothermal power generation is getting increased all over the world. According to the outlook for the power supply by geothermal energy forecasted by the International Energy Agency (IEA) in 2011, a worldwide growth of geothermal energy developments are expected in the coming decades (Fig. III-1.1.17).

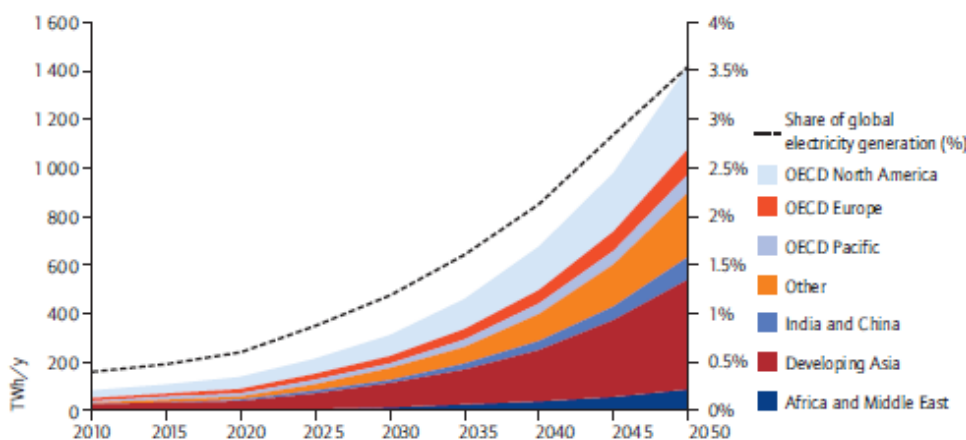


Fig. III-1.1.17 Outlook of world's power supply by geothermal resources

The concrete numeric target for power developments by renewable energies including geothermal resources has not been decided yet since “the National Plan for Renewable Energies” has not been formulated and is not open to public. However, the law for promoting power generation by renewable energies states that the power purchase with fixed price is guaranteed for up to 5% of total power demand (excluding hydro/micro-hydro power generations), and this could be regarded as the practical target for power generation by renewable energies. If the target for renewable energy power generation will be remained unchanged as 5% of the total power demand, it can be expected from the bidding results for renewable energy projects that the power generation by various renewable energies other than geothermal will cover the targeted amount of power demand (Fig. III-1.1.18). Thus it is desirable to increase the numeric target of power generation by renewable energies in future.

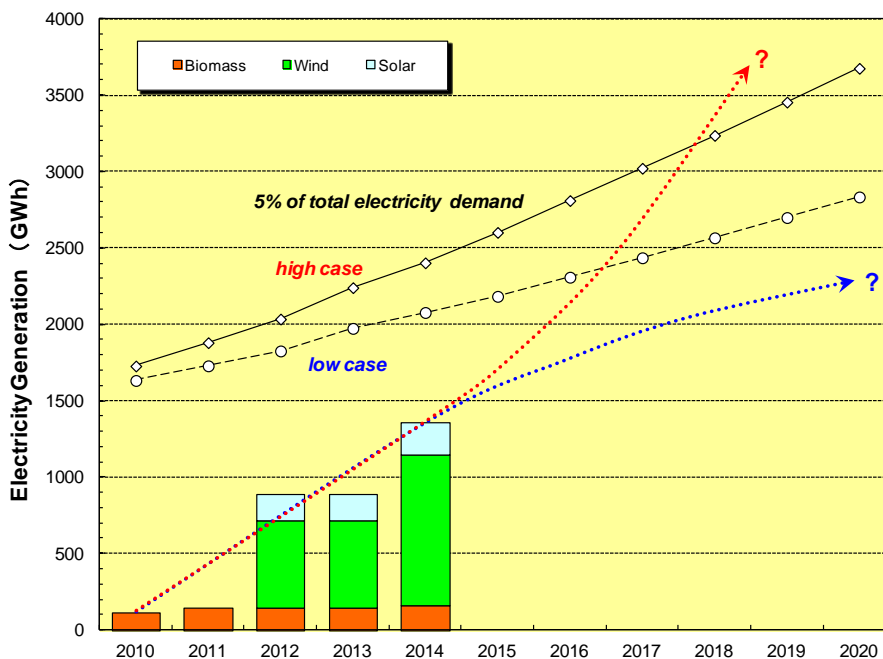


Fig. III-1.1.18 Prediction of growth in power generation by renewable energies other than geothermal

It is desirable to increase the target power generation by renewable energies to be 10% of the total electricity demand. The amount of the target power generation will be revised in every five years, and the next revision will be made on 2014. Thus it is expected to increase the target amount of power generation to be increased to 10% of total electricity demand in 2014. In the Republic of Chile, the neighboring country, a target goal was determined so that the amount of power generation by non-conventional renewable energies to achieve 10% of national power demand, by the year of 2024.

It is desirable to set the target goal of the power output by geothermal energy to be 50% of power generation by renewable energies, that is, the goal should be set as to supply 5% of total national power demand by geothermal energy. In this case, forecasting the growth of demand according to an optimistic scenario, and assuming the load factor of a geothermal power plant to be 85%, the target of power generation capacity by geothermal energy in 2030 will be 1,000 MW. This numeric target of development, that is, to newly develop 1,000 MW in the coming 18 years, is not impractical, considering that the total resource potential in 13 promising fields is 735 MW as previously described, and considering that there are other fields to be exploited in the near future.

⇒ It is longed for geothermal resources to be developed as much as possible for power generation and other heat utilization purposes, as indigenous energy resources in Peru. The development will be started with resource exploration and will take rather long time. However, to develop 1,000 MW geothermal power by 2030 is desired from the viewpoint of mid/long-term energy mix strategy.

III-1.2 Legal and Organization Framework for Geothermal Power Development

III-1.2.1 Recommendations on Legal Framework

(1) Organic Law of Geothermal Resources

In Peru, there exists the Organic Law of Geothermal Resources and its Regulation, which establish the framework for the promotion of geothermal development by the private sector. Under this framework, a number of requests for exploration right (authorization) have been requested. However, the grant of authorization by MEM is just beginning and most of them are still in the process of evaluation. Therefore, it is still early to judge how effectively this legal framework may promote the geothermal development principally by the private sector. Currently, the authorization holders have the mandatory payment of small right fee of ever year as prescribed by the Article 62 of the Regulation of the Organic Law of Geothermal Resources. And in case of that the authorization holders do not advance their activities as planned, the guarantee (5% of the budget) presented by them for the phase II of exploration period will be executed as prescribed in the Article 17 of the Regulation of the Organic Law of Geothermal Resources. However, for the phase I for the exploration period, there is no penalty even though the authorization holders do not proceed their activities as planned. Therefore, if the authorization holders consider difficult to develop the project as private business, it may happen the case that they don't develop the fields but keep holding the authorizations. If this situation occurs in practice, it requires for the MEM to strengthen their supervision on whether or not the exploration activities are being proceeded as planned.

On the other hand, if the authorization holders cannot proceed their exploration activities due to the high risks on resources, it is recommend that the governmental institution or other state-own enterprises participate on the exploration activities. In such case, the options such as the drilling by the public entity or the project implementation through the Public-Private Partnership should be considered.

(2) Law for Electricity Generation with Renewable Energies

This Master Plan study recommends the realization of the renewable energy resources auctions for geothermal generation projects in accordance with the law for electricity generation with renewable energies. However, in Peru, geothermal development is still in the phase of exploration, and so, the auctions for geothermal power generation have not been realized yet. In case of other renewable energy resources projects, since the development period is short, comparing to the geothermal projects, it is not required to get the concession right to participate on the auctions. However, in case of geothermal projects, it takes a long period for development, some measures should be considered to secure the power generation within certain years after the awarding. For example, to get the concession right must be a precondition for the participation on the auctions.

On the other hand, in the renewable energy resources auctions, the bid price must include the investment cost for transmission lines necessary for the connection to SEIN. However, in case of geothermal generation, the installed capacity is generally much larger than other renewable energy resources generation and most of geothermal potential is concentrated in the same area of southern part of the country. Therefore, it is not realistic either economically or technically for each geothermal developer has to construct their transmission line to be connected to the systems. So, in case of geothermal power generation projects, the investment for transmission lines should be considered separately from the bid price for the renewable energy resources auctions, and the law for electricity generation with renewable energies should be modified accordingly.

Finally, according to the Article 11 of the law, the MEM would elaborate the National Plan of Renewable Energies. However, it has not been announced up to now. The elaboration of this plan is essential in order for the country to achieve the best mix of electricity generation sources. Furthermore, the composition of renewable energy resources in the auctions in the future will take into account this plan. In this sense, it is very important to incorporate the result of this Master Plan to the National Plan of Renewable Energies.

- ⇒ Any major problem does not been identified in the present legal and regulatory framework for geothermal development. However, in case of that it is revealed that the geothermal resource development only by the private sector is difficult; it is recommended to review and modify accordingly the related laws. The possibility of participation of the government or the public company for exploration stage and construction stage must be evaluated in order to reduce the resource risks and the investment burden for the private sector

III-1.2.2 Development System and Organization

It is expected that the power utility business in Peru will primarily evolve under private initiatives. In principle, so will be the geothermal development once it acquires certain momentum. Though it may follow such development path, those government bodies under DGE which are responsible for the power sector policy and the supervision of IPP must retain and develop wide range of technical experts related to the geothermal technology, including the legal and economical issues, so that they will be able to enact appropriate policies on the geothermal concession, to determine proper price level under FIT system or to provide proper supervision and guidance on the private developers during each stage of their activities such as exploration study, plant construction and its operation. Proper capacity building will not be realized if it consists of just sending bright young engineers to overseas training course. They need to go through actual projects in order to accumulate experiences. As the experts in the supervising organization gain more experience and knowledge in the geothermal technology, they shall bring more benefits to the country since they are capable to implement better judgment, policy and control on the development and use of the geothermal resource which is one of the precious assets of this country.

In the past, there have been some attempts initiated by several government agencies as they tried to exchange information with the others or even tried to form alliances between them by setting up geothermal committees or some other way. But in order to deal with the actual issues they face during geothermal development, it will be necessary to reinforce mutual coordination and network among those organizations. Furthermore the implementation of the policies proposed under this geothermal Master Plan requires extensive use of the database developed under this study, which consequently asks for establishing an appropriate structure in terms of the operation of the databases, for its effective utilization as well as for the rigorous implementation of the data update in order to maintain its usefulness.

As more fundamental issues to be addressed before discussing future prospect, private developers have to face difficult business decision when embarking geothermal project, as it requires high initial investment cost such as for drilling geothermal wells and for constructing fluid system on top of the power plant construction, while resource risk is not eliminated. Consequently the development tends to get longer as it has to accumulate detail knowledge of the field in order to mitigate the project risk. It will not be easy to attract private investors for geothermal project, even if lucrative return on investment is offered for the purpose of promoting their appetite.

Under such circumstances, those developing countries which have been successfully introduced geothermal power plants, at least during the initial stages, opted a way that their public instruments undertook the projects, because they could absorb larger resource risk and they could utilize financial aid from bilateral and multilateral donors, thus the development cost can be reduced (Refer to Table III-1.2.1). During the early stage of the geothermal development in these countries, they also faced mounting problems including those for confirming resource quality and those on capacity building. Even after the construction of the first pilot plant, things did not go smoothly as they were encountered by numerous problems. In a way, these experiences showed difficulty of geothermal development, which makes private investors hesitating from entering green field development and in return proves the necessity for involvement of the public instruments. In case of Peru, as public entities which could undertake geothermal development are the state owned companies such as, 1), INGMET which has accumulated long experience in the geothermal study, 2), Perupetro S.A. which has knowledge on the

drilling sector which also plays important role in geothermal development, 3), Electroperú S.A. which was in past engaged in the geothermal study and can handle downstream side of the project. They could be reinforced with help from Universidad Nacional de Ingeniería when it comes to the technology pertaining to the geothermal power plant.

