Promotion of Least Cost Renewables in Indonesia (LCORE-Indo)

Diesel-Fuel Replacement: Potential Analysis for Grid-Connected Photovoltaic-Systems in Indonesia

Compiled by:
Thomas Strobel

July 2014

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Executive Summary

This study presents the theoretical and technical potential for grid-connected Photovoltaic-Systems in Indonesia. In regards to the potential for diesel-fuel replacement, the calculations are done on provincial level due to regional variations in solar irradiation and the possible system capacities for grid-connection.

Presently, the electric energy supply in Indonesia is mainly provided by fossil fuels, wherein coal- and gas-fired power plants are most common. Indonesia's different geographical conditions are also reflected by different structures of power supply. While a joint transmission grid on Java-Bali and Sumatra is supplied by power plants with larger capacities, the situation in the Eastern part of Indonesia differs drastically. There, smaller island grids which are mainly powered exclusively by smaller diesel-generators with an average capacity of 700 kW are the common cases which amount to 4,500 units in outside Java-Bali and Sumatra.

The overall diesel-fuel consumption in Indonesia in 2012 was 8.5 billion liters, resulting in high fuel expenses of 7 billion USD. These numbers can be interpreted as a theoretical potential of disel fuel reduction, leading to an annual GHG-emission reduction of 22.7 MtCO2.

Renewable energy resources such as solar energy are often fluctuating and intermittent. Thus, it requires an intelligent control communication to ensure grid stability. To overcome the unique characteristic of each network in Indonesia and the resulting differences in penetration levels, a general baseline for technically reliable grid-penetration of PV-systems was assumed to be 20% of the daily minimum load. This assumption shows that currently around 2000 MWp capacity of PV implementation is possible without grid- or load management.

The technical potential generates 2,800 GWh annual solar energy yield, resulting in a diesel-fuel reduction by 850 million liter (almost 10% of fuel consumption in 2012) and consequently2.2 MtCO2 of GHG-emission reduction. The largest reduction potential (80%) is in the Java-Bali and Sumatra grid. However,low generation costs for Solar PV in the range of 1500 – 3000 IDR/kWh, and high diesel fuel costs up to 1 USD per liter in the Eastern part of Indonesia, offer huge additional economic potential.

A more detail implementation scenario for grid-connected PV-systems as promising contribution to Indonesia's climate goals in 2020 was observed. The technical potential of grid-connected PV-systems will increase to 4,000 MWp by 2020 due to the annual energy demand increase of almost 10%. An initial implementation of 350 MWp in 2014 and additional annual extension of 50%, will result in an accumulated diesel-fuel reduction of 4.8 billion liter in 2020. By 2020, 30% of the diesel-fuel can be replaced and could provide economic savings of 4 billion USD to PLN as off-taker or investor of Solar Energy.

Under these assumptions, the total GHG-emission reduction by 2020 accumulates to 13 MtCO2 and thus shows that grid-connected photovoltaic can provide not onlyhuge economic benefit, but also a significant contribution of 34% to Indonesia's goals to reduce 38 MtCO2 in the Energy and Transport Sector by 2020.

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Abbreviations and Formula

BAU	*Business-as-Usual*
CAPEX	*Capital Expenditure*
CC	*Combined Cycle*
E	*Energy*
HSD	*High Speed Diesel*
FIT	*Feed-In-Tariff*
G	*Giga*(10^9)
GHG	*Green-House-Gas*
IDO	*Industrial Diesel Oil*
IDR	*Indonesian Rupiah*
IPP	*Independent Power Producers*
k	*Kilo* (10^3)
LCOE	*Levelized Cost of Energy*
M	*Mega* (10^6)
MFO	*Marine Fuel Oil*
P	*Power*
NTB	*Nusa Tenggara Barat*
NTT	*Nusa Tenggara Timur*
PLN	*PT Perusahaan Listrik Negara (Persero)*
PV	*Photovoltaic*
T	*Terra* (10^{12})
tCO2e	*Tons of CO2 equivalent*
USD	*US Dollar*
W	*Watt*
WACC	*Weighted Average Capital Costs*
Wh	*Watt Hour*
Wp	*Watt Peak*

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1. Background and Objective

Indonesia is the world's largest archipelago country consisting of more than 17,000 islands and islets, of which about 6,000 are inhabited. This unique condition results in a big challenge to provide sustainable and reliable electricity supply as larger transmission networks are partly not possible or not yet developed. On Java (Java-Bali Grid) where around 60% of the population is located, the electricity supply is mainly supplied by an integrated transmission and distribution network using coal-, gas- and diesel-fired power plants and hydropower.

