# GENERATION MIX STRATEGIES
# USING OPTIMUM GEOTHERMAL UTILIZATION IN INDONESIA

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**SUMMARY** - In the last two decades, people have realized how dependent most communities are on energy; and most of this energy comes from oil, gas and coal, which means that we are reliant on fossil fuels. Promotion of sustainable energy development has become a public concern.

Therefore, Indonesia reaffirmed its commitment to Agenda 21, hence the development of sustainable energy policies for renewable energy development being established with its derivative regulations. Presidential Decree No.76/2000 for geothermal, Agenda 21 for energy sector, Law No.27/2003 for geothermal, Law No.30/2007 for energy and derivative regulations in the energy and electricity sector have been enacted as a legal basis in the framework of sustainable development.

Finally the Government of Indonesia enacted Regulation No.5/2006 in which it mentions that from 2010, the utilization of fossil energy should decrease to 5 % of the energy mix allocation, this is from 37% in 2006.

Indonesia is one of the most active volcanic regions with geothermal resources across the archipelago. The optimum utilization of geothermal energy however can be a significant solution in response to this request.

## 1. BACK GROUND

In the 1980s scientific evidence linking greenhouse gas emission from human activities with the risk of global climate change started to alert the public. Concerned Governments held a series of international conferences that echoed this concern by issuing urgent calls for a global treaty to address the problem.

The United Nations General Assembly responded in 1990 by establishing the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC). The INC drafted the Convention and adopted it on 9 May 1992 at United Nations Headquarters in New York. The Convention was signed in June 1992 at the Rio de Janeiro Earth Summit and adopted the United Nations Framework Convention on Climate Change (UNFCCC) which was signed by heads of state and other senior representatives and was put into force by 21 March 1994.

Agenda 21 is a comprehensive plan of action to be observed globally, nationally and locally by organizations of the United Nations, Governments, and major groups in every area in which human behaviour impacts on the environment.

The Kyoto Protocol adopted under the UNFCCC in December 1997, commits industrialized country signatories (called “Annex I” countries) to reduce their greenhouse gas emissions by an average of 5.2 percent compared with 1990 emission, in the period of 2008 – 2012.

At the United Nations Millennium Summit in September 2000 adopted the Millennium Declarations Goals (MDGs), in 2003 government leaders, heads of industry, civil society and

representatives of United Nations organizations met in Johannesburg at the World Summit for Sustainable Development (WSSD).

Energy is central to achieving sustainable development goals. The challenge its in finding ways to reconcile this necessity and demand for energy with its impact on the natural resources base in order to ensure that sustainable development goals are realized. The energy demand in Indonesia has grown significantly since the 1980s. However, prior to 1980s the energy generation mix was dominated by fossil fuel plants which were 77% of the total. Diversification strategies were initiated, and big coal fired plants, big hydro, and Kamojang geothermal plant (30 MW) construction followed, in 1990s this continued with big coal and natural gas fired, geothermal and IPP's non oil fired construction. And again in 2000s, coal, natural gas LNG fuels, IPP's non oil and conversion generating plants oil to gas fired construction program continued. During 2005 the utilization of oil fired increased to 30% due to the high growth of electricity demand after the economic crisis.