Table III-1.2.1 Examples of geothermal development promoted by government-owned entities

Country	Resource development / Steam supply	Power Plant	Project examples / Remarks
Indonesia	PGE (PERTAMINA Geothermal Energy)	PLN	Kamojang : 200MW, Lahendong : 60MW As to Kamojang unit 4, PGE undertakes both resource development and power plant operation.
Philippines	PNOC-EDC (Philippines National Oil Company-Energy Development Company)	NAPCOR	Bac-Man : 150MW, Mindanao : 106MW Northern Negros : 49MW Southern Negros : 192.5MW Leyte : 700.9MW PNOC-EDC was privatized and sold in 2007. NPC has been selling its assets upon the enactment of Electric Power Industry Reform Act in 2001.
Turkey	MTA (General Directorate of Mineral Research & Exploration)	TEAS (Turkey's Electricity Generating & Transmission Corporation)	Kizildere : 20MW Kizildere GPP was later sold to a private company as the power generation sector is now under IPP market. The private geothermal developers have been very active in recent years. MTA, however, retains strong influence as they are given special status on the concession right and also undertake geothermal exploration for private developers.
Mexico	CFE (La Comisión Federal de Electricidad)	CFE	CerroPrieto : 720MW LosAzufres : 188MW LosHumeros : 35MW LasTresVirogenes : 10MW
Costa Rica	ICE (Corporativo del Instituto Costarricense de Electricidad)	ICE	Miravalles : 133MW Las Pailas : 35MW Government-owned power electric corporation which covers 80% of generation and monopolies transmission/distribution of the country.
El Salvador	LaGeo	LaGeo	Berlin : 100MW, Ahuachapan : 95MW When Berlin III was developed, Italy's ENEL acquired 20% of La Geo share.
Kenya	KENGEN	KENGEN	Olkaria I,II and IV, total 127MW Regarded as having least power development cost, development priority on geothermal is fueling rapid growth. State owned GDC was created which is responsible for the resource development and the steam supply with an intention that the state takes care of upstream sector while private developers take care of the downstream sector. Meanwhile privatization of KenGen is ongoing as they had IPO in 2006.

As geothermal development initiated by the public sector achieves success, it is expected that experience on the unique technical conditions pertaining to Peruvian environment such as those caused by high altitude (low atmospheric pressure and temperature) accumulates and a group of experts in this technology develops, which should enhance capacity of the governmental organizations who are responsible for supervising, controlling and advising the private developers as well as for setting the development policy.

⇒ It is desirable that, while the governmental organizations such as DGE and INGEMMET streamlines their organizations and promote capacity building in order to promote geothermal energy, the others expected to be involved directly such as Electroperú S.A. should start building geothermal task team in their organizations.

III-1.3 Recommendations on assistance and incentives for promotion of geothermal development

III-1.3.1 Feed in Tariff (FIT) System

The current legislation in Peru gives the incentive of “Feed-In-Tariff” to the private companies selected through the tender process to develop renewable energy resources for power generation, including geothermal energy. Under this system, it is important for the government to determine the Base Price at reasonably high level to motivate the private companies to invest for the power generation projects with renewable energy sources.

Figure III-1.3.1 shows the price level for FIT systems for geothermal power generation in other countries. In many cases it is around 10 US cent/kWh. However, there are some countries where the price for geothermal power generation is set above 15 US cent/kWh.

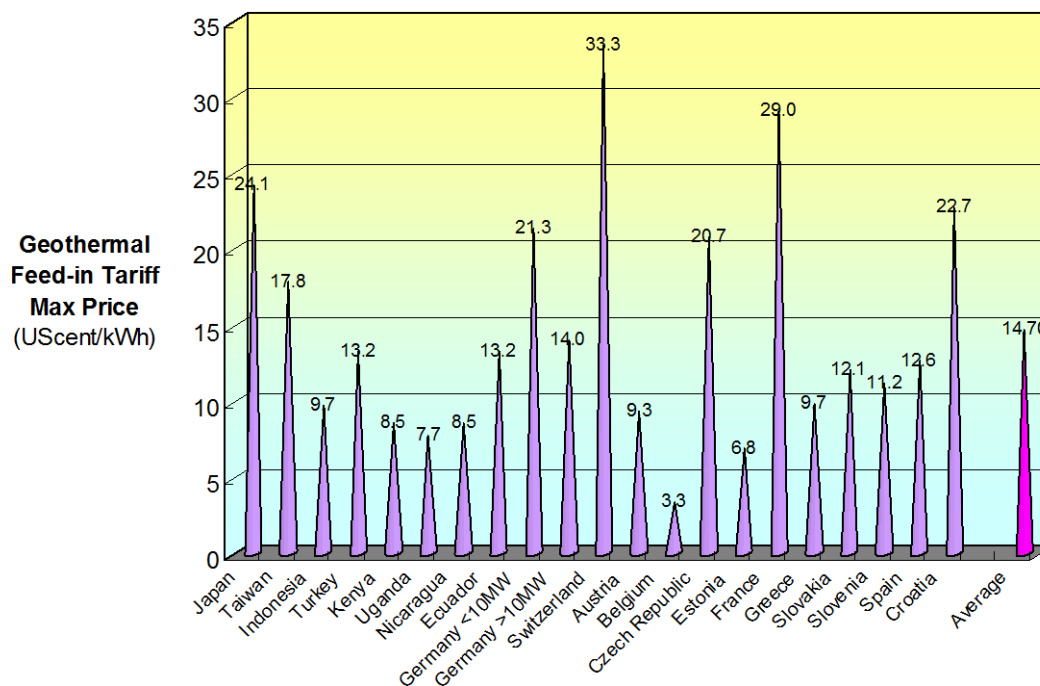


Fig. III-1.3.1 Price for FIT of geothermal power generation in the world (maximum price)

However, the cost to sustain the FIT system (premium to cover the difference between the fixed price and the market price) is borne by the users as the tariffs for electricity consumption. Thus, the higher the price level of FIT becomes, the burden to the consumers becomes larger.

Therefore, it is desirable for the government to provide some additional support for the promotion of

geothermal development other than the current FIT system so that the direct impact on the electricity tariff for consumers can become relatively small.

⇒ To promote geothermal development through the current FIT system inducing the private investments, it is desirable to set the base price as high as possible. However, it means that the impact on electricity tariff for consumers may become significant. To avoid that, it is desirable to implement other means of assistance and incentives.

III-1.3.2 Financial Support, Tax Incentive and Fiscal Assistance

(1) Financial Support (low-interest loans for construction costs)

The main characteristic of geothermal power generation are its relatively large initial investment cost compared to thermal power generation cost and its long lead-time for development. Thus, the loan interest for the initial investment has a significant impact on the electricity selling price. In this sense, the financial support for geothermal development may bring a significant effect.

In the economic evaluation conducted for the promising geothermal projects, the following conditions are assumed; 70% of construction costs are financed with a loan on conditions of 4.5% of interest rate, 3 years of grace period, 12 years of repayment period (15 years of loan period). The electricity price of 10.5 US cent/kWh for the Field-A project is calculated under these conditions. The calculations of electricity price on the different financial conditions for the same field are also conducted, in the interest rate is decreased down to 1.0% with 3 years of grace period and 17 years of repayment period (20 years of loan period). Table III-1.3.1 and Fig. III-1.3.2 shows the results of these calculations.

Table III-1.3.1 Effect of low-interest financing for construction costs on reduction of electricity selling price

Case	Steam Dev. Section		Power Plant Section		Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Incentive Cost (cents/kWh)
	Interest Rate (%)	Loan Period (yrs)	Interest Rate (%)	Loan Period (yrs)				
Base Case	4.5%	12	4.5%	12	3,940	10.5	-	-
IPP-1	4.0%	12	4.0%	12	3,920	10.3	▲ 0.2	0.14
IPP-2	3.5%	12	3.5%	12	3,900	10.1	▲ 0.4	0.28
IPP-3	3.0%	12	3.0%	12	3,880	9.9	▲ 0.6	0.41
IPP-4	2.5%	12	2.5%	12	3,860	9.7	▲ 0.8	0.54
IPP-5	2.0%	12	2.0%	12	3,840	9.5	▲ 1.0	0.68
IPP-6	1.5%	12	1.5%	12	3,820	9.3	▲ 1.2	0.80
IPP-7	1.0%	12	1.0%	12	3,800	9.1	▲ 1.4	0.93
IPP-8	4.5%	17	4.5%	17	3,940	10.5	▲ 0.0	▲ 0.17
IPP-9	4.0%	17	4.0%	17	3,920	10.3	▲ 0.3	▲ 0.01
IPP-10	3.5%	17	3.5%	17	3,900	10.1	▲ 0.5	0.15
IPP-11	3.0%	17	3.0%	17	3,880	9.9	▲ 0.7	0.30
IPP-12	2.5%	17	2.5%	17	3,860	9.7	▲ 0.9	0.45
IPP-13	2.0%	17	2.0%	17	3,840	9.5	▲ 1.1	0.60
IPP-14	1.5%	17	1.5%	17	3,820	9.3	▲ 1.2	0.75
IPP-15	1.0%	17	1.0%	17	3,800	9.1	▲ 1.4	0.90

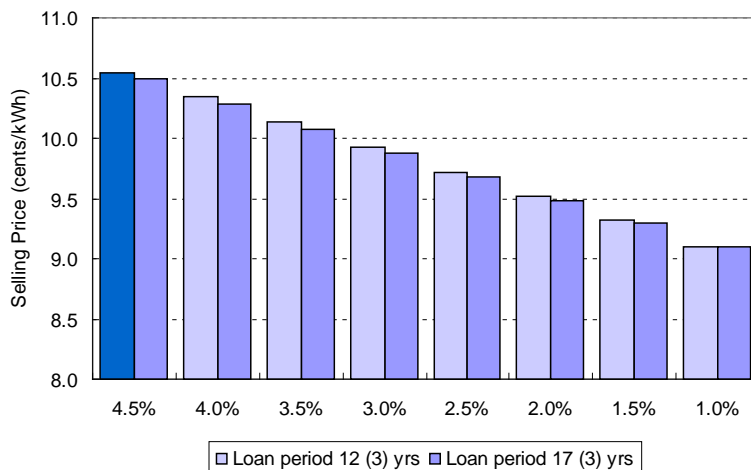


Fig. III-1.3.2 Effect of low-interest financing for construction costs on reduction of electricity selling price

According to the results of those calculations, the effect of low-interest financing for the construction costs on electricity price is large. For example, when the loan with the interest rate of 2.0% is provided, the electricity price decreases by 1.0 US cent/kWh (9.7% reduction). Also, the extension of loan period can, even slightly, contribute to the reduction of electricity price.

When the loan with preferential interest is provided to the private companies, its cost will be borne by the financial institutions (the government). Here we assume two values², (A) the present value of interest rate to be repaid by the developer financed by a loan without a preferential interest rate, and (B) the present value of interest rate to be repaid by the developer financed by a loan with a preferential interest rate. When the difference (A-B) is divided by the amount of power generated during 30 years, it can be considered as the cost per kWh of this financial support³. Table III-1.3.1 also shows the cost of support in each case. In case of the 2.0% interest rate with the repayment period of 17 years (Case IPP-13), the electricity price can reduce by 1.1 US cent/kWh (10.1% reduction), while the financial cost for this remain in 0.6 US cent/kWh.

Consequently, if financial assistance for geothermal power generation is provided in Peru, it is recommended to establish a scheme in which the governmental financial institution such as COFIDE (Corporación Financiera de Desarrollo, SA) provides the Two Step Loan (TSL) etc. to the private sector, utilizing the low-interest financings such as ODA loans.

(2) Tax Incentive

Due to the fact that geothermal power generation does not require the expenses for fuel but the large initial capital investment, the tax burden of geothermal power generation is large compared to thermal power generation. Therefore, a measure to reduce this burden for geothermal energy power generation through tax incentives can be a powerful measure to promote geothermal development.

As an example, the impact on required electricity selling price for a project in the Field-A is calculated by applying various tax incentives in place of the current tax rate of 30%. The results are shown in Table III-1.3.2 and Fig. III-1.3.3. In case of tax holiday, the tax holiday for 5 years brings little effect on the reduction of selling price. This is because the most of this period (5 years) is in the deficit, thus the amount of tax is small. In case of 10 years of tax holiday, the selling price declines to 9.9 US cent/kWh (reduction of 0.7 US cent/kWh or 6.3%).

² Converted to the net present value using 12% discount rate.

³ The generated power energy is also converted to the net present value using 12% discount rate.