The situation outside Java – especially in the Eastern part of Indonesia – differs significantly. In the outer Islands, electricity supply is usually provided by smaller grids which are mainly operated by diesel generators. In these areas, the price of diesel-fuel is high due to high transportation costs

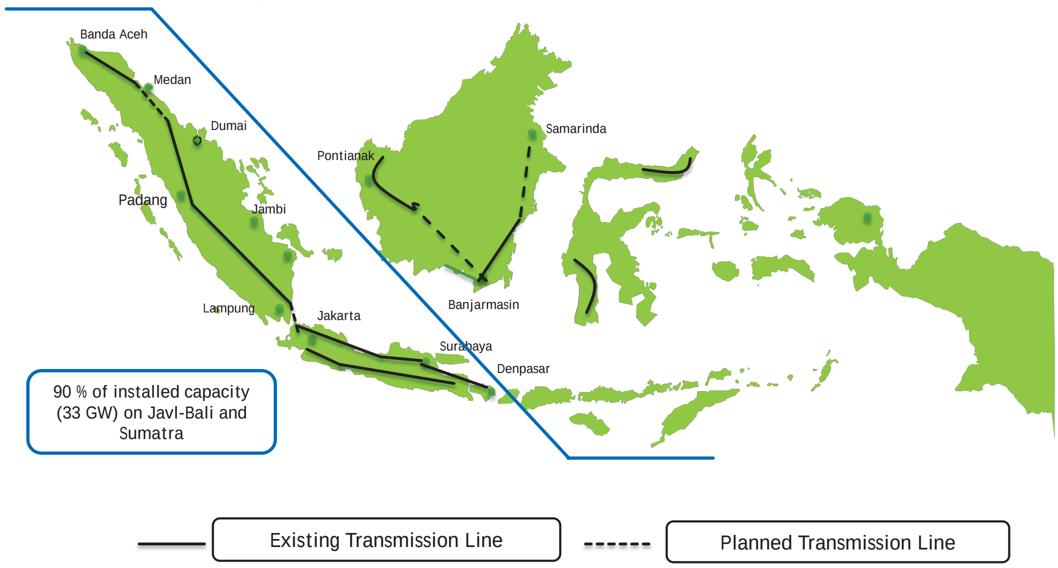

Figure 1: Map of Indonesia

which result in expensive electricity generation.

The different electricity infrastructures (integrated transmission and distribution network on Java-Bali and Sumatra, smaller island grids in the Eastern part of Indonesia) result accordingly in varying electrification ratios. The average electrification ration in Indonesia is 73%[1], where the Java is the most electrified island (78%), whereas on Papua, only 32% of the people have access to electricity.

These conditions offer big potential for Renewable Energies to contribute significantly to Indonesia's future energy supply. Besides offering a solution to electrify remote areas, especially Renewable Energies can contribute to reduce Indonesia's Green-House-Gas (GHG) emissions and electricity subsidies. Indonesia's challenging goal, to reduce GHG emissions by 26% (41% with international

[1] PLN Statistics 2012

support) referred to the business-as-usual case (BAU)[2] requires development of Renewable Energy potential and policies to fulfill the GHG-emission reduction in the Energy Sector.

Due to high electricity generation costs (1217 IDR/kWh average generation costs in 2012) and low electricity tariffs (730 IDR/kWh average) electricity is highly subsidized. In 2012, the Government of Indonesia allocated IDR 6.5 trillion IDR (US$ 65 billion) for electricity subsidies – resulting in 6% of the state budget in 2012.

Compared to other countries, Indonesia has a big unexploited potential of Renewable Energies. The islands of Sumatra and Kalimantan offer high bioenergy and hydropower potential, whereas in the Eastern part of Indonesia, high solar irradiation promises large opportunities for photovoltaic. Despite these large potentials, in 2012 only 14 GWh, or 7%[3] of Indonesia's Electricity Supply (2012 total 200,317 GWh) is covered by Renewables, in which Solar, Wind and Bioenergy were still neglect able.

The objective of this study is to evaluate the technical and economic potential of grid-connected photovoltaic to substitute diesel fuel powered electricity in PLN grid.

2. Methodology

The methodology of this study is briefly described in Figure 2. To elaborate the potential of diesel-fuel replacement in Indonesia by photovoltaic (PV) systems, mainly three sectors contributing to Indonesia's electricity production have to be considered more detailed.

Besides the main energy supply by the state-own utility PT PLN Persero (PT Perusahaan Listrik Negara), Independent Power Producers (IPP) and the Captive Power sector (which includes mainly agriculture and mining industry) provide options for Renewable Energy.

The overall fuel consumption in Indonesia's Captive Power sector amounts to around 370,000 kilo liter and the emission reduction potential for the Captive Power sector was investigated separately and amounts to 1.1 MtCO2e per year[4]. As the reduction potential for captive power strongly depends on individual conditions, the reduction potential is not considered in this study.

As there are no detailed numbers on the proportion of diesel-fired power plants in the IPP sector available, and thus the reduction potential in this sector is not known, this study will focus more detailed on PLN's own reduction potential and – as PLN to be the major electricity producer – also the biggest reduction potential.

Due to Indonesia's geographical character as discussed above, the diesel-fuel replacement potential in PLN grid will be broken down into province level as high differences in solar irradiation, the electricity generation costs of PV (Levelized Costs of Electricity *LCOE*) and expected energy yield will differ.