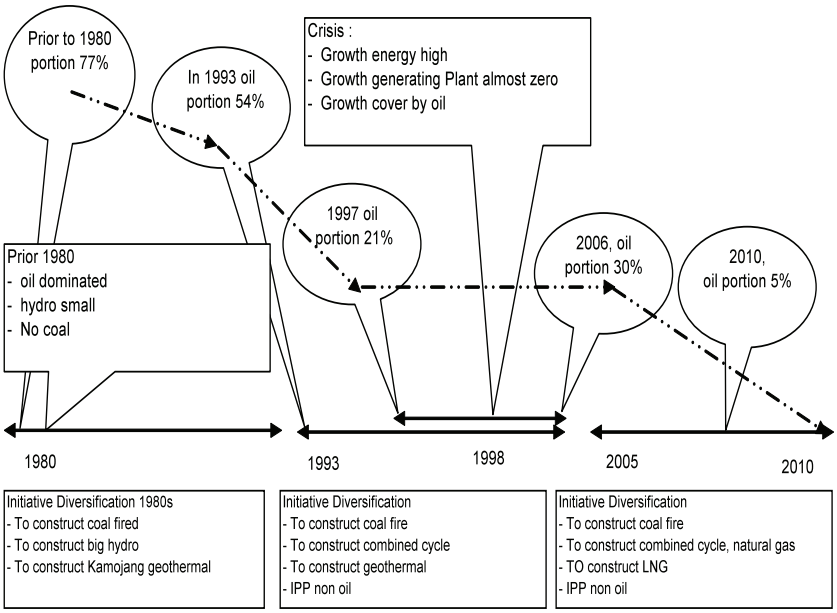


Figure 1, Process Energy Diversification

Due to the soaring oil prices and applying diversification and conservation policy, the Government of Indonesia (GoI) enacted finally, Government Regulation PP No.5/2006 which is known as the Energy Mix Policy, which defines that utilization of oil fuel in electricity plants should be decreased to 5% in the year of 2010.

## 2. OVERVIEW OF POWER SECTOR INDONESIA

Since the Second World War the ownership and control of the power sector in Indonesia had been in government hands. The state owned electricity company PLN was established in 1950 following the requisition by Government of Indonesia and merging of number of independent power companies that had operated under the colonial administration.

In 1994, PLN was reorganized into a public corporation (PT Persero) and in 1995; its two-generation operations in Java–Bali System were set up under subsidiary companies. Today, PLN remains a vertically integrated state owned monopoly responsible for all transmission, distribution and for about 70% of generation (excluding captive power and Independence Power Procedure / IPP) in Indonesia as stated in the Law No.15/1985, while electricity reform consisting multi buyers/multi sellers arrangement which was stated in the Law No. 20/2002 had been annulled by Constitution Council since December 2004.

**EVOLUTION SCEME OF ELECTRICITY SYSTEM**

**INTEGRATED (LAW No. 15/1985)**

| | | | |
|---|---|---|---|
| Indonesia Power | Java – Bali Generation Company | Outsi de Java | IPPs |
| Java – Bali Transmission and Load Dispatch Centre | North Sumatera | South Sumatera | |
| PLN Java Distribution, PLN Regions, Indonesia Power, JBEC | Captive and Utility IPPs | | |

**MULTI BUYESR MULTI SELLERS LAW**

| | | |
|---|---|---|
| Privatized Ex – Indonesia Power | Rationalized IPPs | New IPPs |
| Java – Bali Transmission and Load Dispatch Centre | | |
| PLN Java Distributions, PLN Bali Region, Indonesia Power, JBEC | | Captive Power and Utility IPPs |

Figure 2, Power Sector Framework

| | |
|---|---|
| Installed Capacity | |
| Total PLN | 24, 846 MW |
| IPP | 3,900 MW |
| Captive | 7,707 kVA |
| Generation Mix PLN | |
| Coal Fired Plant | 8,220 MW (33 %) |
| Gas Fired Combined Cycle | 7,021 MW (28 %) |
| Hydropower | 3,529 MW (14 %) |
| Diesel | 2,941 MW (12 %) |
| Gas Turbine | 2,727 MW (11 %) |
| Geothermal | 395 MW (2 %) |
| | |
| Energy Production PLN | 104,468 GWh |
| Energy Purchases | 28, 689 GWh |
| Energy Sales | 112, 609 GWh |
| Coal | 38,362 GWh (37%) |
| Natural gas | 15,843 GWh (15%) |
| Hydro | 8,759 GWh (8%) |
| Diesel | 38,363 GWh (37%) |
| Geothermal | 3,141 GWh (3%) |
| Customers | 35,751,224 |
| Energy | 11.45 % |
| Losses | 58.78 % |
| Electrification Ratio | |

Table 1, Key Indonesian Power Statistic 2006

At the end of 2006 PLN and its subsidizers owned and operated 5,037 generating units with a total installed capacity of 24,846 MW of which 74 % has on Java. Of the total 8,220 MW (33%) of steam turbine 7,021 MW (28%) combined cycle, diesel 2,941 MW (12%) hydro 3,529 MW (14%) 2,727 MW (11%) of gas turbines and 395 MW (2 %) geothermal.

