# DEVELOPMENT OF MINI / MICRO HYDRO POWER PLANT FOR RURAL ELECTRICITY IN INDONESIA

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**ABSTRACT**

Indonesia has a lot of water energy resources, some of it could be developed for rural mini / micro hydro power plant. The resources have been estimated to be able to provide electricity of 74,976 MW capacities with annual energy output equal to 401 billion kWh. However, it is only 5% that has been exploited for electricity, 62% in Java and 38% outside Java. This shows that the opportunity to develop electricity from water resources is widely opened especially outside Java. The increase price of fossil fuel has shown an important drive to explore the alternative energy. Development of rural electricity could be initiated by developing mini / micro hydro power plant (PLTMH) in rural area either by PLN or by Private Sector of Middle Small Industry (rural UKM) or by Rural Co-Operative. Schemes to push development of PLTMH have been introduced by the Government and in some areas have been working successfully. Some constraints have been identified and with right and good governance, it is believed that participation of rural society in development of PLTMH to support rural electricity will work successfully.

**Keyword:** Potential of water energy, Development of PLTMH, Rural electricity

**ABSTRAK**

Indonesia banyak memiliki sumberdaya air, di antaranya baik untuk dikembangkan bagi pembangkit listrik mini /mikro hidro (PLTMH). Sumberdaya air ini diperkirakan dapat menghasilkan 74.976 MW listrik dengan keluaran tahunan sebesar 401 juta kWh. Namun baru 5% yang dimanfatkan untuk kelistrikan: di Jawa 62% dan di luar Jawa 38%. Ini menunjukkan bahwa pembangunan kelistrikan dg tenaga air masih terbuka luas terutama di luar Jawa. Kenaikan harga bahan bakar fosil menjadi dorongan yang penting dalam mengembangkan energi alternatif. Pengembangan listrik pedesaan dapat dimulai dengan pengembangan pembangkit listik mini / mikro hidro di perdesaan oleh PT. PLN, atau oleh industri skala menengah (UKM) di perdesaan atau Koperasi desa. Skema untuk mendorong pengembangan PLTMH telah diperkenalkan oleh pemerintah dan berfungsi dengan baik. Beberapa kendala telah diidentifikasikan, dengan upaya pemerintahan yang baik dan tepat diyakini bahwa partisipasi masyarakat desa dalam pengembangan PLTMH untuk pengadaan listrik pedesaan akan berhasil dengan baik.

**Kata kunci:** Sumberdaya air, Pengembangan PLTMH, Kelistrikan desa

## 1. INTRODUCTION

Indonesia has huge water resources and some have been utilized for various needs. The locations of these resources are widespread in many islands and some are very remote. The increase price of fossil fuel (BBM and coal) and the existing possibility of government policy to delete subsidy of fossil fuel have given an important drive to find an alternative

energy for electricity. Energy from water is one of the best alternatives to superseded BBM and coal for electricity.

Data of fossil fuel burned by PLN for electricity in the year 2003 and 2005 and its cost per kWh are given in **Table 1** and **Table 2**. The price of fossil fuel increases to 21.3% per year for BBM and 7.7% per year for coal. The price is still moving up due to the lack of BBM supply in the world.

Based on PLN data in the year 2003 and 2005, the operating expenses of power plant using fossil and hydro power plant are compared and shown in **Table 3** and **Table 4**. The data show a significant increase in operating expenses of fuel in fossil power plant. The increase reaches up to 11.7% per year for PLTU (BBM + coal) and 15.9% per year for PLTD (BBM). On the other side, operating expenses of hydro power plant tend to decrease as the depreciation cost decrease.