Table III-1.3.2 Impact of tax incentives on the reduction of electricity selling price

Case	Tax Rate (%)	Tax Holidays (yrs)	Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Tax (cents/kWh)	Incentive Cost (cents/kWh)
Base Case	30%	0	3,940	10.5	-	1.9	-
T-1	30%	5	3,940	10.5	0.0	1.6	0.00
T-2	30%	7	3,940	10.2	▲ 0.3	1.3	0.23
T-3	30%	10	3,940	9.9	▲ 0.7	1.0	0.51
T-4	30%	12	3,940	9.7	▲ 0.8	0.8	0.65
T-5	30%	15	3,940	9.5	▲ 1.0	0.6	0.80
T-6	25%	0	3,940	10.3	▲ 0.3	1.3	0.21
T-7	20%	0	3,940	10.0	▲ 0.5	1.1	0.41
T-8	15%	0	3,940	9.8	▲ 0.7	0.9	0.60
T-9	10%	0	3,940	9.6	▲ 1.0	0.6	0.77
T-10	5%	0	3,940	9.4	▲ 1.2	0.4	0.94
T-11	0%	0	3,940	9.2	▲ 1.4	0.2	1.10

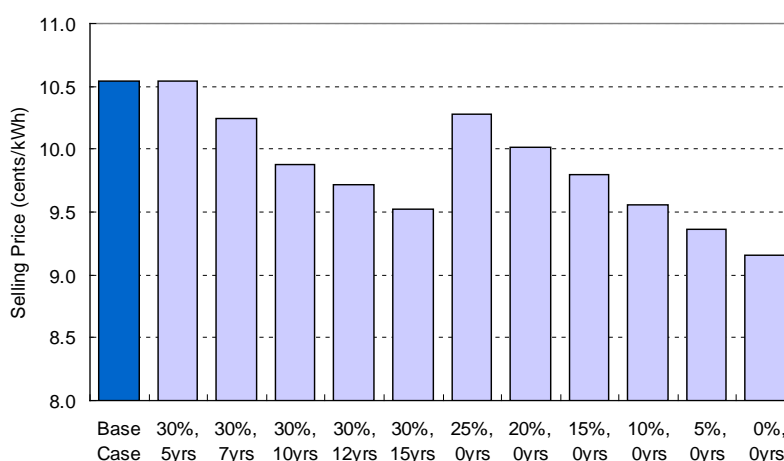


Fig. III-1.3.3 Impact of tax incentives on the reduction of electricity selling price

For natural gas-fired power generation, tax amount is about 0.6 US cent/kWh. In order that the tax burden of geothermal power generation could be equal to the one of natural gas-fired power generation, it is required to implement tax holiday for 15 years, maintaining the current tax rate (Case T-5) or to reduce the tax rate to 10% without tax holiday (Case T-9). In this case, the selling price results in 9.5 US cent/kWh (Case T-5) or 9.6 US cent/kWh (Case T-9), which means the price reduction of around 1.0 US cent/kWh.

Furthermore, it is possible to combine the financial support described above with tax incentives. Table III-1.3.3 and Fig. III-1.3.4 show the calculation result of the impact in electricity selling price of geothermal project in the Field-A by the simultaneous application of financial assistance of the loan with 2.0% of interest for construction, 3 years of grace period and 17 years of repayment period (20 years of loan period) and tax holiday during 10 years. According to this calculation, electricity selling price declines to 8.9 US cent/kWh (reduction of 1.7 US cent/kWh or 15.7%).

Table III- 1.3.3 Impact of the simultaneous application of financial assistance and tax incentives on electricity selling price

Case	Financial Incentive		Tax Holiday (years)	Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Incentive Cost (cents/kWh)
	Interest Rate (%)	Loan Period (yrs)					
Base Case	4.5%	12	0	3,940	10.5	-	-
Financial Incentive (r=2%)	2.0%	17	0	3,840	9.5	▲ 1.1	0.60
Tax Incentive (T.H=10yrs)	2.0%	17	10	3,840	8.9	▲ 1.7	1.08

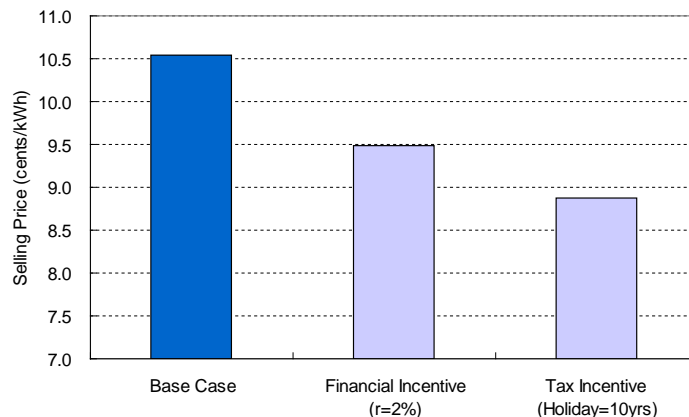


Fig. III-1.3.4 Impact of the simultaneous application of financial assistance and tax incentives on electricity selling price

From the above, to promote the geothermal development, the application of the combined measures of financial assistance described above and the tax incentives such as tax holiday for around 10 years.

(3) Fiscal Assistance

Term “fiscal assistance” is used in a narrow sense and refers to direct government expenditure. In other words, government can provide subsidies for renewable energy developers and reduce their up-front investment burden to promote renewable energies. Also the government itself can carry out some activities to promote renewable energies, such as a nation-wide survey of the geothermal energy inventory. Many countries provide this kind of fiscal assistance.

In case of Peru, one example of this kind of fiscal assistance may be the construction of transmission line by the government. If each private geothermal developer has to construct the transmission line independently to connect the geothermal power plant to the national grid, it may cause the double investment or congestion in the transmission. From the viewpoint of national economy as a whole, it is not efficient. To avoid such an economic inefficiency, it is recommended that the government will be in charge of constructing the transmission line in the geothermal potential area, based on the geothermal development plan of the private developers, based on the advance promising geothermal areas. In that way, the government can assist and promote the geothermal power generation by the private sector.

Table III-1.3.4 shows the effect of the fiscal assistance for the project in Field-A, by which the transmission line is constructed by the government. Since the investment in transmission lines is not large compared to the investment in resource development and power generation, the effect of such incentive is limited. However, the construction of transmission lines by the government is significant in terms of that it can prevent the overlapping investment. However, in the actual law of electricity generation with renewable energy defines that the construction of transmission line for the connection with the existing grid is a responsibility of each IPP developer. Thus, the law should be modified accordingly so that the construction of the transmission line for geothermal power generation projects will be managed by the government.

Table III-1.3.4 Impact of the construction of transmission lines by the government on electricity selling price

Case	Land costs (M\$)	T/L costs (M\$)	Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Incentive Cost (cents/kWh)
Base Case	0.28	9.31	3,940	10.5	-	-
Without T/L	0.0	0.0	3,870	10.4	▲ 0.2	0.10

The other form of fiscal incentive, which requires the further commitment of the government, is the direct participation of public company (state-owned enterprises) to geothermal development projects. There are principally two benefits on the participation of public company; one is the access to the concessional loan provided by the World Bank, the Inter American Development Bank, JICA, etc. As mentioned above, financial assistance at low interest rates bring relatively large effect. The other benefit is the accumulation and integration of knowledge and experience of geothermal development in the public company. Instead of relying on foreign companies for geothermal development, the creation of public entity, where knowledge and experience of geothermal development will be accumulated, can make it possible to develop geothermal resources increasingly in an economic and efficient manner.

Currently, in Peru there is no public entity which is able to implement geothermal resource development itself. However, if we assume that the state-owned generation company such as Electroperú can be the entity in charge of geothermal development, there may be two possible forms of participation;

(a) Joint development between private sector and Electroperú (Public Private Partnership)

Development through Public Private Partnership (PPP); Electroperú will be responsible for up-stream development (steam development) and the private sector will be responsible for down-stream development.

(b) Consistent development by Electroperú

Electroperú will be engaged in all the stages of geothermal development and power generation.

The participation of the public entity on geothermal development may reduce the resource risk of geothermal development. However, it is difficult to quantify such reduction. Instead, the effect of participation of public entity in geothermal development can be evaluated, assuming that such entity can access the concessional ODA loan. Table III-1.3.5 shows the impact on electricity selling price for two cases, (a) Electroperú develop geothermal resources, using the concessional loan (0.6% of interest, 10 years of grace period, 30 years of repayment period (40 years of loan period)) and the private company generates the electricity (a case of PPP), and (b) Electroperú is in charge of all the stages from resource development to power generation, using the concessional loan (a case of 'All Public'). The assumed project is the project in Field-A. Figure III-1.3.5 shows the effect of direct participation of public sector in geothermal development.

According to the results, in case of (a: PPP), the selling price is 9.9 US cent/kWh, which means decline of 0.7 US cent/kWh (6.5% reduction), compared to the case in which a private company is in charge of all the stages. In case of (b: All Public), the electricity price is 8.9 US cent/kWh, which means decline of 1.6 US cent/kWh (15.5% reduction), compared to the case in which a private company is in charge of all the stages. This is the effect of using low-interest financing.

Table III-1.3.5 Effect of the participation of the public company on geothermal development

Case	Steam Dev. Section		Power Plant Section		Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Incentive Cost (cents/kWh)
	Interest Rate (%)	Loan Period (yrs)	Interest Rate (%)	Loan Period (yrs)				
Base Case	4.5%	12	4.5%	12	3,940	10.5	-	-
PPP	0.6%	30	4.5%	12	3,870	9.9	▲ 0.7	0.42
All Public	0.6%	30	0.6%	30	3,790	8.9	▲ 1.6	0.95

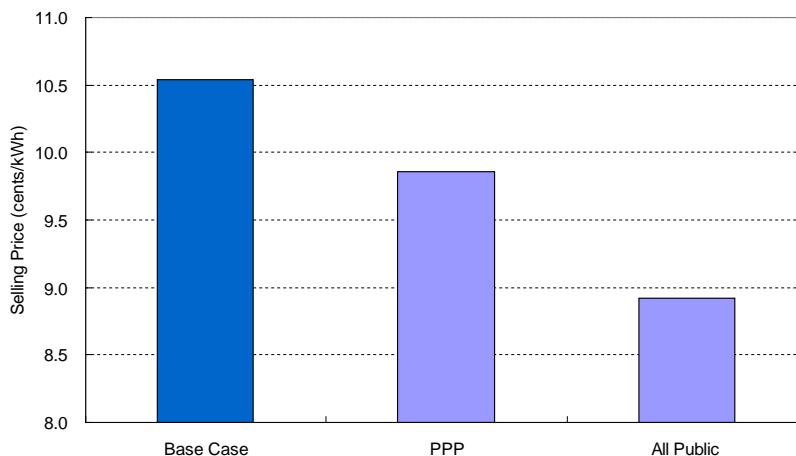


Fig. III-1.3.5 Effect of participation of the public company on geothermal development on electricity selling price

The good example of the PPP is Philippines’ case. In Philippines, in the late 1990s the public company PNOC-EDC developed steam and then let the private companies generate electricity. In this case, since there was no risk taken by the private sector in steam development, many companies participated on generation, thus the country has made a significant progress on its use of geothermal energy.

Finally, the effect of public participation on geothermal resource exploration (including drilling of deep exploratory wells) is evaluated. This measure not only provides the fiscal incentive, but also contributes a lot to reduce the resource risk for private companies. As shown in Fig. III-1.3.6, this measure reduces the risk for the private sectors, but also contributes on (i) reduction of the exploration (well drilling) cost and (ii) reduction of lead-time for development. Therefore, it is also effective in reduction of electricity selling price.

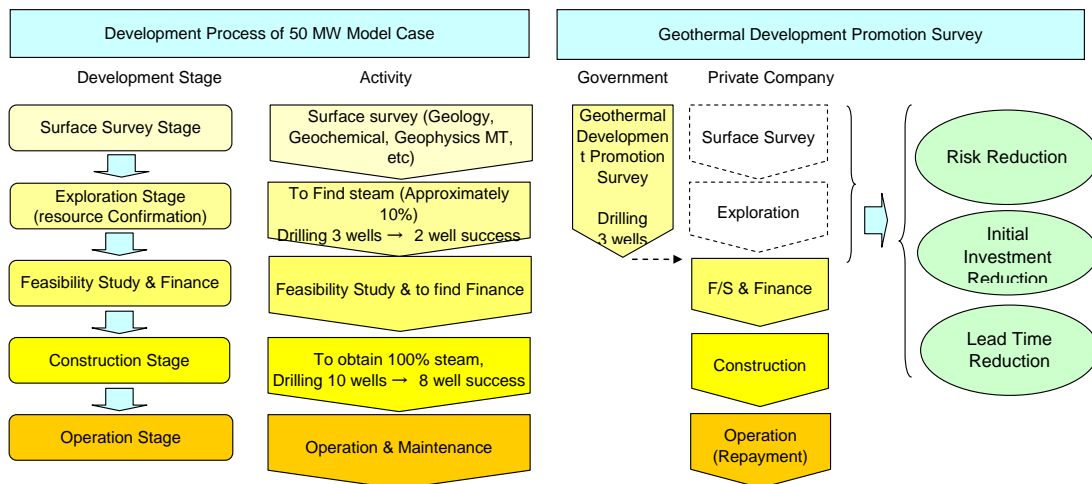


Fig. III-1.3.6 Effect of resource exploration by the government

The result of calculation of this effect in Field-A is shown in Table III-1.3.6. If the government conducts the exploration study and drills three exploratory wells, the electricity selling price becomes 9.7 US cent/kWh, which means decline of 0.8 US cent/kWh (7.8% reduction), compared to the case of development only by the private sector. The cost for this measure is small enough at 0.25 US cent/kWh, which is calculated by dividing the initial investment cost by the amount of power generated during 30 years.