The total energy production (including purchase from utilities outside PLN) during 2006 was 139,108,39 GWh, an increase of 2,55% GWh or 10% over the previous year of this energy production, the energy purchased from other utilities outside PLN amounted to 28,634 GWh (22 %) this was increased by 2,552 GWh or 10 % over the previous year.

Losses decreased 0.09 % from 11.54 % in 2005 to 11.45 % in 2006.

The total number of employers 43,048 at the end 2006, with its productivity of 2,636 MWh and 890 customer per employee.

From that total energy purchased, the greater part were 9,116 GWh (37 %) from PT Paiton Energy Co. and 9,109 GWh (36.7 %) from PT Jawa Power in East Java.

At the end of 2006, the total of transmission lines was 32,917 kmc, increased by 6.4% over the previous year, of which 4,619 kmc was 500 kV, 23,228 kmc was 150 kV, 4,619 kmc was 70 kV and 12 kmc was 25 kV and 30 kV circuit level.

While the total length of distribution lines amounted to 573,049 kmc, also increased by 12% compared with the previous year of which about 246,775 kmc was medium voltage lines (20 kV, 12 kV, 6-7 kV distribution networks) and 326,274 kmc was low voltage lines (220/380 V).

Total capacity of substation transformers operated was 54,527 MVA up to 0.02 % compared to the previous year. Total substation transformer was 1,101 units, consisting of 32 substitution transformers with 500 kV, 4 substation transformers with 275 kV system, 828 substation transformers with 150 kV systems, and 225 substation transformers with 70 kV system and 12 substation transformers with < 30 kV systems.

Indonesia as country, which is made up more than 17,000 islands of varying sizes, the stretch the length of the seas between its islands, the distribution of population and the pattern of load growth, means that an interconnection system is technically, and economically not viable solution for the time being.

The electricity system has been interconnected for Java Island through 500 kV, while for Java, Bali and Madura islands through 150 kV by using of submarine cables.

## 3. LEGAL FRAME WORK

The regulatory framework for the electricity sector established in 1985 when the Electricity Law (UU No.15/1985) was enacted as a basis legal instrument in this country.

Furthermore it has been followed by government regulations, presidential decrees and ministerial decrees which have been set as a operational legal instrument in the electricity sector business and its supporting industry.

Key components of the framework applicable to these industries are described briefly below:

- Electricity Law UU No. 15/1985: The law sets out the objectives of power sector development and covers such matters as national electricity planning, responsibility for supply, distribution and use of electricity, energy sources for electricity generation, authorizations for electricity undertakings, and remedies for violations.
- Regulation: PP No.10/1989: covers the supply and use of electricity and sets out the requirements for power supply including the submission of business plans, proxy for power affairs, issue of licenses for electricity business and the standards to be met in power installations.
- Presidential Decree: Keppres No.37/1992: opened the way for private sector investment in power supply including the submission of business plans, proxy for power affairs, issue of license for electricity business and the standards to be met in power installations.
- Ministerial Decree: Kepmen No.2.P/03/MPE/1993 and No.4.P/03/MPE/1995: that provide a comprehensive framework to guide reform and restructuring of the power sector, including provision for dealing with solicited and unsolicited projects.
- Regulation: PP No.23/1994: under this regulation the status of PLN was changed from a public (Perum) to a limited liability corporation (Persero)
- Presidential Decree: Keppres No.139/1998 provided for the establishment of a committee to oversee the restructuring of PLN to improve its operational efficiency and financial position, and to renegotiate the existing PPAs.
- Presidential Decree: Keppres No.76/2000: provided that geothermal development not in the Pertamina authority anymore
- Geothermal Law No. 27/2003: distinct autonomous issue being adopted in geothermal development.
- Regulation: PP No.3/2005 enacted as a amendment of the Regulation No.10/1989, that provide a comprehensive electricity planning and its supply, energy sources for electricity generation with accommodate district autonomous issues which is stated in Law No.32/2004
- Ministerial Decree: Kepmen No.001/2006 covers the procedure of energy sales and/or transmission rental for public utilities.
- Ministerial Decree: Kepmen No.002/2006 provides generating plant utilities arrangement for renewable energy resources in medium scale (1-10 MW) including pricing index price to PLN as authority holding for public electricity
- Regulation PP No.5/2006: provides that in the year 2010 energy mix have to only cover 5% of oil generating plant.
- Regulation: PP No.57/2007 cover the tendering process for obtaining geothermal license from local district authority
- Energy Law No.30/2007: provision and utilization renewable energy should be increased and apply government incentives.