[2] Guideline for Implementing Green House Gas Emission Reduction Action Plan (INDONESIAN MINISTRY OF NATIONAL DEVELOPMENT PLANNING/ NATIONAL DEVELOPMENT PLANNING AGENCY YEAR 2011)
[3] Including Geothermal and Hydropower / PLN own production (PLN Statistics 2012)
[4] Overview of Diesel Consumption for Captive Power in Indonesia, LCORE-INDO, GIZ Indonesia, November 2013

By breaking down into province level, a more detailed and realistic potential of diesel-fuel replacement will be presented. To get a more in depth detailed study, the conditions of each (island) grid have to be evaluated separately to consider the challenges of the archipelago character of the energy supply situation.

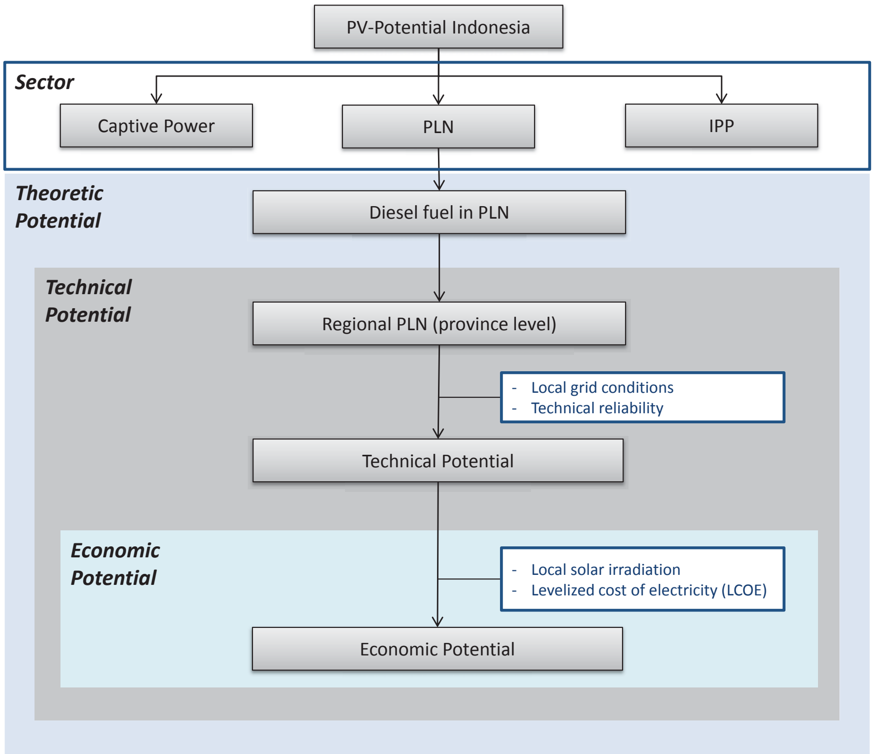

Figure 2: Methodology

3. Governmental regulations and Subsidies

3.1. Feed-In-Tariff Regulations

Current and upcoming governmental regulations – mention the Ministerial Regulation No. 17, 2013 and the existing Feed-in-Tariff (FIT) for bioenergy – will allow Indonesia to increase its share of Renewable Energy in future. New options of electricity generation will contribute to Indonesia's goal – to reduce the GHG emissions by 0.038 GtCO2 in 2020 in Energy and Transport Sector (referred to the BAU-Case) and increase the share of Renewable Energy by 20% - and also open en enormous potential replacing the still high contribution of diesel fuel resulting in lower electricity subsidies and GHG emissions.

At present, Feed-In-Tariffs for the following Renewable Energy resources are given in Table 1. For PV-Systems, there are currently no Feed-In-Tariffs available whereas for Roof-Top Systems[5], the state utility PT PLN introduced net-metering in 2014. Planned electricity tariff increase in 2014 for the industrial tariffs I2 and I3 will make roof-top systems under net-metering[6] regulation more attractive and an increasing number of systems can be expected.

For grid-connected green-field systems[7] a tender using quota is currently under process[8], which allow private sector to connect PV-Systems on tendered locations.

Table 1: Feed-in-Tariffs in Indonesia for Capacities smaller than 10 MW [9]

Source	Feed-In-Tariff [IDR/kWh]	Comment
Hydropower	656	Connected to Medium Voltage (MV)
	1,004	Connected to Low Voltage (LV)
Bioenergy	975	Based on Biomass and Biogas (MV)
	1,325	Based on Biomass and Biogas (LV)
	1,050	Based on municipal solid waste by using a zero waste technology (MV)
	1,398	Based on municipal solid waste by using a zero waste technology (LV)
	850	Based on municipal solid waste by using a sanitary landfill technology (MV)
	1,198	Based on municipal solid waste by using a sanitary landfill technology (MV)

Source	Feed-In-Tariff [USCent/kWh]	Comment
Geothermal[10]	9.7	Connected to High Voltage

The Feed-In-Tariffs for Hydropower and Bioenergy are weighted with a factor ranging from 1.0 to 1.5 depending on the regions the power plant are located. The FIT for Bioenergy is currently under revision (2014) and FIT for PV-Systems and Wind Energy are not yet adopted.