**Table 1. Fossil fuel burned by PLN for electricity in the year 2003 [1]**

| Type of Fuel | Price | Usage | Electricity Production | Efficiency | Cost per kWh |
|---|---|---|---|---|---|
| BBM | HSD: Rp 1.741/L<br>IDO: Rp 1.705/L<br>MFO: Rp 1.595/L<br>Avg. Rp 1.680/L | 7,613,481 kilo litre | 27,941 GWh | 0.73 L/kWh | Rp 458 / kWh |
| Coal | Rp 230.8 / kg | 15,260,305 ton | 31,736.6 GWh | 0,481 kg/kWh | Rp 111 / kWh |

**Table 2. Fossil fuel burned by PLN for electricity in the year 2005 [2]**

| Type of Fuel | Price | Usage | Electricity Production | Efficiency | Cost per kWh |
|---|---|---|---|---|---|
| BBM | HSD: Rp 2.819/L<br>MDO: Rp 2.486/L<br>MFO: Rp 2.418/L<br>Avg. Rp 2.574/L | 9,912,558 kilo litre | 39,048 GWh | 0.254 L/kWh | Rp 653 / kWh |
| Coal | Rp 252 / kg | 16,900,972 ton | 33,253 GWh | 0.508 kg/kWh | Rp 128 / kWh |

**Table 3. Operating expenses of power plant in the year 2003 [1]**

(in Rp/kWh)

| Source of Energy | Power Generation | Fuel ++ | Maintenance | Depreciation | Other Cost | Labor Cost | Total |
|---|---|---|---|---|---|---|---|
| Water | PLTA/PLTMH | 6.57 | 13 | 92.12 | 3.23 | 13.89 | 128.81 |
| Fossil | PLTU (BBM + Coal) | 187.5 | 16.51 | 61.57 | 2.15 | 3.73 | 256.47 |
| | PLTD (BBM) | 467.85 | 123.97 | 71.70 | 6.45 | 31.91 | 701.89 |

**Table 4. Operating expenses of power plant in the year 2005 [2]**

(in Rp/kWh)

| Source of Energy | Power Generation | Fuel ++ | Maintenance | Depreciation | Other Cost | Labor Cost | Total |
|---|---|---|---|---|---|---|---|
| Water | PLTA/PLTMH | 7.53 | 13.9 | 74.97 | 3.84 | 14.47 | 114.71 |
| Fosil | PLTU (BBM + Coal) | 240.88 | 14.92 | 53.9 | 2.58 | 4.43 | 316.71 |
| | PLTD (BBM) | 713.38 | 110.11 | 60.99 | 8.47 | 32.23 | 925.18 |

From environmental aspect, energy from water is known as environment friendly. Its clean and renewable characters give a high opportunity to be developed in the future as one solution to face global warming issue. This opportunity with a right management process will bring a good development of water power plant in Indonesia to support sustainability to fulfill energy need for the society.

## 2. POTENCY OF HYDRO FOR POWER PLANT

In 1982 PLN executed energy study throughout Indonesia. The purpose of this study is to identify potency of hydro for electricity. The study has identified 1210 locations having hydro potential with capacity estimated equal to 74,976 MW electricity and output energy equal to 401 billion kWh annually. The spreading of these hydro potential throughout Indonesia is given in **Table 5** and **Table 6**. To date, only 5% of these potential have been developed to generate electricity by the Government, PLN and private sector. The exploitation of hydro outside Java is very limited. It is only 3% has been used for electric generation. The total conversion of hydro power to electricity in GWh is given in **Table 7**.

**Table 5. The spreading of this water energy potency throughout Indonesia [3]**

| No | Island | Numbers of Location | | | Capacity (MW) | Energy (GWh/year) | % |
|---|---|---|---|---|---|---|---|
| | | Type ROR | Type Reservoir | Total | | | |
| 1 | Sumatra | 188 | 259 | 447 | 15,587 | 84,110 | 20.9 % |
| 2 | Jawa | 37 | 83 | 120 | 4,200 | 18,042 | 4.5% |
| 3 | Kalimantan | 9 | 151 | 160 | 21,581 | 107,202 | 26.7% |
| 4 | Sulawesi | 26 | 79 | 105 | 10,183 | 52,592 | 13.2% |
| 5 | Maluku | 14 | 39 | 53 | 430 | 2,292 | 0.6% |
| 6 | Papua | 130 | 75 | 205 | 22,371 | 122,759 | 33.3% |
| 7 | Bali + Nusa Tenggara | 66 | 54 | 120 | 624 | 3,287 | 0.8% |
| Total | | 470 | 740 | 1,210 | 74,976 | 401,284 | 100 % |