The framework for Independence Power Producer (IPP) development of geothermal projects in Indonesia has different from the development framework for other IPP Projects.
Geothermal development is authorized under Presidential Decree No.22/1981 as amended by Presidential Decree No.45/1991 contemplates two different processes:

(i) Either: PERTAMINA (National Oil Company) and its partners can develop and operate just the steam field, and sell the steam to PLN or other parties for electricity generations.
(ii) Or PERTAMINA on its partners can develop and operate the steam field and generate electricity as well. The electricity can be sold directly to consumers or to PLN.

By these decrees, 11 Energy Sales Contracts (ESC) has been signed by Pertamina/Investors with PLN.

However by 2000, this decree had amended by Presidential Decree No.76/2000 which templates that PERTAMINA has no more exclusive authority in geothermal business.

More over by 2003, the Law No.27/2003 of geothermal energy has been enacted, again the district autonomous issues being adopted in this geothermal law, however it should be noted that so far there is no ESC being established since than. And finally The Regulation No. 57/2007 provides the tendering process for mining right in geothermal development.

To ensure that the sustainable energy policy can be implemented most effectively and efficiently, which related to economic competitiveness and open market as well as environmental issues, GoI commitment towards renewable energy utilization has been built in its regulation as describes bellows:

- Law No.15/1985: Section III, article 4 (2);
  "The policy of primary energy supply and its utilization is designed by government base on security, equality principle, and environmental sustainability"
- Regulation No.3/2005: Section II, article (a);
  The procedure of purchase of electricity can be conducted by direct appointment if electricity supply from renewable energy, natural gas in marginal field, coal mine mouth, and local energy resources."
- Ministerial Decree No.002/2006 describing generating industry using renewable energy with special incentives.
- Presidential Decree No.76/2000 and Law No.27/2003 have been enacted to spur development a geothermal energy. Regulation PP No.5/2006 enacted that the portion of diesel generating plant should decrease to 5% only in the frame of energy mix policy.
- Energy Law UU No.30/2007: utilization of renewable energy should increase and apply incentives

## 4. ENERGY POTENTIAL

The primary energy resources of Indonesia to consist of (1) oil with its potential of 86.9 billions, 9 billion barrels of proven deposit and 500 billion barrels production per annum (2) natural gas with its potential of 385 TSCF, 88 TSCF of proven deposit and 3 TSCF production per annum (3) hydro with its potential of 75,670 MW and 4,200 MW installed capacity (4) geothermal with its potential of 27,273 MW and 947.9 MW installed capacity.

| Resources | Potential Resources | Proven Deposit | Production | Ratio (Reserve /Production) |
|---|---|---|---|---|
| Oil | 86.9 billion barrels | 9 billion barrels | 500 million barrels | 23 year |
| Natural gas | 385 TSCF | 188 TSCF | 3 TSRF | 62 year |
| Coal | 57 billions tond | 19.3 billion tons | 130 billion tons | 147 year |
| Hydro | 75,670 MW | - | 4,200 MW Installed | |
| Geothermal | 27,000 MW | 2,300 MW | 947.9 MW Installed | |
| Minihydro | 500 MW | 206 MW | | |
| Biomass | 49.81 MW | 445 MW | | |
| Solar | 4.8 KWh/M²/day | 10 MW | | |
| Wind | 3.6 M/sec | 0.6 MW | | |

Table 2, Resources Potential of Primary Energy

Besides, for renewable energy potential, the minihydro of 500 MW capacities is also identified spread out along the archipelago. There is large difference of wind energy potential from site to site, like most tropical countries, the average wind speed in Indonesia is relatively low compared to areas where wind power project are commercially viable, the viability of wind power project starts in the wind speed range of 5 to 6 m/5 at 10 m high.