3.2. Electricity Subsidies

The Government of Indonesia, like many countries around the world, has used subsidies for decades to promote a range of social and economic objectives. Subsidies for fuels and electricity receive huge

[5] Grid-connected PV-Systems on roofs of public and private buildings.
[6] Net energy (Difference between Solar Energy generation and energy purchase from PLN) will be settled
[7] Grid-connected PV-Systems on open space
[8] Regulation of the Minister Of Energy And Mineral Resources of The Republic Of Indonesia (Number 17 of 2013) on the Purchase of Electricity by PT Perusahaan Listrik Negara (Persero) from Solar Photovoltaic Power Plants
[9] Ministerial Regulation No. 4, 2012
[10] Ministerial Regulation No. 2, 2011

amounts of public support in Indonesia. The revised budget for 2012 allocated IDR 202 trillion (US$ 22 billion) for fuel and electricity subsidies.

In 2012, the average PLN electricity generation costs amounted to 1,217 IDR/kWh whereas the average electricity tariff was 728 IDR/kWh. The allocated subsidies for electricity were 6 Billion USD. To reduce the subsidies for electricity, the industrial tariffs for electricity are expected to be risen in 2014.

4. Energy Supply in Indonesia

4.1. PLN Power Generation

In 2012, the overall installed capacity in PLN grid was 32,902 MW of which 25,787 MW was installed on the Island of Java (78%). Figure 3 shows the proportion of the various generation units in detail. The majority of the installed capacities are coal-fired steam power plants followed by combined cycle and natural gas. The share of diesel generators (2,600 MW) results in 8% of the overall installed capacity.

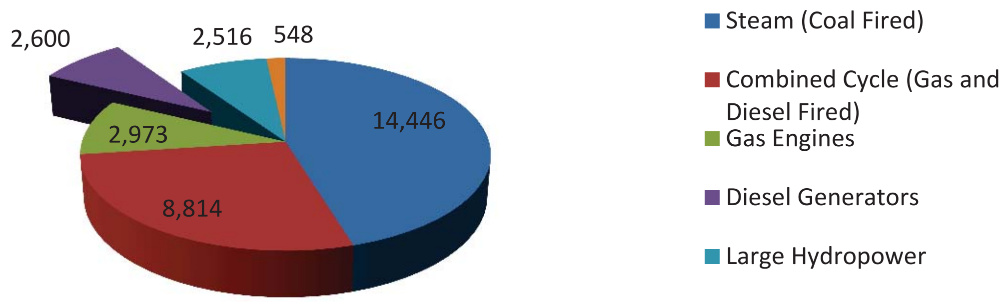

Figure 3: Installed Capacities in PLN Grid 2012 in MW

Due to Indonesia's unique geographical conditions, the energy supply is - besides the Java-Bali Grid and regional larger grids in Sumatra, Kalimantan and Sulawesi – mainly provided by smaller island-grids which are mainly located in the Eastern Part of Indonesia. The overall installed capacity in Indonesia amounted in 2012 to 32,902 MW.

The total number of PLN owned power plant unit stands at 5,048, out of this 3,600 are outside Java-Bali-Grid and Sumatra.

It can be concluded, that on the islands of Java, the energy supply is mainly dominated by larger power plants with an average capacity of around 90 MW (25,787 MW installed capacity, 282 units).

In contrast to that, the remaining part of Indonesia (without Java-Bali and Sumatra) is mainly powered by smaller generators with an average capacity of 700 kW (2,555 MW installed capacity, 3,600 units).

Diesel generators participate with an overall number of 4,576 units with 91% dominantly to the power supply infrastructure whereas the share of energy production contributes only with around 13% to the energy production in PLN grid[11] (18,913 GWh).