**Table 6. The developed potency**

| No | Island | Capacity Potency (MW) | Developed (PLN / Private) (MW) | Percentage % |
|---|---|---|---|---|
| 1 | Sumatra | 15,587 | 833.5 | 5.3 % |
| 2 | Jawa | 4,200 | 2,597 | 62 % |
| 3 | Kalimantan | 21,581 | 30.5 | 0.2 % |
| 4 | Sulawesi | 10,183 | 190 | 2 % |
| 5 | Maluku | 430 | - | 0 % |
| 6 | Papua | 22,371 | 3.4 | 0.1 % |
| 7 | Bali + Nusa Tenggara | 624 | 1.3 | 0.2 % |
| Total | | 74,976 | 3,455 | 5 % |

(Note : in the Directory of PLTMH and PLTS operated by Small and Medium Industry (UKM) and Rural Co-Operative published by the Office of Directorate Co-Operative, Small and Medium Industry, Year 2002, the water energy that has been exploited is 4,200 MW)

**Table 7. The percentage of total energy converted to electricity**

| Location | Energy Potency (GWh/year) | Energy converted to electricity (GWh/year) | Percentage % |
|---|---|---|---|
| Total Indonesia | 401,284 | 13,297 | 2,6% |

The PLN study is very useful as a data based to implement road map target of hydro power plant in Indonesia. However, it does not give clear picture on division of potential of small scale hydro power plant (< 5 MW) known as PLTMH and medium/big scale hydro power plant (> 5 MW ) known as PLTA.

On the other hand, definition of PLTMH itself in Indonesia is still unclear. Some Indonesian experts stated that hydro power plant smaller than 250 kW referred as micro hydro and those smaller than 5 MW referred as mini hydro. As to comparison, the definitions of mini/micro hydro in several countries are given in **Table 8**.

The Master Plan of Development of New Energy (RIPEBAT) published by The Directorate General of Electricity and New Energy, described that the estimation of the potency of micro hydro (PLTMH) reach 459 MW (1% from potency of water energy). This data is compared to the study of PLN and is shown in **Table 9**.

**Table 8. The definition of mini/micro hydro by countries**

| Country | Micro Hydro (kW) | Mini Hydro (kW) | Small PLTA (MW) |
|---|---|---|---|
| USA | < 100 | 100 – 1000 | 1 – 30 |
| China | - | < 500 | 0,5 – 25 |
| Rusia | < 100 | - | 0,1 – 30 |
| France | 5 - 5000 | - | - |
| India | < 100 | 101 - 1000 | 1 – 15 |
| Brazil | < 100 | 100 - 1000 | 1 – 30 |
| Norwegia | < 100 | 100 - 1000 | 1 – 10 |
| Other country | < 100 | < 1000 | <10 |

**Table 9. The comparison between exploited capacity and potency**

| Energy | Capacity Potency (MW) | Capacity has been exploited (MW) | Note |
|---|---|---|---|
| Hydro | 74,517 | 3,637 | PLTA |
| Mini Hydro | - | 64 | PLTM owned by PLN |
| Micro Hydro (PLTMH) | 459 | 54 | |
| Total Indonesia | 74,976 | 3,655 | |

## 3. MINI / MICRO HYDRO POWER PLANT.

Based on history in the past, the electricity from mini / micro hydro power plant was used in plantation industries such as: tea plantation, paddy hulling, coffee processing, or wood

sawmill. During the Dutch colonization period, this electricity was distributed to the society near the power plant. Although the Dutch has built several mini/micro hydro power plants, it is unclear when the first hydro power plant was conducted in Indonesia. Several references mentioned that micro hydro power plant of Pelton type 50 kW has been installed in 1892 and used for plantation of tea in Patuah Watee, West Java. According to PLN data, the oldest mini hydro power plant developed by the Dutch was PLTM Cijedil (550 kW) which was operated in 1923 and PLTM Bengkok Dago (700 kW) both located in West Java. These PLTM to date is still operated by PLN.