There is no large difference of solar mediation site to site in Indonesia. The average value of solar radiation is 4.8 kWh/m².d avg. The area most sustainable for the application of PV in Indonesia is in Nusa Tenggara, eastern part of Indonesia.

Indonesia located at the eastern side of the Mediterranean Belt and western side of the Pacific Belt, this fact makes this archipelagos is one of the most tectonically active region as the belt contains many of the world's largest and hottest geothermal resources. Regional study put its potential around 27,273 MW, using a conservative methods estimation.

Geothermal resources are continuous sources of energy, regardless of climatic or weather conditions, this fact makes geothermal energy especially attractive as a source for base load electricity generation or direct use applications that need consistent heat. Geothermal energy is an alternative energy, renewable, clean and environmental benign, non exportable resources with specific advantages such as long term operating, low operation and maintenance costs.

## 5. LOAD FORE-CAST

Soaring oil prices and shortage of domestic natural gas supply recently make such difficulties in establishing general planning electricity input criteria, however the fore-cast suggest its growth being of 9% and peak load of 6-7% annually.
While the target of total generation plants would be 36,222 MW installed capacity including 26,086 MW of Java-Bali System and 10,136 MW of Outer-Java-Bali systems. The portion of oil base generation plants should be decreasing to 5%. Interconnection System Sumatra by 2009, Java-Sumatra (through sub-marine cable) by 2010, and Kalimantan South-Central-East by 2008, reducing isolated system by transferring several load centers to transmission grid. Increasing ratio electrification to 70% from 58.78 (in 2006) with total consumers of 44 millions.

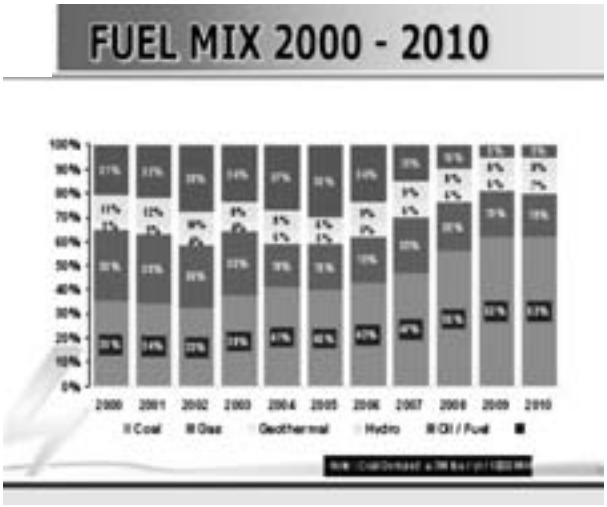


Figure 3. Fuel Mix 2000-2010

Diversification action program is stipulated in general planning PLN 2006-2015 to consist of the following programs:

- Construction of new geothermal plants with total installation of 400 MW
- Repowering Muara Karang (Jakarta) coal fired 3 x 100 MW to combined cycle 740 MW, extension Priok (Jakarta) 740 MW, construction Muara Tawar block -5 (West Java) 225 MW
- Construction of Bojanegara (West Java) combined cycle of LNG 5 x 740 MW
- Construction of pump storage upper Cisokan (Wet Java) of 4 x 250 MW
- Construction of coal fired big scale in Java-Bali System and medium / small scale Outside-Java-Bali.