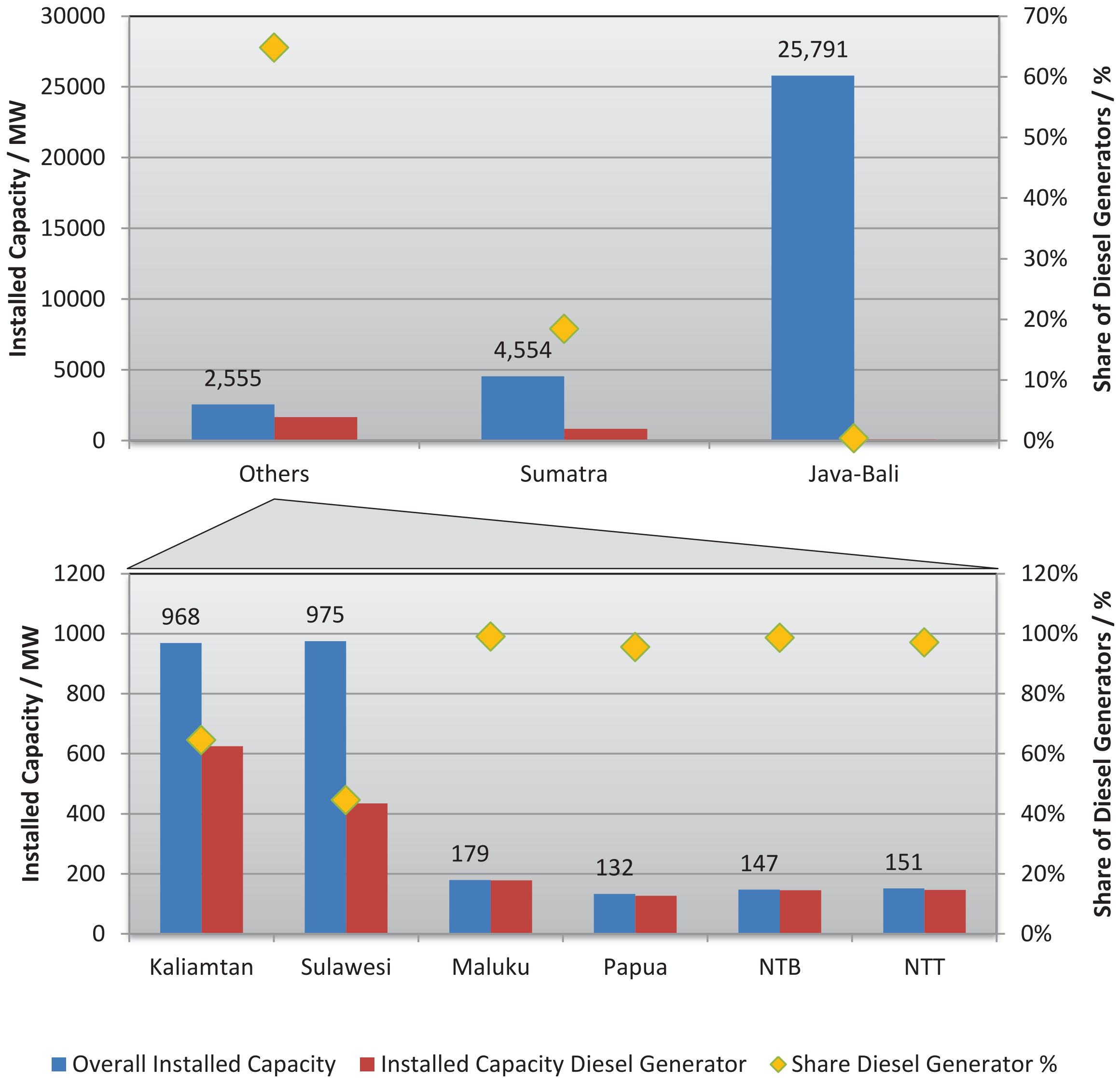

Figure 4: Regional installed capacities and share of diesel generator

The graph above reflects this situation by showing the number of overall installed generation units and the local share of diesel generators (Figure 4). In the Java-Bali-grid (including generation units on Bali itself) the share of diesel generators to the overall power supply is negligible. On Sumatra, the local share of diesel generators amounts to 19%. The region Sumatra includes in the following chapters the Power Generation of Northern and Southern Sumatra[12], as well as local generation units and the regions Bangka-Belitung and PT PLN Batam.

[11] Energy production by PLN (own and rented generation units) and IPP
[12] Based on definition in PLN Statistics 2012

In the remaining part of Indonesia, the average share of diesel generators amounts to an average share of 65%. Especially in the regions besides Kalimantan and Sulawesi which still have a share of coal- and gas-fired power plants, the regions Maluku, Papua and Nusa Tenggara are mainly exclusively supplied by diesel generators. Combining the results on diesel generator share and the average capacities underlines, that the Eastern part of Indonesia is mainly operated in smaller island diesel-grids with an average generator capacity of 700 kW.

4.2. Energy Production in PLN Grid

In 2012, the overall energy production in the PLN grid was 200,317 GWh. PLN's own production amounted to 149,755 GWh, whereas purchased energy from third parties (IPPs) accounted to 50,563 GWh.

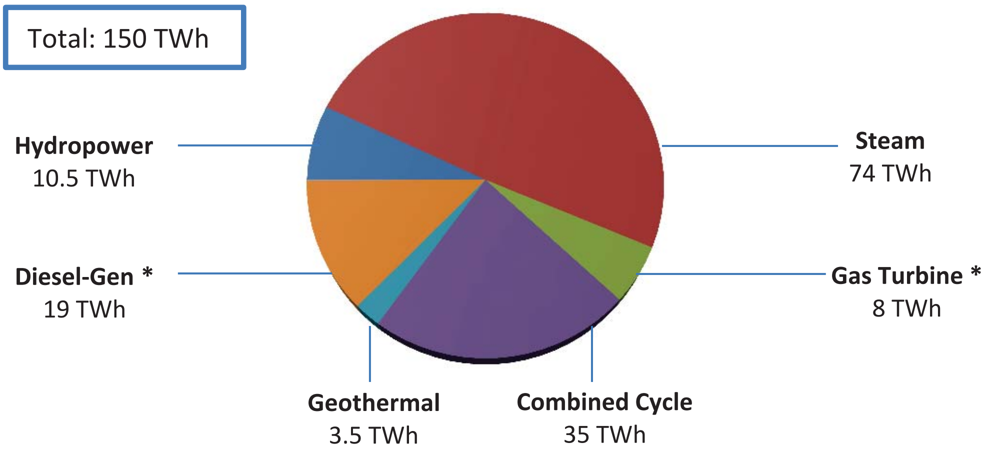

Figure 5: PLN Electricity Generation in 2012 (* included rented generation units, rounded figures)