There are two categories of electricity distribution:
1. distributed directly through PLN distribution line (called "on grid") and
2. distributed separately from PLN distribution line (called "off grid").

PLTMH on grid mostly are PLTMH operated by PLN, whereas the PLTMH off grid are mostly developed by private UKM sector and village cooperative, see **Table 10**.

The electricity from PLTMH on grid is entirely sold by PLN to society either in urban or rural area, while the electricity generated from PLTMH off grid, known as "isolated power plant" usually is managed and operated by small / medium Industry (UKM) or Village Co-Operative (KUD). The electricity mostly distributed for rural society. With some support in technology & management, empirically, the rural society has the capability to manage and operate PLTMH.

**Table 10. Comparison on grid and off grid PLTMH**

| Distribution | unit | Total Capacity (kW) | Average capacity per Unit (kW/unit) | Owner |
|---|---|---|---|---|
| On grid | 86 | 64,566 | 750 | Mostly PLN |
| Off grid | 178 | 5,000 | 28 | Private UKM, Village Cooperative |

## 4. DEVELOPMENT OF PLN MINI / MICRO HYDRO (PLTMH)

The total installed capacity of PLTMH by PT PLN reaches up to 64,566 kW, see **Table 11**. Several PLTMH was built during the Dutch colonization. In dry season, the total electricity generated reduced to 79% of its installed capacity or become 50,979 kW. The low capacity of water flow in the dry season, made some of the PLTMH only able to operate for several hours, 4 up to 5 hours.

Considering the total numbers of villages in Indonesia and electrification ratio, it can be said that the potency of growth for rural electrification is widely open, see **Tables 12** for the numbers of villages, the number of customers and ratio of electrification [4]. The amount of customer increases, while the percentage of electrified village decreases. This is caused by the development of additional new villages as an impact of government

autonomy policy (OTODA). **Table 13 – 15** show almost all villages in Java have been electrified, while outside Java reaches up to 70%.

**Table 11. Installed capacity of PLN PLTMH**

| No | Island | Installed Capacity (kW) | Operated Capacity (kW) |
|---|---|---|---|
| 1 | Sumatra | 12,984 | 9,105 |
| 2 | Jawa | 33,262 | 31,120 |
| 3 | Kalimantan | 400 | 395 |
| 4 | Sulawesi | 12,750 | 10,070 |
| 5 | Maluku | - | - |
| 6 | Papua | 2,100 | 2,100 |
| 7 | Bali + Nusa Tenggara | 2,420 | 536 |
| Total Indonesia | | 64,566 | 50,979 |

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**Table 12. Number of village, electrified villages, customer**

| Year | Number of village | Number of electrified village | Number of customer |
|---|---|---|---|
| 1998 | 58,987 | 47,676 (80. 8%) | 17,682,122 |
| 1999 | 58,987 | 48,562 (82.3 %) | 18,569,810 |
| 2000 | 58,545 | 49,155 (83.9 %) | 19,264,138 |
| 2001 | 60,049 | 49,476 (82.4 %) | 19,905,537 |
| 2002 | 66,215 | 52,007 (78.5 %) | 20,031,297 |
| 2003 | - | - | - |
| 2004 | 68,593 | 55,346 (80.6 %) | 21,439,614 |