## 6. OPTIMUM GEOTHERMAL UTILIZATION

Regional study of a geothermal potential using conservative formula put the potential 27,237 MW, which to consist of resources potential 14,409 MW (speculative 9,655 MW and hypotetive 4,574 MW), and reserves potential 12,828 MW (probable 9,800 MW, possible 728 MW, and proven 2,300 MW).

| Island | Resources | | Reserve | | |
|---|---|---|---|---|---|
| | Speculative | Hypotetive | Probable | Possible | Proven |
| Sumatra | 5,730 | 24,333 | 5,419 | 15 | 499 |
| Java | 2,325 | 1,641 | 2,850 | 603 | 1,722 |
| Bali | 75 | - | 226 | - | - |
| Nusa Tenggara | 150 | 438 | 226 | - | 14 |
| Sulawesi | 1,000 | 125 | 531 | - | 65 |
| Maluku | 275 | 117 | 632 | 110 | - |
| Papua | 50 | - | - | - | - |
| Kalimantan | 50 | - | - | - | - |
| | 9,655 | 4,754 | 9,800 | 728 | 2,300 |

Table 3.,Geothermal Potential and its Classification

Figure 4, Distribution Map 2,000 MW

Recent target of geothermal utilization puts 2000 MW in 2010, 3,442 MW in 2012, 4,600 MW in 2016, 6,000 MW in 2020 and 9,500 MW in 2025's planning horizon which called Road Map of Geothermal Development in Indonesia, while installed capacity just recently is 947.9 MW.

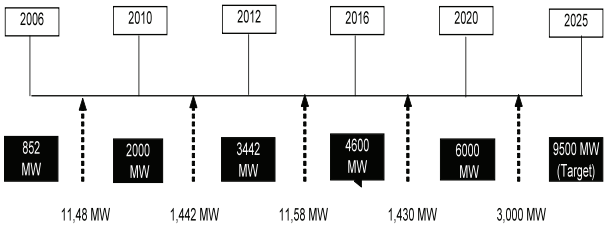


Figure 5, Geothermal Road Map

An optimum utilization for geothermal development requires maximizing the power output for a given geothermal fluid flow rate, while ensuring that the plant capital cost, and operating and maintenance costs are minimized. It also requires sufficient flexibility to permit efficient operation if reservoir condition change overtime. The precise characteristics of a geothermal resource can not be determined from ground surface prior to drilling and flow testing. To control the investment risk, geothermal development project are typically undertaken in process. As each successive phase is completed, the investment requirements for continued project development increase, while knowledge of the resources increases and risk decreases. Risks can never be eliminated, but phasing helps reduce them progressively to acceptable levels.

| Plant Location | Installed Capacity (MW) | Turbine/ Generator | Commencement Date | Power Plant Operator | Steam Filed Operator |
|---|---|---|---|---|---|
| **AWIBENGKOK** | | | | | |
| **SALAK** | | | | | |
| 1 | 61 (uprating from 55 in 2006 | ANSALDO | 1994 | PLN | CHEVRON/PERTAMINA |
| 2 | 61 (uprating from 55 in 2006 | ANSALDO | 1994 | PLN | CHEVRON/PERTAMINA |
| 3 | 61 (uprating from 55 in 2006 | ANSALDO | 1997 | PLN | CHEVRON/PERTAMINA |
| 4 | 66,7 (uprating from 55 in 2006 | FUJI | 1997 | CHEVRON/PERTAMINA | CHEVRON/PERTAMINA |
| 5 | 66,7 (uprating from 55 in 2006 | FUJI | 1997 | CHEVRON/PERTAMINA | CHEVRON/PERTAMINA |
| 6 | 66,7 (uprating from 55 in 2006 | FUJI | 1997 | CHEVRON/PERTAMINA | CHEVRON/PERTAMINA |
| **KAMOJANG** | | | | | |
| 1 | 30 | MITSUBISHI | 1982 | PLN | PERTAMINA |
| 2 | 55 | MITSUBISHI | 1987 | PLN | PERTAMINA |
| 3 | 55 | MITSUBISHI | 1987 | PLN | PERTAMINA |
| **DARAJAT** | | | | | |
| 1 | 55 | MITSUBISHI/ FUJI | 1994 | PLN | CHEVRON/PERTAMINA |
| 2 | 81.3 | MITSUBISHI | 2001 | CHEVRON/PERTAMINA | CHEVRON/PERTAMINA |
| **DIENG** | | | | | |
| 1 | 60 | ANSALDO | 1998 | PLN & PERTAMINA | PLN & PERTAMINA |
| **LAHENDONG** | | | | | |
| **Binair** | 2,5 | Thermodyn | 1991 | BPPT | BPPT |
| 1 | 20 | ALSTHOM | 2001 | PLN | PERTAMINA |
| **SIBAYAK** | | | | | |
| 1 | 2 | Geothermal Thermal Co. | 1996 | PERTAMINA | PERTAMINA |
| **Wayang Windu** | | | | | |
| 1 | 110 | FUJI | 2001 | STAR ENERGY | STAR ENERGY / PERTAMINA |