The largest share of PLN's own energy production (150 TWh, including PLN own[13] and units rented by PLN) in 2012 were steam power plants with an overall electric energy production of 73,823 GWh (around 50%), followed by combined cycle power plants which are usually operated using diesel-fuel or natural gas with 34,569 GWh. The proportion of the remaining sources as diesel generators (18,913 GWh), hydropower (10,525 GWh) and geothermal (3,558 GWh) amounts to an overall contribution of around 22% to PLN's own production.

Renewable Energy (large hydropower and geothermal power plants) contribute to Indonesia's Energy mix of 7%. The installed capacity of photovoltaic systems in PLN grid in 2012 amounted negligibly to 6.2 MW with an annual energy production of 2.8 GWh. The total energy produced in 2012 from diesel-fuel (including diesel generators, combined cycle and diesel gas) amounted to 29,640 GWh. Out of this, diesel generators produced only 18,913 GWh. Figure 6 shows a detailed overview on the overall energy production, the energy production using diesel fuel and the energy produced by diesel generators.

[13] Including PLN subsidiaries i.e. PT Indonesia Power, PT PJB, PT PLN Batam, PT PLN Tarakan

Especially on Sumatra, the total diesel fuel consumption led to an energy production of 11,511 GWh whereas the produced energy using diesel-generators amounted to 6,587 GWh. On Java, the total energy produced by diesel fuel was 6,758 GWh compared to 1,505 GWh using diesel-generators. In the remaining regions of Indonesia, the share of additional diesel-fuel usage by Combined Cycle Power Plants is nearly neglectable.