**Table 13. Number of electrified village between Java and outside Java**

| Location | Number of village | Number of electrified village | Number of customer |
|---|---|---|---|
| Outside Java | 41,099 | 28,805 (70.0 %) | 7,251,67 |
| Java | 25,116 | 23,412 (93.2 %) | 12,779,628 |
| Indonesia | 66,215 | 52,127 (78.5 %) | 20,031,297 |

**Table 14. Number of electrification ratio between Java and outside Java, 2003**

| Location | Number of village | Number of customers | Home customer | Electrification Ratio | Sale kWh /capita |
|---|---|---|---|---|---|
| Outside Java | 89,277,000 | 21,881,000 | 10,146,753 | 46.37 % | 223 |
| Java | 125,875,000 | 34,682,000 | 19,850,801 | 57.24 % | 560 |
| Indonesia | 215,152,000 | 56,562,000 | 29,997,500 | 53.03 % | 420 |

**Table 15. Number of electrification ratio between Java and outside Java, 2005**

| Location | Number of village | Number of customers | Home customer | Electrification Ratio | Sale kWh /capita |
|---|---|---|---|---|---|
| Outside Java | 91,200,500 | 22,748,100 | 10,979,508 | 48.27 % | 260.27 |
| Java | 130,126,400 | 36,766,500 | 21,195,414 | 57.56 % | 640.11 |
| Indonesia | 221,326,900 | 59,514,600 | 32,174,922 | 54.06 % | 483.59 |

The electrified village has reach 78.5%, but the national electrification ratio is still about 54%. In the year 2003 until 2005, it increased 1.03%. Considering, all un-electrified villages, the potency to develop rural electrification is widely open. PLN blueprint shows that PLN will develop up to 13.25 MW PLTMH in 2010. The locations of these projects are spread outside Java [5]. Some PLTMH has been designed by PLN, see **Table 17** and are planned to be offered to private sector in Independent Power Producer (IPP) scheme**.**

**Table 16. The locations of the projects at outside Java [5]**

| No | PLTMH | Location / Province | Capacity | Operation | Rural Development Program |
|---|---|---|---|---|---|
| 1 | Lobong | Kotamobagu, Sulawesi Utara | 1.6 MW | April 2009 | Power Welfare Scheme |
| 2 | Mongango | Gorontalo | 1.2 MW | April 2009 | Power Welfare Scheme |
| 3 | Merasap | Pomtianak, Kalimantan Barat | 1.5 MW | April 2009 | Power Welfare Scheme |
| 4 | Ndungga | Sumbawa, NTT | 1.9 MW | Sep 2009 | Power Welfare Scheme |
| 5 | Poigar 2 | Sulawesi Utara | 2.3 MW | Mid 2010 | - |
| 6 | Amai | Papua | 1.1 MW | End of 2010 | - |
| 7 | Tatui | Papua | 1.2 MW | End of 2010 | - |
| 8 | Prafi | Papua | 1.6 MW | Sep 2009 | - |
| 9 | Santong | Lombok | 0.85 MW | Sep 2009 | - |