Table III-1.3.6 Effect of execution of resource exploration by the government

Case	Initial Survey Support (%)	Const. Cost (\$/kW)	Selling Price (cents/kWh)	Effect (cents/kWh)	Incentive Cost (cents/kWh)
Base Case	0%	3,940	10.5	-	-
Gov't Survey	100%	3,770	9.7	▲ 0.8	0.25

- ◇ In case of geothermal development only by the private sector, it is recommended to provide them with the financial assistance through Two Step Loan to COFIDE, for example, utilizing the concessional loan. Additionally, tax incentives such as tax holiday can also work to promote geothermal development principally by the private sector.
- ◇ However, in many cases, the geothermal development only by the private sector is difficult. In such a case, it is recommended to evaluate, in early stage, the possibility of Public Private Partnership utilizing the ODA concessional loan for the portion of investment by the public company.
- ◇ It is desirable that the government conducts the resource exploration as a part of fiscal assistance. This contributes to reduce the resource risk, development cost and lead time for development for the private companies.

III-1.4 Environmental and Social Considerations Preservation for Geothermal Power development

III-1.4.1 Issues of organizational capacity and laws for enforcement of environmental and social considerations with respect to geothermal power development projects

(1) Implementation structure of Environmental Impact Assessment (EIA)

With no history of geothermal power development in Peru, the Directorate General of Energy Related Environmental Affairs (Dirección General de Asuntos Ambientales Energía: DGAAE), which is responsible for reviewing and approving EIAs for geothermal development, has no experience with EIAs for geothermal projects. In fact, nobody in the DGAAE has first-hand experience with EIAs in geothermal power generation projects. It is thus essential to educate and develop a human resource pool in the DGAAE that is qualified to evaluate and review EIAs for geothermal power generation projects.

(2) Environmental Impact Assessment system

Under the Peruvian Law of Electricity Concessions and Regulations (Law No. 25844), an EIA is required for power development projects with 20 MW or greater energy output capacity. In addition, though an EIA is required under the Law of Geothermal Resources (Law No. 26848) for the development of geothermal resources, the law provides no regulations or details. Since geothermal resource development precedes power plant planning, the situation urgently requires the preparation of guidelines for geothermal resource development, defining the scales of projects for which an EIA is required, full details of the scope to be covered in the EIA, and detailed process, contents and implementation methods for the EIA.

III-1.4.2 Issues for EIA of Geothermal Power Project

According to the past cases and experiences of problems in the process of EIA for hydropower development, the particular attention should be paid to the following in implementing the EIA for geothermal power development in Peru.

(1) Issues

- Most of the possible geothermal power development areas in Peru are located in a high mountain region with limited industry. The talk and implementation of such a project will generate high hopes with the local residents for increased job opportunities and improvements in their way of life.
- The project site is possibly located near a reserve or natural area with no human intervention. In such a case, the local residents and NGO groups may have concerns over impact on the natural environment.
- Since places of geothermal manifestation are often tourist attractions, the local residents and interested parties may have concerns over impact on tourism.

(2) Improvement Measures

- To disclose information to the local residents in each stage prior to, during and after the EIA survey, incorporate their requests, and present accurate and truthful information
- To prepare detailed documentation and give explanations to the local residents in terms that they can understand
- To prepare documents and make contacts with the local residents before beginning the field survey of the EIA to notify them in advance
- To check the contents of all documentation to ensure accuracy and no mistakes
- To build a good solid relationship with the local residents and win their trust

- ◆ To employ local residents
- ◆ To carry out the project to the final completion, and not to implement it for speculative purposes

III-1.4.3 Geothermal Development in the Regional Conservation Area Vilacota-Maure (ACRVM) of Tacna Province

In 2009 Vilacota-Maure Regional Conservation Area (ACRVM: Area de Conservación Regional Vilacota Maure) was established around the northern part of Tacna Province, in southern Peru, where promising geothermal fields are concentrated. Up to now, although some applications for geothermal resource exploration rights have been presented for those geothermal fields inside the ACRVM, SERNANP concludes that the exploration activities are not compatible in relation to those objectives of creation of ACRVM. However, if the adequate measures of environmental and social considerations are taken, it can be assumed that in some geothermal fields the development activities can be implemented without ignoring the objectives of ACRVM. In this section, the environmental impacts which may be caused by the geothermal development activities within ACRVM are evaluated based on the matrix of critical threats in ACRVM determined in the Master Plan of ACRVM (2009-2014) elaborated by the Regional Government of Tacna.

III-1.4.4 Environmental Improvement Effect of Geothermal Projects

The expected emission reduction of CO₂ which will be derived from the substitution of thermal power plant to geothermal power plants to be constructed in the selected promising 13 geothermal field (735 MW in total) is estimated. The result is that CO₂ emission will be reduced by 4,493,000 tCO₂ per year.

III-1.5 Suggestion on Multi-purpose Use of Geothermal Energy

III-1.5.1 Multi-purpose Use of Geothermal Energy

The use of the geothermal fluids been usually regarded useful to generate electricity only, however depending on the temperature of the resource at surface or after the process to generate electricity; geothermal fluids can be utilized in multiple ways. Figure III-1.5.1 lists the possible utilizations of geothermal fluids depending on its temperature.

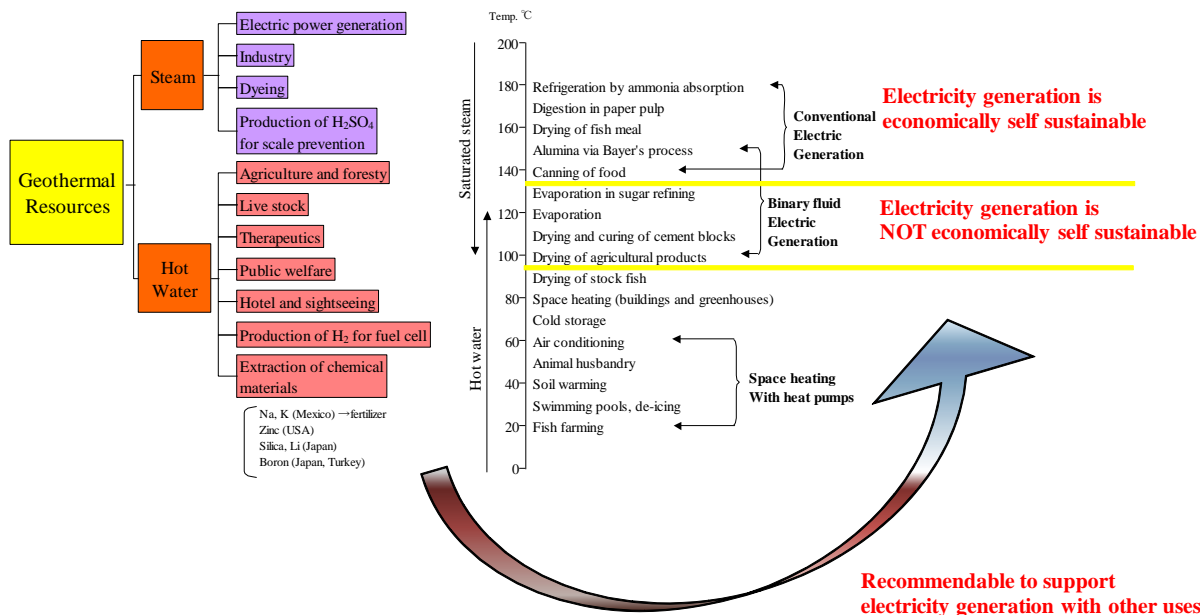


Fig. II-1.5.1 Application of geothermal resources depending on temperature

It is common sense that lower temperature geothermal resources are more widespread than high temperature geothermal resources. These resources can provide useful energy for heating buildings and spaces to be used in animal or plant farming or in industrial processes. Such heat can also be available as a by-product of geothermal power generation projects or as a by-product of other industrial process that starts using the geothermal resource at high temperature to subsequently utilize the heat in a cascade fashion (Fig. III-1.5.2).

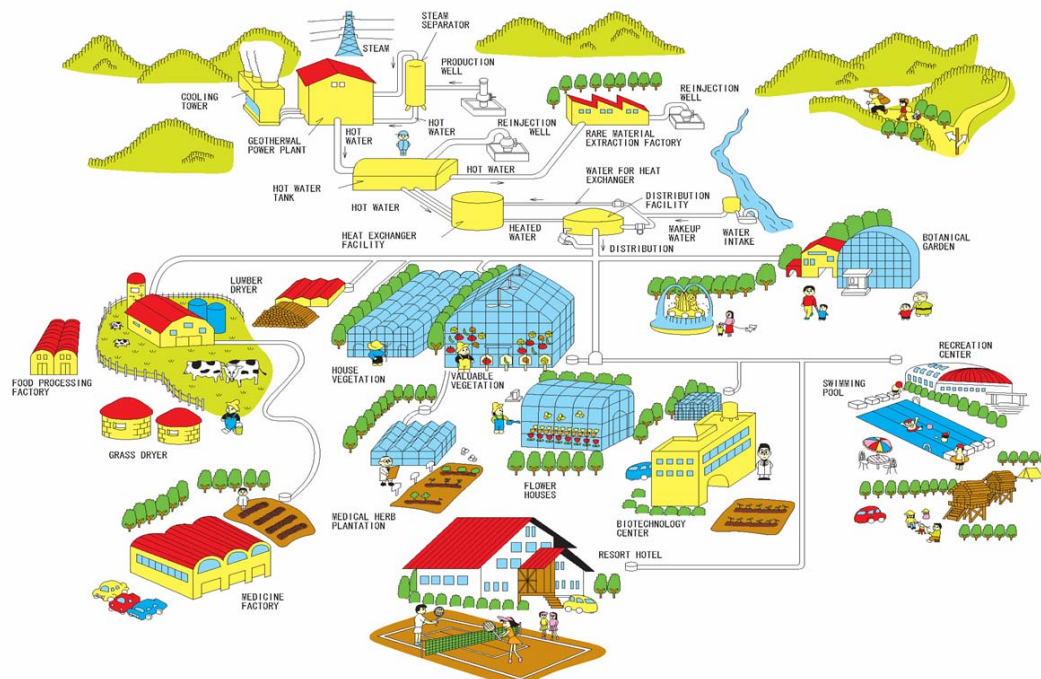


Fig. III-1.5.2 Schematic representation of a cascade utilization of geothermal resources

III-1.5.2 Kind of multiuse applications to the geothermal areas of Peru

The term geothermal heat direct use may differ from the applications that can be available for the case of Peru. In the case of Peru due to the location of most of the geothermal resources in very high lands of dry to very dry climate and where daily ambient temperatures varies from 20°C to -20°C the application would be more to the use of hot fluids in combination to other exploitation such as power generation. Therefore, of the applications listed above; space heating, agriculture, aquaculture, recreation, mineral recovering, would be appropriate.

What application will suit the most will depend on the type of current economic activity of the area, which in turn will depend on the uses of land the kind of existing industry, soil, type of animal farming and population. Nevertheless, once a pole of social-economic development is started other application can be implemented as the need of the region changes.

However in general terms the geothermal areas covered in this study had animal farming of South American camelids (Vicuña, Alpaca, Llama, and Guanaco) as a common element. These animals feed themselves of Brown grass, Alfalfa or Corn Silage which is a natural product. The Llama and Alpaca are only known domesticated South American camelids. The Guanaco and Vicuña are wild, the former being endangered. The vicuña lives in herds on the bleak and elevated parts of the mountain range bordering the region of perpetual snow, amidst rocks and precipices, occurring in various localities throughout Peru some of which are bestowed with geothermal resources. The fiber of their hair is extremely delicate and soft, and highly valued for the purposes of weaving, but the quantity which each animal produces is minimal. The most commercially valuable of the Camelids is the Alpaca.