Table 4. Present Geothermal Installation

Figure 6 Recent Geothermal; Fields Development

The minimum risk in geothermal development in Indonesia absolutely to focus on proven reserve fields area, which to cover of 2,300 MW of Reserve potential.

| Location | Installed Capacity | Proven Reserve | Under Construction |
|---|---|---|---|
| Sibayak (North Sumatera) | 2 MW | 39 MW | - |
| Sarulla (North Sumatera) | - | 400 MW | - |
| Lempur (Jambi) | - | 40 MW | - |
| Salak (West Java) | 383,1 MW | 485 MW | - |
| Patuha (West Java) | - | 170 MW | - |
| Kamojang (West Java) | 200 MW | 227 MW | |
| Darajat (West Java) | 136 MW | 280 MW | 110 MW |
| Wayang Windu (West Java) | 110 MW | 250 MW | 110 MW |
| Karaha (West Java) | - | 30 MW | - |
| Dieng (Central Java) | 60 MW | 280 MW | - |
| Ulumbu (East Nusa Tenggara) | 12,5 MW | - | 2 x 2,5 MW |
| Mataloko (East Nusa Tenggara) | 1,5 MW | - | 1,5 MW |
| Lahendong (North Sulawesi) | 42,5 MW | 65 MW | 20 MW |

Table 5. Installed Capacity and Proven Reserve Geothermal

The optimum development can be addressed to utilize all of the proven reserve available, while the knowledge of resources and reserve should be updated gradually to have higher level of optimum development plant.

## 7. GENERATION MIX STRATEGY

Geothermal provides good option for improving base load power mix due to the following reasons:

- Energy security by utilizing an abundant national resource, by mean of the enhance energy security by exploiting dependable indigenous which non tradable resources.
- Environment benefits of utilizing a clean energy source by mean reduction in local pollutants (TSP, NOx, SO2 ) and reduction in green house gases
- Hedge against volatile prices for oil and coal as geothermal steam prices does not fluctuate unlike fossil fuels, providing a natural hedge in managing Indonesia's energy mix portfolios.

General planning 2006-2015 put the target of geothermal development to 400 MW additional, however according to Geothermal Road Map its allocation should be 2,000 MW in 2010.

The geothermal industry, with its solid experience and proven technology, has indicated that the engineering, procurement and construction (EPC) processes of this environmentally friendly energy resources on worldwide basis for proven field which recently 2,300 MW can be executed in two years periods, hence its Road Map with a target of 2,000 MW can be achieved.

Utilization of natural gas combined cycle as substitution for oil fired as mentioned in General Planning guidance could probably be facing serious difficulties in term of security supply.
The generation mix strategy, by utilizing all the proven geothermal reserve available however intern of electricity supply can be considered more reliable and secure.

## 8. CONCLUSION

Basically sustainable energy policy by means of promoting renewable energy utilization should be supported by serial policy and incentives to spur development of these environmentally benign resources.

Serial legal and its derivative regulations have to be enacted to spur development of renewable energy resources. However fiscal policy and incentives treatment should be applied in this respect.

Optimum utilization of geothermal energy should refer to the available proven reserve and to be implemented as soon as possible as geothermal is non tradable energy, renewable, environmental friendly and as hedge against volatile security supply of natural gas and coal as well.

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