**Table 17. PLTMH developed by private sector by IPP scheme [6]**

| No | PLTMH | Location / Province | Capacity | Operation | Rural Development Program |
|---|---|---|---|---|---|
| 1 | Menarung | Kaltim | 220 kW | - | - |
| 2 | Pa Betung | Kaltim | 240 kW | - | - |
| 3 | Puruk Cahu | Kalteng | 240 kW | - | - |
| 4 | Muara Kendihin | Kalsel | 600 kW | - | - |
| 5 | Gendang T | Kalsel | 560 kW | - | - |
| 6 | Parigi | Sulteng | 600 kW | - | - |
| 7 | Tindaki | Sulteng | 800 kW | - | - |
| 8 | Sawidago II | Sulteng | 800 kW | - | - |
| 9 | Sansarino | Sulteng | 900 kW | - | - |
| 10 | Hanga-hanga 2 | Sulteng | 3400 kW | - | PSK tersebar |
| 11 | Kalumpang | Sulteng | 1700 kW | - | PSK tersebar |
| 12 | Palangka | Sulsel | 1900 kW | - | - |
| 13 | Rante Balla | Sulsel | 2200 kW | - | - |
| 14 | Kadundung | Sulsel | 1600 kW | - | - |
| 15 | Batu Sitanduk | Sulsel | 2700 kW | - | - |
| 16 | Usu Malili | Sulsel | 5000 kW | - | - |
| 17 | Mikuasi | Sulteng | 2400 kW | - | - |
| 18 | Rongi | Sulteng | 1500 kW | - | - |
| 19 | Sambilambo | Sulteng | 5000 kW | - | - |
| 20 | Rate Lemb II | Sulteng | 1895 kW | - | - |
| 21 | Ira | Maluku | 2990 kW | - | - |
| 22 | Kombenur | Irian | 6600 kW | - | - |
| 23 | Marioratu | Irian | 775 kW | - | - |
| 24 | Pekatan | NTB | 700 kW | - | - |
| 25 | Wolodeso | NTT | 540 kW | - | - |

## 5. DEVELOPMENT OF RURAL SOCIETY

Program PLN for development of rural society will attached side by side with construction of PLTMH. For PLTMH funded by ADB, those are PLTMH Lobong, Mongango, Merasap and Ndungga, PLN and ADB has a program called Power Welfare Scheme or PWS [7]**.** The PWS is one of the community development programs run by PLN.
The basic principle of PWS is that the development of PLTMH should give an impact on surrounding society and increase the welfare of low income people around the location of PLTMH.

The objectives of PWS are:
- Assisting rural society to use electricity from renewable energy (RE) system installed in the rural area.
- Provide sustainable fund to increase economic standard of living of low income people.
- Enhancing the use of electricity for productive purposes.
- Assisting the establishment of rural society organization, such as rural co-operative (KUD) in order to improve rural group capability.

At the moment, the fund for PWS comes from ADB grant and is managed by Government institute named DJLPE, PLN and Non Government Organization. Local fund for this program is provided by PT PLN's community development fund program. The macro scheme of PLN PWS is shown in **Fig. 1** below.

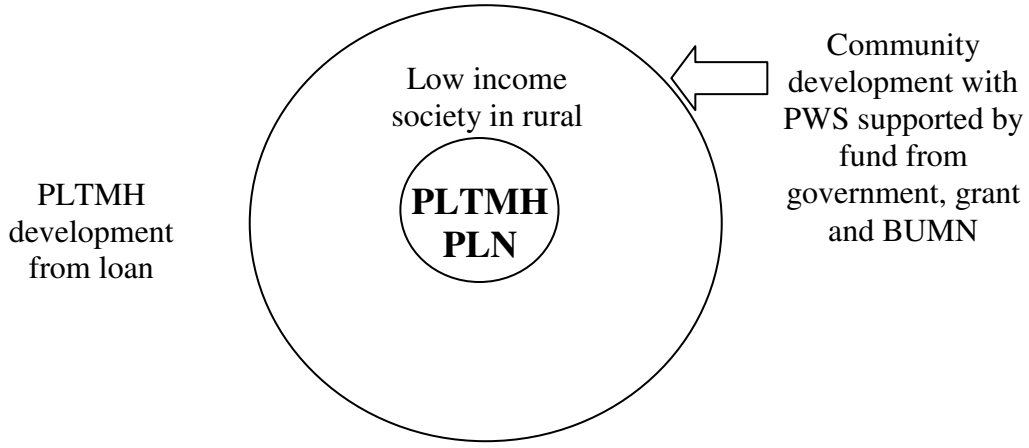


**Fig. 1. The PLN Power Welfare Scheme (PWS)**

Several schemes, similar to the PWS scheme, to help people to connect to PLN electricity has also been developed by PLN. These schemes are: Community Development, PUKK, Village electricity credit from BRI. Basically the objective of community development by PLN has two principle objectives, those are:
- rural society reinforcement through forming of society organization and
- training and establishment of cheap fund.