Therefore a cascade type application can be designed to social and economic development of communities living nearby and around areas of geothermal development. In generic terms what geothermal energy can do from up-stream to down-stream for these poles of social development is summarized in Fig. III-1.5.3. Electricity from the geothermal resource can be applied for water pumping, food preservation, illumination and small industry that will enhance the human resource quality of the communities; will improve their health, the possibilities to education and the security of their towns. These elements will provide a human resource with capacity to utilize more efficiently their natural resources in plant and animal farming to produce raw materials for their industry or other processing industry and basically to produce food security for human and animal use. Then these raw materials in turn can be the supply for the communities own small-medium industry or be preserved (using heat from geothermal resources for refrigeration or heating) to be sent to external markets for procession. All this process ends up with income to the local community and improvement of their life standards.

In Peru, since most of the field is in very high and dry lands, water is an essential element. Soil tends to be good because of its volcanic origin which makes it full of nutrients to the vegetation that can co-exist under the climatic conditions and exposed to winds and solar radiation of the high Andes. Shall water be available a prosperous agriculture can be put in practice and specially that kind of agriculture that will feedback other industry such that of animal farming. Therefore, production of water that can be used for human and animal consumption as well as for irrigation is of high priority. Water from geothermal fluids after being utilized in power generation is of two types; one, is a brine resulting from the separation of steam from the geothermal fluids and the other is water resulting from the condensation of steam after passing through the power generation facilities. The brine and condensed water can deliver heat; brine before reinjection and water before treatment for animal/plant farming or human use. An example of a cycle to produce water for the case of power generation using binary power plants is presented in Fig. III-1.5.4. Water can also be produced for power facilities operating steam cycles (water collected in the cooling tower pool). Since in Peru there are many low temperature geothermal resources, for this small power project, binary cycle will be applicable.

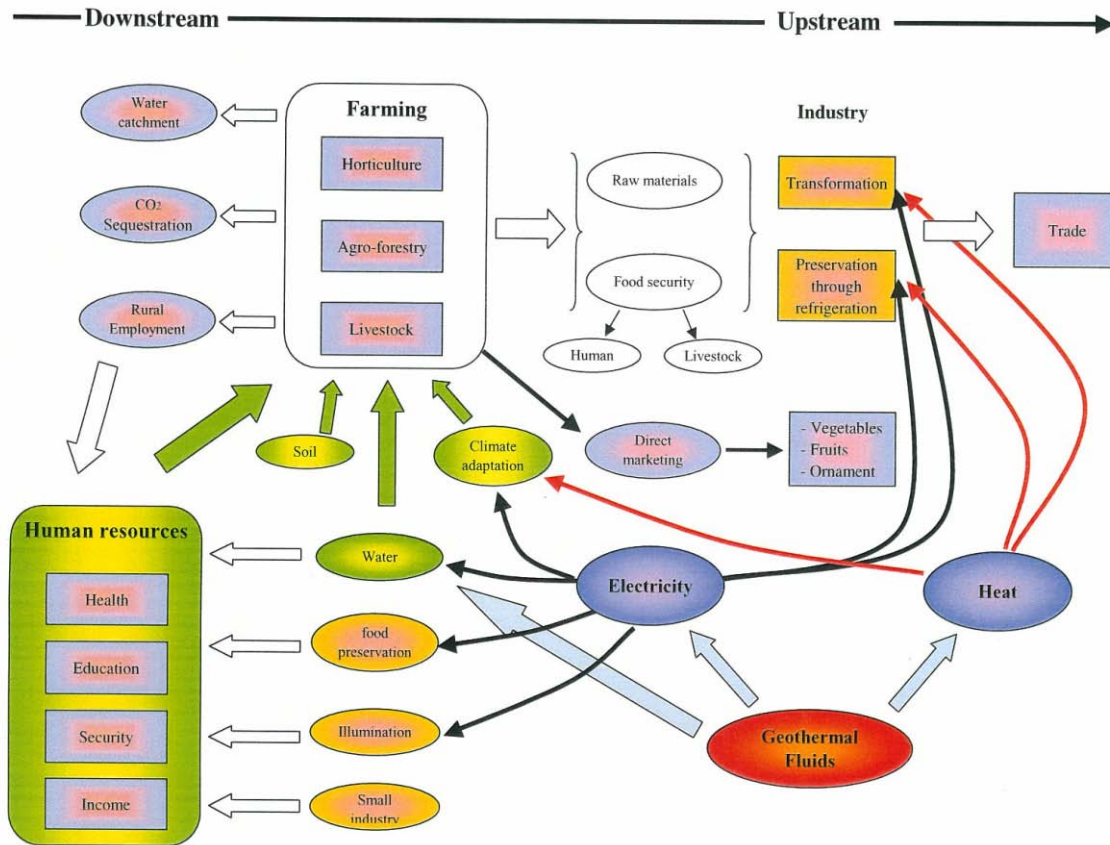


Fig. II-1.5.3 Hypothetical participation in the socio-economics of a region

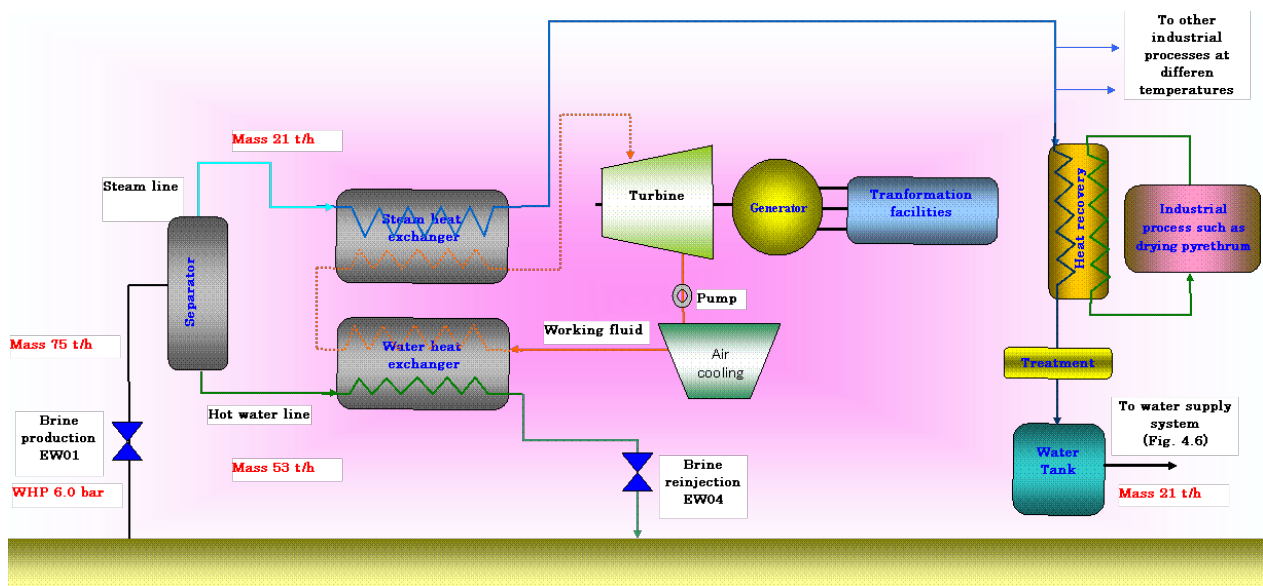


Fig. III-1.5.4 Utilization of water byproduct of a geothermal power application (binary case)

III-1.5.3 Suggested pilot project for multi-use applications of geothermal energy in Peru

(1) Objectives

This pilot project should serve the purpose of demonstrating:

- The feasibility of cascade utilization of geothermal resources
- Applicability in the promotion of socio-economic development

(2) Place

Ancocollo for a pilot project for an animal farming base socio-economic development

(3) Product to develop

As the product to develop, Alpaca is suggested. There is no existing extensive agriculture because the place is over 4300 m.a.s.l. and because there is deficiency in water supply. There are approximately 1800 heads of Alpaca and 400 Llamas. The livestock is 3 0% for self-consumption and 70% for trading. The price of one standing animal (Alpaca or Llama) varies according to the size and weight between S/.80 and S/.150; the price of meat varies between S/.5.00 and S/. 8.00, and that for wool fiber, the pound varies between S/.4.00 and S/. 6.00 (white wool) and between S/.2.00 and S/. 4.00 (colored wool). The livestock farming is extensive and practiced at family base. Only traditional technology is used with very limited technical assistance.

(4) Problems to solve

a) Poverty

There are two barriers to overcome to fight poverty; one is the middle man that takes the product at very low price and raises the price to the market. The way of eliminating the middle man is to provide the farmers with means for them to preprocess the wool of their animals to sell yarn (thread) or even final product such apparel. The main element of geothermal to help the solution is electricity form the power plant to operate the spinning machines and apparel factories.

b) Reduce mortality of new born or young animals

This problem is due to the low ambient temperatures that reduces the survival rate of young animals. The main element of geothermal to help the solution is heat from either the geothermal brine or steam condensate. Shelters shall be constructed and space conditioned for the animals to spend nights at milder temperatures.

c) Improve the quality of animal fibber

The quality and it is the price of the fiber depends on color and softness (silkeness). This in turn depends on the kind and quality of the nutrients in the pasture the animals eat. These again in turn depend on the quality and quantity soil and water. The main element of geothermal to help the solution is heat and water than can be provided form steam condensation and or heat extracted from geothermal brine prior reinjection. Salts and minerals can be extracted from brine to improve nutritional contents in pasture.

(5) Pilot project contents

- Geothermal power plant to provide electricity to the grid and to feed local the community; their illumination and electricity to power their wool procession shops.
- Treatment of steam condensate and pipeline network to space condition

- Treatment of steam condensate to improve nutrition contents
- Pipe network for water supply and for irrigation.

(6) Project organization and barriers to overcome

For the project to successful it requires the coordination of following several institution of the government.

- MEM and the DGE, currently in charge or planning and overseeing the execution of power generation. This institution shall be the center in promoting coordination with the respective public institutions for the proper legislation and enforcement of rule for the multi-utilization of geothermal resources.
- INGEMMET: TO be in charge of the creation and maintenance of the database for geothermal resources and technological assistance to developers of geothermal sites and of multi-utilization projects.
- MDA-ANA (Ministry of Agriculture - Autoriddad Nacional del Agua, ANA): in charge of the exploitation and disposal of the underground water resource. This institution shall establish the way water has to be exploited and utilized at surface prior to its disposal.
- MEM-DGAAE: In charge of the regulatory and enforcement of the dispositions to protect the environment impacted by power development activities.
- MINAM-SERNANP: In charge of the regulatory and enforcement of dispositions to protect the environment impacted by activities for the multi-utilization of geothermal resources.
- MINCENTUR (Ministry of External Trade and Tourism): In charge of promoting trading of local products and to promote tourism.
- MEF-Proinversion-Cofide: that shall take responsibility the promotion of future investments in the multi-utilization of geothermal resources
- Universities: To take charge of the preparation of necessary human resources to oversee and or execute geothermal projects and their multi-utilization.
- Geothermal Multi-sectorial Commission: To be in charge of assisting MEM-DGE in the coordination of all ministries and institutions.

⇒ Regarding the multi-use of geothermal energy, development of legal system for the geothermal resource development and exploitation regarding is required considering the combined use with power generation purpose. In addition, governmental support such as subsidy, preferential tax system, etc. for multi-use project is required. To validate the feasibility of the multi-use project, implementation of a government-led pilot project is recommended.

III-1.6 Action Plan for Geothermal Development

In this section, the study team proposes the action plan relating with all areas (legal framework, system/organization, supporting/assistance by the government and multipurpose use) for promoting geothermal developments in Peru, based on various recommendations described in the previous sections. The yearly schedule of the action plan is shown in Table III-1.6.1, and the action plan that are wanted to be executed by related organizations are shown in Table III-1.6.2.

In the yearly schedule shown in Table III-1.6.1, each action to be taken is classified into two groups, one of which is desired to be achieved in a short term, and the other is the actions to be continuously taken for medium or long term. As for the short-term objectives, first of all, the basic policy to promote geothermal developments should be clearly proclaimed. Secondly, proper management and appropriate

instructions should be given steadily for the geothermal exploration and exploitation activities carried out by private sector. The items relating with the management or direction of the development activities by private sector are enumerated in the short-term objectives. In addition, the necessary items to prepare for the governmental direct participation (for example by a state-owned enterprise) to geothermal power generation projects are also listed in the short-term objectives. It is assumed that the short-term objectives shall be achieved within three years, since the resource exploration activities in the fields of which exploration rights granted in 2011 will be basically completed in 2014 (exploration period of three years). The items such as actions to realize geothermal developments by state-owned enterprises, continuous capacity building for various organizations, additional resource potential study at unexplored area, are listed in the mid or long-term objectives.