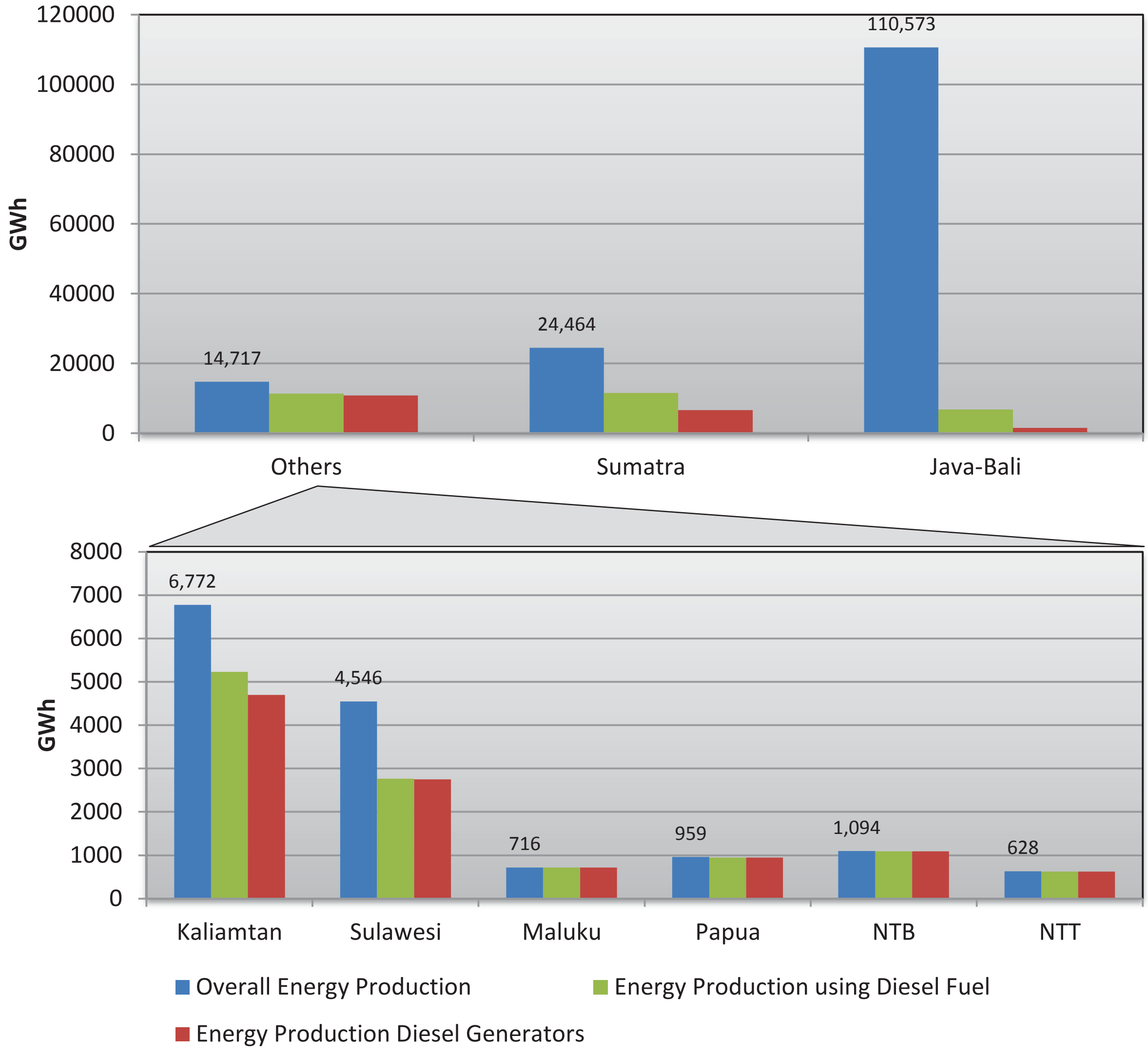

Figure 6: Overview on total energy production, energy production by diesel fuel and diesel-generators on province level

This number underlines, that the overall diesel fuel replacement potential also requires taking the diesel-fuel of Combined Cycle Power Plants into account. The additional reduction potential of Combined Cycle power plants (Diesel Gas neglected) amounts to around 11,000 GWh diesel-fuel equivalents (29,640 GWh produced using diesel fuel compared to 18,913 GWh using diesel-generators)

4.3. Diesel Fuel Consumption

For further investigation, we calculated the total diesel fuel consumption (including HSD, MFO and IDO[14]) based on an assumed average generator efficiency of 35% and based on regional fuel prices paid by PLN from their 2012 statistic. PLN data in 2012 show a diesel-fuel consumption of 8.2 Mio kilo liter. Compared to our calculation, the results differ only by 3%.

As mentioned earlier, the generation costs for electricity differ drastically in the different regions of Indonesia mainly caused due to varying share of more cost-efficient steam power plants abut also due to different levels of diesel-fuel costs (Figure 8).

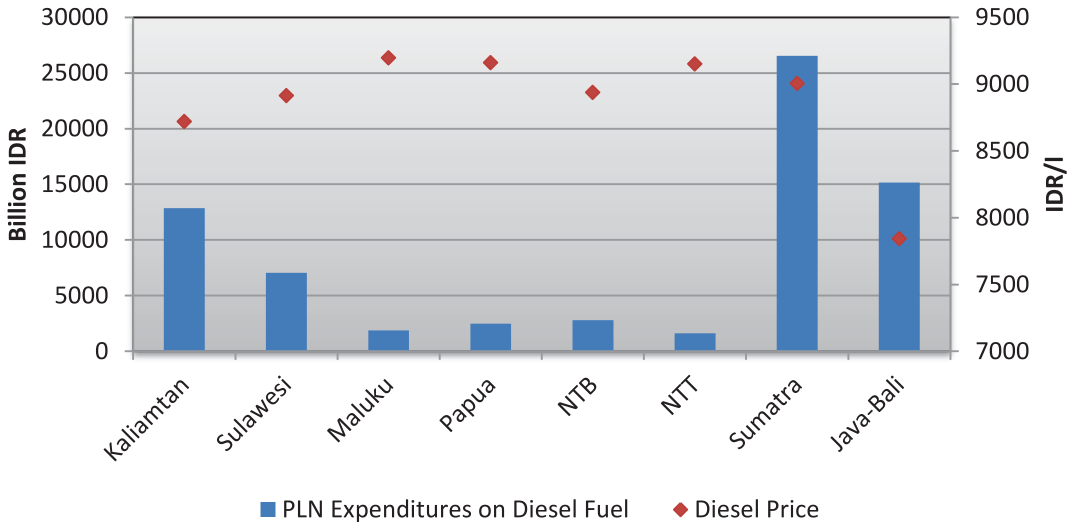

Figure 8: Diesel fuel costs per liter and overall PLN expenditures on diesel fuel 2012

The lowest level of diesel-fuel costs with an average value of 7843 IDR/l is in Java. The costs for diesel-fuel in Sumatra (average) are with 9006 IDR/kWh close to the high costs in the more remote areas of Indonesia. This comparable high number results of the respective high diesel costs for the smaller energy production in Sumatra besides the larger production of Northern and Southern Part of Sumatra[15] (average 8750 IDR/l). The regions Maluku and Nusa Tenggara Timur show the highest diesel-fuel costs (9195 IDR/l respectively 9150 IDR/l).

As presented in Figure 9, the main fuel consumption is on Java (1.9 million kilo liter) and Sumatra (3.3 million kilo liter). Taking the actual share of diesel generators and the respective energy production into account (Figure 6) this high share is mainly caused due to the contribution of Combined Cycle Power Plants. The comparable lower share of the remaining regions to Indonesia's fuel-consumption is mainly exclusively caused by diesel-generators.