Several constraints have encounter during implementation of the scheme.

## 6. DEVELOPMENT OF PLTMH BY PRIVATE SECTOR AND VILLAGE COOPERATIVE

The government realizes that development of PLTMH in rural areas could not be done by PLN alone. To push society and private sector participation, Government have published Ministerial Decree (KEPMEN) No. 1122.K/30/MEM/2002 regarding small scale hydro power plant. In this KEPMEN, small / medium private business (UKM) or rural Co-Operative could develop small scale PLTMH and sell its electricity to PLN as on-grid [8]. The selling price is equal to 80% from Cost of Goods Sold (HPP) of medium voltage line or TM-PLN, if electricity channeled to TM PLN. The selling price is equal to 60% from HPP low voltage or TR-PLN if the electricity channeled to TR PLN. Although this KEPMEN has been socialized, several constraints during implementation have encountered, especially on selling tariff from developer to PLN.

For the off-grid isolated area, some donor through its financial institution like USAID, JICA Japan, GTZ Germany have conducted cooperation with private sector in the development of PLTMH in which the electricity output is directly used by the society, see **Table 18**. Development PLTMH represents one of best choice for rural electricity program as it is considered easy in technological point of view and easy in maintenance and operation. From the financial aspect, PLTMH need relatively small budget. From environmental point of view, PLTMH would decrease the use of fossil fuel. From the economic aspect, the development of PLTMH in rural areas will enhance development of rural society, create jobs and reduce un-employment. The development PLTMH by private sector or rural Co-Operative where its management is combined with PSK scheme, and in operation, is shown in **Table 19**.

**Table 18. PLTMH funded by the Governmental or overseas grants, and operated by private sector or rural Co-Operative**

| Location | PLTMH | Capacity | Operated by | Customers |
|---|---|---|---|---|
| Aceh Tenggara | Rerebe | 250 kW | - | - |
| Payung Selaki, Solok Sumatra Barat | Batu Bejanjang, 1997 | 35 kW | KUD Sirukam, Solok | 207 |
| Payung Selaki, Solok Sumatra Barat | Simanau, 1996 | 30 kW | KUD Sirukam, Solok | - |
| Sukarami, Bengkulu | Sukarami, 2001 | 35 kW | KUD Harapan | 265 |
| Sukabumi, Jawa Barat | Cicemet, 1997 | 60 kW | KUD Hikmat Tani | - |
| Bogor, Jawa Barat | Citalahab, 1997 | 5,12 kW | KUD Tani Berkah | - |
| Cisarua, Jawa Barat | Leuwijamang, 2002 | 34 kW | KSM Pada Asih | - |
| Sirnarasa, Jawa Barat | Ciganas, 1997 | 80 kW | Koperasi Kommet | - |
| Aikmel, Mamben Daya,Lombok | Kukusan, 2001 | 20 kW | KUD Sinar Rinjani | 200 |
| Sumba Barat, NTT | Waikilosawa, 2000 | 15 kW | | 50 |
| Sa'dan Basalu, Toraja SulSel | Sa'dan Ulusalu, 1996 | 15 kW | PLDSa'dan UluSalu | 65 |
| Rinding Alio, Toraja, SulSel | Ta'Ba, 2000 | 46 kW | PLD Pasamboan | 305 |
| Bunto Rante bua, Toraja, SulSel | Bokin, 2000 | 13 kW | PLD Bokin | 80 |
| Saluputi, Toraja, Sulsel | Tendan Dua, 2000 | 64 | PLD Tendan Dua | 276 |