Table III-1.6.1 Action plans for each areas and yearly schedule

	Short-term Target		Long-term Target							Note
	2012	2013	2014	2015	2016	2017	2018	2019	2020-	
Revision of targeted RE participation			▼					▼		present status: 5% of total energy demand
Tender for RE projects		▼		▼		▼		▼		every two years
Legal Framework										
- Enactment of policy	■									National Plan for RE etc.
- Revision of Geothermal Law (as necessary)	■	■	■	■	■	■	■	■	■	Management of development by private sector, etc.
- Revision of RE Law (as necessary)	■	■	■	■	■	■	■	■	■	
- Guideline for natural and social environmental considerations	■	■								
System/Organization										
- Capacity building to develop. management	■	■	■	■	■	■	■	■	■	DGE · INGEMMET
- Network for promoting geothermal	■	■	■	■	■	■	■	■	■	MEM Geothermal Committee
- Database updating system	■	■	■	■	■	■	■	■	■	
- Organization in state-owned utilities	■	■	■	■	■	■	■	■	■	Electroperú, etc.
- Capacity building of the public sector for their participation in geothermal			■	■	■	■	■	■	■	
Support from the Government										
- Development finance system (TSL, etc.)	■	■	■	■	■	■	■	■	■	COFIDE etc.
- Establishment of PPP scheme	■	■	■	■	■	■	■	■	■	Financing at low interest, etc.
- Exploration by the public sector	■	■	■	■	■	■	■	■	■	
- Upgrade knowledge of geo-potential	■	■	■	■	■	■	■	■	■	INGEMMET
Multi-purpose Heat Use										
- Management of hot water resources	■	■	■	■	■	■	■	■	■	
- Legal framework for multi-purpose use	■	■	■	■	■	■	■	■	■	
- Establishment of subsidy system	■	■	■	■	■	■	■	■	■	
- Public demonstration project	■	■	■	■	■	■	■	■	■	

Table III-1.6.2 Action plans for each organizations

	Legal Framework	System/Organization	Support by the Govt.	Multi-purpose Heat Use
MEM-DGE	- Proclamation of policy - Revision of Geothermal Law - Revision of RE Law - Guideline for natural and social environmental considerations	- Capacity building for develop. management - Network for promoting geothermal - Database updating system - Organization in state-owned enterprise	- Development finance system (TSL) - Establishment of PPP scheme - Exploration by public sector	- Management of hot water resources - Legal framework for multi-purpose use - Establishment of subsidy system - Pilot project by public sector
MEM-DGAAE	- Guideline for natural and social environmental considerations	- Capacity building for develop. management - Network for promoting geothermal - Database updating system		- Management of hot water resources (water pollution)
MEM-Multisectoral Geothermal Committee	- Proclamation of policy	- Network for promoting geothermal (as pivotal element of the network)	- Exploration by public sector - Continuous study in unexplored fields	- Management of hot water resources - Pilot project by public sector
MEM-INGEMMET		- Capacity building for development management - Network for promoting geothermal - Database updating system - Organization in state-owned enterprise - Capacity building of public sector for project participation	- Exploration by public sector - Continuing studies of unexplored fields	- Management of hot water resources - Pilot project by public sector
OSINERGIMIN	- Revision of RE Law	- Network for promoting geothermal	- Establishment of PPP scheme	
COES-SINAC		- Network for promoting geothermal		
University, etc.		- Network for promoting geothermal	- Continuous study in unexplored fields	- Pilot project by public sector
State-owned Companies (Electroperu, etc.)		- Network for promoting geothermal - Organization in state-owned enterprise - Capacity building of public sector for project participation	- Development finance system (TSL) - Establishment of PPP scheme - Exploration by public sector	- Pilot project by public sector
Ministry of Environment	- Guideline for natural and social environmental considerations	- Network for promoting geothermal		
Ministry of Agriculture, Ministry of Exterior Commercial Trade and Tourism		- Network for promoting geothermal		- Management of hot water resources
Ministry of Economy and Finance		- Network for promoting geothermal	- Development finance system (TSL) - Establishment of PPP scheme - Exploration by public sector	- Establishment of subsidy system

- MEM-DGE should formulate the “National Plan for Renewable Energy” as early as possible, and concrete objectives and policies of the government should be clearly stated in the national plan.
- The present legal framework comprised of the geothermal resource law and the law for promoting power generation projects by renewable energy, does not appear to contain fundamental problems. However, when problems come out in the application of the framework, or when delays frequently occur in developments by private sector, the legal system relating to management of the development by private sector and the direct participation of state-owned companies to geothermal development should be revised or updated.
- It is desirable that MEM-DGAAE raise their knowledge about geothermal-related environmental impacts through collaborative works with the Ministry of Environments, and formulate the guidelines for natural and social environmental considerations for geothermal development. Especially for the development in protected areas, care must be taken in formulating the guidelines so that it can enable the geothermal development supplemented with proper mitigation measures for

environmental impacts, considering that geothermal power generation is a low environmental load power source.

- MEM-DGE and INGEMMET should design to deepen their knowledge concerning the exploration/exploitation of geothermal resources, and to build their capacity so that they could properly manage and direct private firm's development activities.
- It is desirable to improve a network among governmental organizations in order to watch and monitor private firm's geothermal developments, and to cope with issues in promoting geothermal developments. It is necessary to intensify the system and administration of the geothermal committee, which is a suitable organization to have a role of the center of the network.
- An updating system should be established in MEM-DGE and INGEMMET, for a continuous utilization of the "Geothermal Development Database" developed in this Master Plan study.
- From mid/long-term viewpoint, it is desirable to establish a system for governmental organizations (ex. state-owned enterprises) to participate in geothermal power generation projects, and to continuously intensify the firm's ability.
- As a part of support scheme for private sector, it is desirable to establish a development finance system including the two step loans so that a private firm to be able to procure low-interest finances. Also, some kind of preferential tax systems should be considered.
- Early undertaking of establishment of a PPP scheme as a governmental project of geothermal power generation is necessary in order to cope with a possible situation where development by private sector does not grow as expected. In addition, a scheme centered on exploration drilling by a governmental organization should be established from mid/long-term point of view.
- A continuous study/exploration work aiming at clarifying the geothermal potential in an unexplored area is necessary for extracting new candidate fields for geothermal development. INGEMMET should be in charge of the exploration work as it used to be until the present. Expansion of the organization of INGEMMET and intensification of its ability is required.
- For promoting the multi-purpose use of geothermal energy, MEM should cooperate with the Ministry of Agriculture and the Ministry of Exterior Commercial and Tourism, the present competent authorities of resources and its utilization, in order to establish a legal system and a subsidy system for geothermal heat utilization businesses including simultaneous heat utilization with power generation. Following to the establishment, it is desirable to carry out a pilot project by governmental organizations, so that the project could be a model case of the application of the established legal/subsidy system.

III-2 Geothermal Development Database

III-2.1 Objectives of Construction of Database

The collection and analysis of the data related to the promising geothermal field in Peru was carried out in this study. The information are contained in the geothermal resource database which was newly constructed I the study. The geothermal development database is constructed based on the geothermal resource database by adding the other information about electric supply and demand balance, power grid, natural and social environmental issues, and so on. Thus, the database does not focus to the specific geothermal field to provide detail information of the field, but rather is comprehensive to provide the general information of geothermal development in Peru and basic information for each geothermal field in the country. The geothermal development database can be utilized to search and update the necessary information regarding the geothermal development in Peru. The database is expected to assist the acceleration of geothermal development in Peru.

III-2.2 Specification of Database

The database of the Peru Geothermal Master Plan has been created using the MS-Access relational database system. In a relational database different categories of data and information are stored in different tables that are linked by one-to-one and one-to-many relationships which allow for efficient and flexible data storage, with minimal duplication and considerable flexibility of data retrieval.

There is a pull-down to choose resource area from home screen. The information of the selected field can be browsed and edited from this screen. A sample screen is shown in Fig. III-2.2.1.

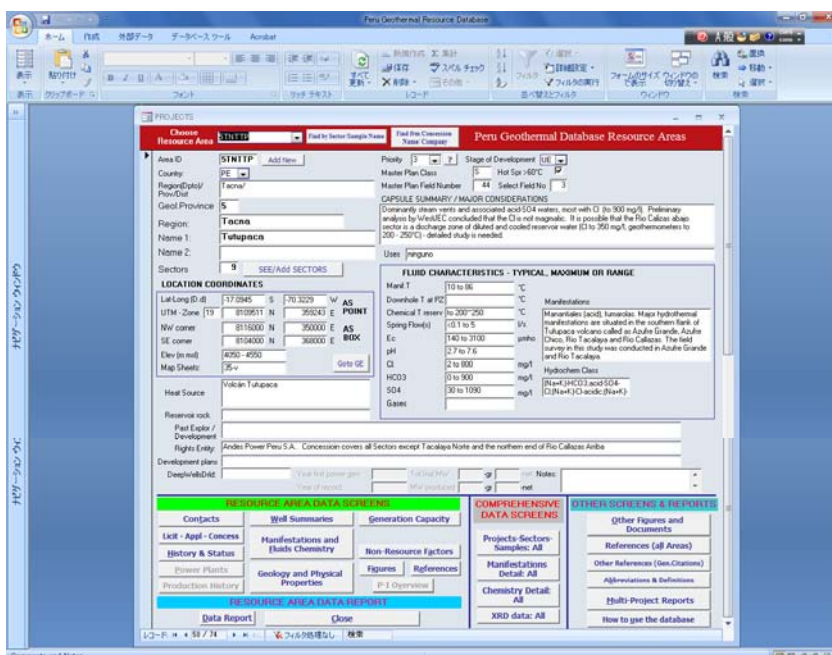


Fig. III-2.2.1 A sample of home screen for a selected field on the geothermal resource database

The geothermal manifestations in Peru were classified to 61 fields. In order to include information for isolated, scattered hot springs around the country that do not fall into one of the already recognized "fields", additional 12 groups, which combine with the 61 fields to make 73 different resource areas, was prepared. There is also one record for Peru country-wide information.

Most of the geothermal fields include numerous hot spring areas scattered over the countryside, so each field has been subdivided into a number of separate “Sectors”. Some of the 73 resource areas have only one sector (that is, there is only one hot spring area, be it small or very large). Some have more than 10

different sectors (that is, there are more than 10 different hot spring areas that may or may not be related one to another).

III-2.3 Data and information in database

The data and information which are contained in the database is shown in Table III-2.3.1. Regarding the whole Peru, the geothermal resource map, national grid system map, etc. are contained. Regarding the each geothermal field, data and information on geothermal resource, electric supply and demand balance, natural and social environmental issues, and other information are stored.

Table III-2.3.1 Data and information in database

Area	category	➤ Data and information
Whole Peru	Geothermal resource	➤ Geothermal resource map ➤ Coordinate of each field
	Electric sector	➤ National grid system map
	Natural and social	➤ Map of environmental protected area
	Others	➤ Geothermal Law
Each field	Geothermal resource	➤ Geological data ➤ Geochemical data ➤ Geothermal model ➤ Conditions and results of resource estimation
	Electric sector	➤ Development plan for power plant and transmission line ➤ Access to the main power grid
	Natural and social	➤ IEE results for promising fields, estimated GHG emission reduction, etc.
	Others	➤ Status of application

III-2.4 Management and Update of Database

It is necessary to adequately manage and update the database when new information become available or there is some changes of the data in the database. DGE would be in charge of the management of the database. INGEMMET is also expected to assist DGE in terms of geothermal resource information. It is preferable that related organization will coordinate on the management and update of the database for the purpose of effective utilization of the database.

III-3 Geothermal Development Plan

III-3.1 Evaluation Criteria for Prioritization of Geothermal Development

In establishing the development plan of geothermal energy in all over the Republic of Peru, evaluation criteria for prioritization of development in geothermal fields (61 fields) were investigated. For determining weights of each criterion, the highest emphasis was placed on the geothermal resource potential in each geothermal field. Relations with the protected areas at each geothermal field were also emphasized. Economic efficiencies of geothermal energy development were also taken into considerations for those areas where its geothermal resources were evaluated to be promising and detailed investigation had been done in the Master Plan study. The second highest emphasis was given to the current situation in acquiring the authorization for exploration, since the grant of authorization would greatly affect the possibility of early development of geothermal energy.

Each geothermal field was classified into Rank A, Rank B, Rank C and Others, based on the evaluation results of each evaluation criterion. The evaluation criteria and the rank categories are shown in Table III-3.1.1.