**Table 19. PLTMH by private sector or rural Co-Operative which its management is combined with PSK scheme**

| No | PLTM | Capacity | Location | Manage by |
|---|---|---|---|---|
| 1 | PLTMH Cinta Mekar | 120 kW | Subang | KUD Cinta Mekar |
| 2 | PLTMH Seloliman | 30 kW | Mojokerto | Paguyuban Masyarakat Kalimaron |
| 3 | PLTMH Curug Agung | 12 kW | Subang | KUD |
| 4 | PLTMH Waikelosawah | 14 kW | Sumba Barat | KUD |
| 5 | PLTMH Dompyong | 25 kW | Lombok Barat | KUD |
| 6 | PLTMH Anggrek Mekar Sari | 900 kW | Sumbar | Swasta UKM |
| 7 | PLTMH Kalumpang | 1000 kW | Luwuk | Swasta |
| 8 | PLTMH Hanga-Hanga | 2 × 1000 kW | Luwuk | Swasta |
| 9 | PLTMH Salido | 900 kW | Sumbar | Swasta UKM |
| 10 | PLTMH Parluasan | 2 × 21 MW | Sumut | Swasta |
| 11 | PLTMH Teluk Berasap | 2 × 3 MW | Jambi | Swasta |
| 12 | PLTMH Ranteballa | 2 × 1.2 MW | Sulsel | Swasta |

Two PLTMH, that is PLTMH Cinta Mekar and PLTMH Seloliman, have shown success. PLTMH Cinta Mekar capacity is 100 kW. It was funded by the grant from UNESCAP (50%) and 50% by a private local company named PT. Hidropiranti Inti Bakti Swadaya Microhydro System. Electricity generated from this PLTMH is used by the society and the rest is sold to PLN. The net revenue each month from selling electricity reaches Rp. 8 millions. Cinta Mekar Cooperative has been established and 50% of income is owned by the society around the PLTMH.

PLTMH Seloliman started operation in October 2003. This PLTMH have capacity of 25 kW and developed by non government organization named YBUL with grant funded from GTZ Germany. The source of water comes from irrigation ditch near the PLTMH. Electricity generated is used to electrify the school and the small industries in the village near by. The rest of electricity output is sold to PT PLN at the price of Rp. 425,- / kWh. From this sale, the organizer of PLTMH Seloliman that is Village Cooperative earns more than Rp. 5 millions per month.

The impacts of these two PLTMH that were developed by private and were well managed by the society raise economic capabilities of rural peoples.

The government continuously pushing development of PLTMH, however some constraints are still need to be encountered, those are:

- In ability of village people to develop PLTMH by themselves
- Lack of knowledge of village people to detect potency of PLTMH.
- Lack of management skill to manage PLTMH business.
- Lack of knowledge to measure electricity usage that some times cause social conflict.
- Lack of knowledge to operate and maintain PLTMH.

## 7. GOVERNMENT AND PLN SUPPORT

The government realizes that the development of PLTMH as a part of renewable energy development should be expedited. To push this, the Ministry for Energy and Mineral Resources (ESDM) as the technical regulatory body has issued a regulation on how private sector and rural cooperative may sell their excess power to PLN [8]. The Department of Public Work also has issued its intention to use excess of water from irrigation to be used as hydro resources for PLTMH [9]. PLN as BUMN in electricity has bought the electricity output of several PLTMH. PT PLN will issue policy that could attract investor to develop PLTMH.

## 8. CONCLUSION

1) Indonesia has great hydro potential; however, only small part has been exploited for electricity generation. The increasing price of fossil fuel will surely raise the urgency in developing RE such as PLTMH for future electricity provision.
2) The empirical experiences show that with good and right management skill, the development of PLTMH, maintenance and operation by rural society has shown a success.
3) Development of PLTMH is one of the alternatives for rural electrification. However, there are several constraints in its development and operation. Schemes to help rural society in develop PLTMH, regulation for better sales electricity output of PLTMH, incentive and support for rural society participation should continuously been developed and implemented, so that PLTMH dissemination could be developed faster in rural areas.

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