Table III-3.1.1 Rank Classification and Evaluation Criteria of Prioritization in Development

Rank	Description	Resource Potential	Authorization for Exploration	Topography and Access	Protected Areas
Rank A	Earliest development is expected. (The development would be done even without any support from the government)	High potential geothermal resource is expected.	Approved	No significant problem seems to exist.	There is no one nearby
Rank B	Following the Rank A (The authorization for exploration is to be waited for.)		Applied but not approved yet		There is no one nearby (to be confirmed)
Rank C	Relatively early development is expected, but the resource potential is to be confirmed.	High potential geothermal resource is possibly expected.	Approved	Detailed survey is necessary.	Not exist (to be confirmed for some fields)
Rank D-1	The resource potential is to be confirmed. (Based on the existing data, high potential resource can be expected.)		Not approved		
Rank D-2	The resource potential is to be confirmed. (Based on the existing data, the existence of high potential resource cannot be expected.)	Resource potential is not clear at present.			
Others	Environmental impact of possible geothermal project should be evaluated. If the impact can be avoided or mitigated sufficiently, the development should be permitted.	—	—	—	Exist a protected area highly regulated

- ◆ Geothermal Resource Potential: All geothermal fields were categorized in the following three levels according to the results of evaluations and surveys conducted so far.
 - Resource studies and explorations have been sufficiently conducted and the existence of high temperature resources is highly expected. (Rank-A, Rank-B)

- Resource studies and exploration results are not sufficient, but the results show relatively high possibility of the existence of high temperature geothermal resources. (Rank C, Rank D-1)
- Only few resource studies had been conducted and resource potential has not been clarified (Rank D-2)

For the classification of Rank D-1 and Rank D-2, resource data that are currently available (temperature and chemical composition of spring water) were investigated, and possibilities of geothermal resources exploitation were roughly evaluated for each field. The criteria in the evaluation were, 1) if temperature of hot spring exceed 80 °C, or, 2) if temperature of hot spring water exceed 50 °C and high geochemical temperatures were obtained (Na-K-Ca temperature exceeds 140 °C, K/Mg temperature exceeds 80 °C). The fields that met these two criteria were classified into Rank D-1, since relatively high possibility of geothermal resource can be expected.

- Authorization for Resource Exploration: Among the fields where the grant of authorization for resource exploration have been published by MEM (as of November 2011), the fields where high temperature resources could be highly expected were classified into Rank A. Other fields were classified in Rank C.
- Topography and Accessibility: The following two criteria were adopted.
 - The result of field survey showed no problems for electric power generation project. (Rank A, Rank B, Rank C)
 - Field survey has not been conducted yet, and the current situation has not been clarified. (Rank D-1, Rank D-2)
- Protected Areas: The fields in or close to some protected area will require detailed EIA studies. Thus such fields were excluded from the priority evaluation. The areas where the “limitations in indirect use” are applied (such as National Parks) were the examples of such strongly regulated regions. Also, the protected area in Tacna Region (Vilacota-Maure Regional Conservation Area) was excluded from the priority evaluation for the time being, since in July 2011 SERNANP have already concluded that the geothermal development in the area is unfavorable.

III-3.2 Prioritization of Geothermal Development

For the evaluation of priority for geothermal development, detailed evaluation based on the anticipated development plans have been applied to the promising fields that were selected in the Master Plan study. Simplified evaluations were applied to the other geothermal fields.

III-3.2.1 Development Plans for Promising Fields

In the Master Plan study, thirteen (13) geothermal fields were chosen as promising fields by investigating the existing resource data, considering the possibility of geothermal resources utilization and various conditions concerning energy developments. In the promising fields, resource studies including geological/geochemical surveys were conducted, and the possible development plans for the promising fields were devised based on the results of the resource studies.

The anticipated development scale and main specifications for the possible power development in the promising fields are summarized in Table III-3.2.1.

Table III-3.2.1 Main Specifications for the Possible Power Development in the Promising Fields

Field Name	Resource Potential P80 (MWe)	Possible Development Capacity (MWe)	Unit	Number of Production well	Number of Reinjection well
Chungara-Kallapuma	84.0	75	25MW x 3	19	9
Ancocollo	98.2	90	30MW x 3	18	9
Tutupaca	113.8	105	35MW x 3	15	9
Crucero	79.4	70	35MW x 2	13	7
Pinaya	36.8	35	35MW x 1	13	6
Calacoa-Putina	108.2	100	25MW x 4	25	13
Ulucan	27.4	25	25MW x 1	5	4
Jesus Maria	17.3	10	10MW x 1	7	3
Ccollo/Titire	39.7	35	35MW x 1	10	5
Cailloma	9.1	5	5MW x 1	5	2
Chivay - Pinchollo	162.9	150	25MW x 6	22	13
Puquio	34.3	30	30MW x 1	12	5
Chancos	15.3	5	5MW x 1	5	2
Total	826.4	735	-	-	-

In addition, the project costs of geothermal energy development in the promising fields and the electricity selling price (US cent/kWh) for maintaining FIRR to exceed 12% were examined.

III-3.2.2 Development Priority

The results of development priority evaluations for 61 geothermal fields including the promising fields are shown in Table III-3.2.2. In the table, various data/information including resource utilization possibility (hot water temperatures and its chemical compositions), estimated resource potentials, relations with protected area and grant of exploration rights are shown together with the results of the ranking.

Table III-3.2.2 Ranking of Development Priorities for 61 Geothermal Fields in Peru

Geothermal Region	No.	Region	Field Name	Elevation (m a.s.l.)	Hot Spring			Resource Potential (MWe)			No. of Sector	Possible Develop. Capacity (MWe)	Grid Connection			Authorization for Exploration (as of December 2011)			Development Rank	
					Hot spring Tmax (°C)	T Na/KCa-max (°C)	T K/Mg-max (°C)	CI max (ppm)	Promising Fields*	Other Fields			Total	Possible Substation	Distancse (km)	Protected area	Application	Authorized		Area Name in Application
Perú Norte	1	Tumbes	Tumbes	64	48	72	117	8,400		15	15	2		Tumbes S/S	11				D-2	
	2	Amazonas	El Almendral	449	45	72	107	565		10	10	2		Nueva Jaen S/S	33				D-2	
	3	Amazonas	Corontochaca	1583	28	39	56	183,000		7	7	5		Caclic S/S (2015)	36				D-2	
	4	San Martin	San Mateo	1048	41	87	44	2,450		14	14	3		Moyobamba Nueva S/S (2015)	36				D-2	
	5	San Martin	Picrohuasi	238	63	176	125	396,000		58	58	6		Tarapoto S/S	36	Area Conservation Regional / Parque Nacional b.z.			-	
	6	Loreto	Contamana	98	84	140	52	15,200		48	48	3		Pucallpa S/S	143	Zona Reservada (direct use)			D-1	
1. Cajamarca-La Libertad	7	Cajamarca	Quilcate	2087	63	218	161	1,240		70	70	7		Cerro Corona S/S	47				D-1	
	8	Cajamarca	Cajamarca	2696	71	71	77	101		29	29	2		Cajamarca S/S	8	Coto de Caza (direct use)			D-2	
	9	Cajamarca-La Libertad	Huaranchal	1941	74	221	123	220		54	54	5		Cajamarca S/S	43	Coto de Caza (direct use)			D-2	
	10	La Libertad	Cachicadan	2855	70	204	83	841		40	40	3		Alto Chikama S/S	22				D-1	
2. Callejón de Huaylas	11	Ancash-La Libertad	Tablachaca	2586	50	220	76	353		29	29	5		Sihuas S/S	29				D-2	
	12	Ancash	Huancarhuas	2487	89	224	159	1,840		89	89	10		Kirman Ayllu S/S	36		V	V	Rupha / Yungay / Huancarhuaz	C
	13	Ancash	Chancos	2943	72	231	143	1,670	15.3	21	36.3	4	5	Huaraz S/S	30		V		Chancos	D-1
	14	Ancash	Olleros	3388	41	146	110	432		29	29	4		Conococha S/S	25	Parque Nacional (indirect use)	V		Olleros Sur / Olleros Norte	-
	15	Huanuco-Ancash	Azulmina	3437	70	69	45	170		53	53	5		Conococha S/S	22					D-2
3. Churin	16	Lima	Conoc	2538	49	93	55	290		21	21	3		Cahua S/S	11					D-2
	17	Pasco	Huayllay	4220	50	-	-	21		10	10	1		Huanuco S/S	22					D-2
	18	Pasco	Tambochaca	3408	60	226	118	673		24	24	2		Uchuchacua S/S	8					D-1
	19	Lima	Oyon	3003	61	190	53	354		45	45	5		Paragsha 2 S/S	47					D-2
4. Central	20	Lima	San Jose	3500	73	189	102	772		25	25	2		Carhuamayo S/S	47					D-1
	21	Junin	Yauli	4100	41	206	108	623		7	7	1		Pomacocha S/S	11					D-2
	22	Huancavelica	Coris	2000	50	221	128	1,880		10	10	1		Cobriza I S/S	18					D-1
5. Eje Volcánico Sur	23	Huancavelica	Nonobamba	3754	44	235	128	1,880		15	15	3		Ingenio S/S	22		V		Ninobamba	D-2
	24	Cusco-Apurimac	Cconoc	2538	41	80	58	45,800		43	43.3	3		Abancay S/S	18	Santuario Historico b.z. (indirect use)				-
	25	Apurimac	Pincahuacho	3098	62	192	103	638		25	25	2		Cotaruse S/S	29					D-1
	26	Apurimac	Antabamba	3628	43	223	136	498		15	15	2		Cotaruse S/S	36					D-2
	27	Ayacucho	Puquio	4053	80	369	210	2,110	34.3	10	44.3	1	30	Cotaruse S/S	113		V	V	Geronta	A
	28	Ayacucho	Paila del Diablo	3814	81	169	119	1,400		54	54	4		Cotaruse S/S via Pararca and Cotahuasi	36		V	V	Umacusiri	C
	29	Ayacucho	Pararca	2775	60	202	127	1,020		31	31	3		Cotaruse S/S via Cotahuasi	72		V	V	Sara Sara / Rio Pararca	C
	30	Arequipa	Ocoruro	4475	85	-	-	-		23	23	1		Cotaruse S/S via Antabamba	61	Reserva Paisajistica (direct use)				D-1
	31	Arequipa	Cotahuasi	2856	56	174	89	209		65	65	7		T-branch between Cotaruse S/S & Pararca	65	Reserva Paisajistica (direct use)				D-1
	32	Arequipa	Orcopampa	4029	55	54	32	66		29	29	4		Cotaruse S/S via Ocoruro and Antabamba	33	Reserva Paisajistica b.z. (direct use)				D-2
	33	Arequipa	Cailloma	4278	58	148	87	1,280	9.1	26	35.1	3	5	Cailloma S/S	11		V	V	Turu	C
	34	Arequipa	Coropuna	2986	51	235	70	237		15	15	3		Chuquibamba S/S	8					D-2
	35	Arequipa	Chivay-Pinchollo	3776	93	208	132	2,740	162.9	136	298.9	10	150	Callalli S/S	70		V		Pinchollo / Achumani / Hualca Hualca	B
	36	Arequipa	La Calera	3943	35	186	56	734		9	9	2		Santuario S/S	8	Reserva Nacional (direct use)				D-2
	37	Arequipa	Yura	2504	33	183	38	340		15	15	4		Yura S/S	8					D-2
	38	Arequipa	Jesus	2655	37	209	50	1,330		7	7	2		Cerro Verde S/S	8					D-2
	39	Moquegua	Ubinas	3077	62	91	56	704		24	24	3		Socabaya S/S	43		V		Ubinas	D-2
	40	Moquegua	Ullucan	2734	80	243	145	7,260	27.4	0	27.4	1	25	Socabaya S/S	127		V		Huaynaputina	B
	41	Moquegua	Calacoa-Putina	3300	91	186	118	1,340	108.2	45	153.2	5	100	Moquegua S/S			V	V	Quellaapacheta / Tiscani	A
	42	Moquegua	Ccollo/Titire	4330	83	217	167	11,400	39.7	27	66.7	4	35		117		V		Ccollo / Titiri	B
43	Moquegua-Tacna	Crucero	4567	73	357	216	7,090	79.4	3	82.4	2	70				V	V	Crucero / Pasto	A	
44	Tacna	Tutupaca	4268	86	215	112	897	113.8	29	142.8	6	105		22		V	V	Tutupaca	A	
45	Tacna	Calientes	4341	90	219	195	3,340	100	0	100	1	100	Moquegua S/S via A S/S	30	Area Conservation Regional	V	rejected	Rio Carientes	-	
46	Tacna	Ancocollo	4216	87	219	206	2,380	98.2	55	153.2	5	90		22	Area Conservation Regional b.z.	V		Ancocollo / Ocururane	B	
47	Tacna	Borateras	4397	87	223	198	2,390	40	31	71	4	50		75	Area Conservation Regional	V	rejected	Borateras / Rio Maure	-	
48	Tacna	Chungara-Kallapuma	4349	85	210	170	2,950	84	17	101	4	75			Area Conservation Regional	V		Casiri / Achuco / Rio Kallapuma	-	
6. Cuzco-Puno	49	Cusco	Machu-Picchu	1924	52	211	129	2,260		49	49	6		Sururay S/S	22	Santuario Historico (indirect use)				-
	50	Cusco	Choquecancha	3010	88	220	124	1,340		43	43	3		Dolorespata S/S	36					D-1
	51	Cusco	Pacchanta-Marcapata	3529	64	192	105	565		40	40	3		Combapata S/S	54					D-1
	52	Cusco	La Raya	3754	52	189	109	4,090		26	26	5		Onocora S/S (2011)	29					D-1
	53	Puno	Ollachea	3313	70	191	113	576		45	45	3		San Rafael S/S	29					D-1
	54	Puno	Pasanocollo	3906	75	172	106	982		65	65	6		Puno S/S	36					D-1
	55	Puno	Hatun Phutina	3724	71	179	109	139		39	39	4		Puno S/S via Putina	50					D-1
	56	Puno	Putina	3986	55	188	79	13,200		53	53	6		Puno S/S	43					D-2
	57	Puno	Chaqueylla	4100	57	119	70	11,300		26	26	3		Tintaya S/S	54		V		Condorama	D-2
	58	Puno	Pinaya	4387	83	193	135	13,400	36.8	27	63.8	3	35	Callalli S/S	70		V	V	Pinaya / Chocopata	A
	59	Moquegua	Jesus Maria	3943	52	152	112	14,300	17.3	17	34.3	3	10	Puno S/S	67					D-1
	60	Moquegua	Exchage	3561	42	176	116	6,360		27	27	5		Socabaya S/S via Ubinas	22					D-2
	61	Puno	Collpa Apacheta	4013	54	153	61	48,600		13	13	2		Puno S/S	40					D-2

The priority evaluation results are summarized in Table III-3.2.3. It can be expected that total 640 MW power generation would be achieved in the fields categorized in relatively high priorities (Rank A and Rank B).

Table III-3.2.3 Result of Development Priority Evaluations

Rank for Priority	Description	Geothermal Field	Possible Power Output (MW)	Total Possible Power Output (MW)
Rank A	Earliest development is expected. (The development would be done even without any support from the government)	Tutupaca	105	340
		Crucero	70	
		Calacoa-Putina	100	
		Pinaya	35	
		Puquio	30	
Rank B	Follow in the Rank A (The authorization for exploration is to be waited for.)	Chivay-Pinchollo	150	300
		Ancocollo	90	
		Ccollo/Titire	35	
		Ulucan	25	
Rank C	Relatively early development is expected, but the resource potential is to be confirmed.	Cailloma	5	(60)
		Huancarhuas	(30)	
		Paila del Diablo	(15)	
		Pararca	(10)	
Rank D-1	The resource potential is to be confirmed. (Based on the existing data, high potential resource can be expected.)	17 fields (including Chancos and Jesus Maria)	—	Unknown
Rank D-2	The resource potential is to be confirmed. (Based on the existing data, the existence of high potential resource cannot be expected.)	24 fields	—	Unknown
Others	Environmental impact of possible geothermal project should be evaluated. If the impact can be avoided or mitigated sufficiently, the development should be permitted.	7 fields (including Borateras, Calientes and Chungara-Kallapuma)	—	>225

Note: Number of the evaluated geothermal fields is 61 in total.

- Rank A: Among the promising fields chosen, five (5) fields where the authorization of exploration right has been already granted are categorized in this class. Early power development can be expected in the fields since the granted private companies are obliged to accomplish their exploration activities within three years.
- Rank B: Four (4) fields where the authorization of exploration right has not been granted are categorized in this class. The fields are next to the Rank A fields, and relatively early developments of geothermal resources can be expected in these fields.
- Rank C: Four (4) fields where the project economy is relatively low, or the fields where relatively high resource potential is expected and the exploration right has been authorized, are categorized in this class. The development scale in the fields except the 13 promising fields is conservatively assumed as 30 % of the estimated resource potential. Although the authorization of exploration right has been granted in these fields, it is desirable to continue investigations for resource confirmation or project feasibility.

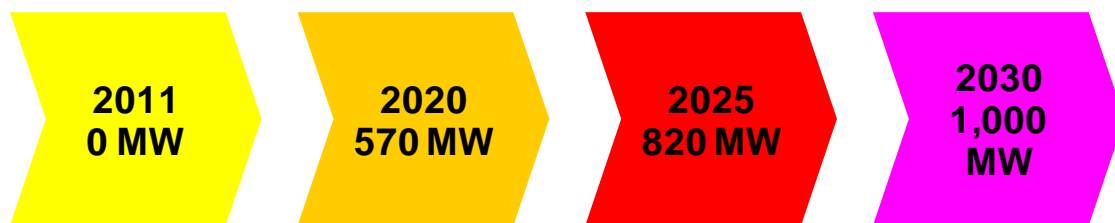
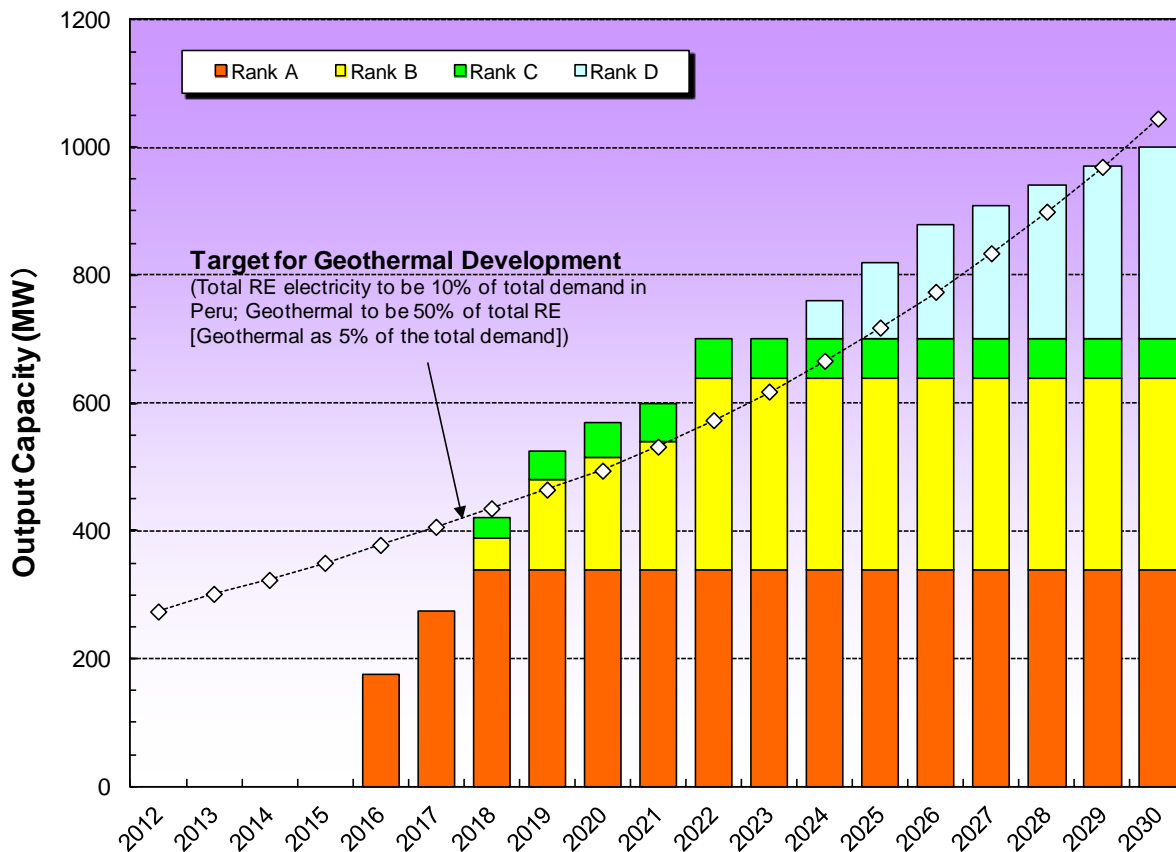
- Rank D-1: The fields where reconnaissance survey has been done are categorized in this class. Additional resource surveys are necessary. In these fields, geochemical data show relatively high prospectiveness. Higher emphasis in resource study should be placed on Rank D-1 fields.
- Rank D-2: The fields where only simple survey has been conducted are categorized in this class. Much more studies are necessary. The existing data obtained so far do not show high prospectiveness.
- Others: Four (4) fields are located in the vicinity of national parks or historical sanctuary. Also, there were three (3) fields that exist inside of regional protected area in Tacna Province (Vilacota-Maure Regional Conservation Area).

III-3.3 Road Map of Geothermal Power Development

An integrated plan for geothermal power development in Peru that aims to develop 1,000MW electricity by 2030 was devised in conformity with the objectives stated in the recommendations, considering the results of ranking of geothermal fields. The yearly progress of the integrated development plan (the Road Map) is shown in Table III-3.3.1 and Fig. III-3.3.1.

Table III-3.3.1 Intended Commencement Year of Power Generation in Geothermal Fields

Rank for Priority	Region	Field Name	Area Name for Application of Authorization	Authorization	Possible Power Output (MW)	Target Year
A	Tacna	Tutupaca	Tutupaca	V	105	2016
A	Moquegua-Tacna	Crucero	Crucero	V	70	2016
A	Moquegua	Calacoa-Putina	Quellaapacheta	V	100	2017
A	Puno	Pinaya	Pinaya	V	35	2018
A	Ayacucho	Puquio	Geronta	V	30	2018
B	Arequipa	Chivay-Pinchollo 1	Pinchollo / Achumani / Hualca Hualca		50	2018
B	Tacna	Ancocollo	Ancocollo / Ocururane		90	2019
B	Moquegua	Ccollo/Titire	Ccollo		35	2020
B	Moquegua	Ulucan	Huaynaputina		25	2021
B	Arequipa	Chivay-Pinchollo 2	Pinchollo / Achumani / Hualca Hualca		100	2022
C	Ancash	Huancarhuas	Rupha	V	30	2018
C	Ayacucho	Paila del Diablo	Umacusiri	V	15	2019
C	Ayacucho	Pararca	Sara Sara	V	10	2020
C	Arequipa	Cailloma	Turu	V	5	2021
D	-	unknown	-		300	2024-2030



Start of Authorization 5% of Total Demand

Development Rank A Fields: 340 MW

Development Rank B Fields: 300 MW

Development Rank C Fields: 60 MW

Development Rank D Fields: total 300 MW

Fig. III-3.3.1 Road Map of Geothermal Power Development in Peru

The intended commencement years of power generation in geothermal fields were so determined that the total output could catch up the 5% of total electricity demand as early as possible. It was assumed that the load factor of future power plants is equally 85%. The earliest commencement of power generation will be 2016 even for the Rank A fields where the authorization of exploration right has been already granted in 2011, since three more years will be required for exploration activities, and three more years will be necessary for plant construction activities. It is assumed that two more years

will be necessary for the commencements of Rank B fields, that is, the commencement of Rank B fields will be 2018. For Chivay-Pinchollo field where the development scale is bigger than others, the first period of development is assumed to be completed by 2018, and the second period of development is assumed to be finished 2022. For Rank C fields, the earliest period of commencement of power generation is assumed to be 2018, since more time will be required comparing with those of Rank A fields for investigation and confirmation of geothermal resources. The resource development in Rank D fields (Rank D-1 and D-2) largely depends on the progress of future studies and it is difficult to estimate the commencement period of power generation in Rank D fields. Thus the commencement period for Rank D fields is assumed to be not earlier than 2024.

The milestones in the intended development Road Map were set as follows: 570 MW in 2020, 820 MW in 2025, and 1,000 MW in 2030. For the realization of the objectives, proper managements and instructions must be given to the exploration activities practiced by private companies, and it is desirable for the government of Peru to support or to participate in the exploration activities when the exploration studies do not work effectively. In addition, the Road Map should be revised and updated if necessary according to the progress of the exploration/development activities.