[14] High Speed Diesel (HSD), Marine Fuel Oil (MFO), Industrial Diesel Oil (IDO)
[15] Definition based on PLN Statistics 2012

Based on this numbers, the total expenditures for diesel-fuel in 2012 amounted to around 70,000 billion IDR (7 billion USD).

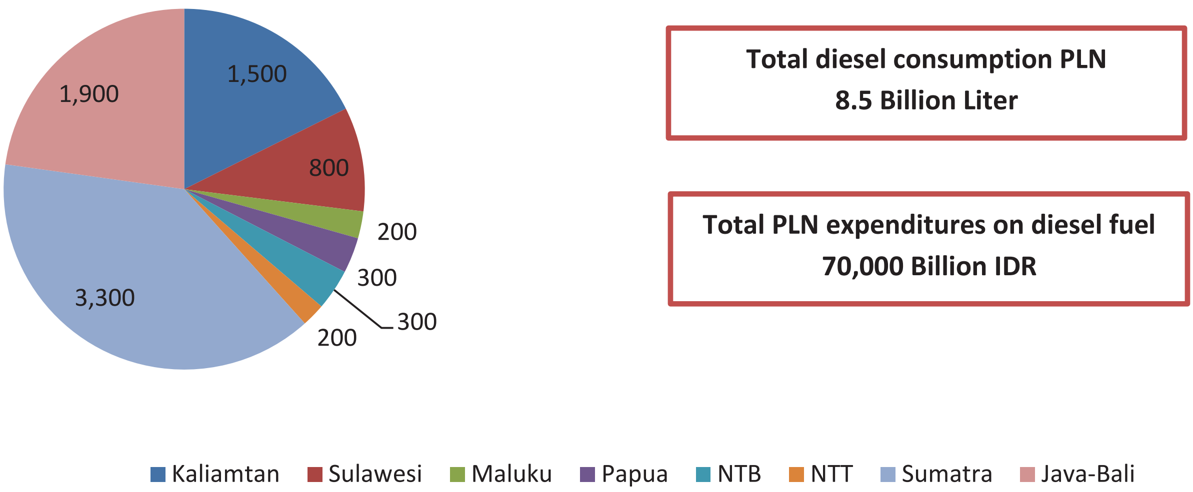

Figure 9: PLN Diesel Fuel consumption in 2012

The main findings of this chapter are highlighted in the following:

Main Findings

- 4,500 diesel generators in total (out of 5,050 units)
- 13% of total electricity production using diesel generators
- 3,600 diesel generators outside Java-Bali and Sumatra
- 2,555 MW installed outside Java-Bali and Sumatra
- 8.5 billion liter diesel fuel consumption in 2012 by PLN
- 70,000 billion IDR expenditures for diesel fuel in 2012 by PLN

5. Potential of Grid-Connected Photovoltaic in Indonesia

5.1. Theoretic Potential

The theoretic potential of replacing diesel-fuel by Grid-Connected Photovoltaic can be evaluated in a first simplifying step by breaking down on province level. The overall diesel-fuel consumption for electricity production by province is shown in Table 2.

With the above assumptions the theoretical saving potential for diesel fuel replacement is 8.5 million kilo liter diesel-fuel (including HSD, MFO and IDO) and respectively 22.7 MtCO2/year[16]. These

[16] Assumption: 2.68 kg CO2 per liter diesel (http://www.eia.gov/oiaf/1605/coefficients.html)

numbers include diesel-fuel consumption for diesel generators, combined cycle power plants and diesel gas engines. The reduction potential only replacing diesel generators would amount to 5.4 million kilo liter diesel-fuel respectively 14.5 MtCO2 per year.

Table 2: Theoretic Diesel-Fuel Replacement based on PLN Statistics 2012

Province	Total Diesel-Fuel[17] consumption Generator + CC	GHG Saving Potential	Diesel-Fuel Consumption[18] Diesel-Generator	GHG Saving Potential
	Mio Kilo liter	MtCO2/year	Mio Kilo Liter	MtCO2/year
Kalimantan[19]	1.54	4.0	1.34	3.60
Sulawesi	0.78	2.1	0.78	2.10
Maluku	0.20	0.5	0.20	0.55
Papua	0.27	0.7	0.27	0.72
NTT	0.31	0.8	0.31	0.84
NTB	0.18	0.5	0.18	0.48
Sumatra[20]	3.29	8.8	1.88	5.04
Java - Bali	1.93	5.2	0.43	1.15
Total	8.50	22.7	5.4	14.48

Compared to Indonesia's goal to reduce greenhouse gas emissions by 20% based on BAU case in 2020 (equal to 0.8 GtCO2 without international support) the theoretical saving potential of 14.45 MtCO2 respectively 22.7 MtCO2 could contribute significantly to Indonesia's GHG-emission reduction plan.

In case the diesel fuel consumption of PLN could be totally replaced by PV in 2015, 72 MtCO2 (113 MtCO2 including Combined Cycle) could be saved until 2020, which would completely cover the GHG-emission reduction goal for the Energy and Transport sector!

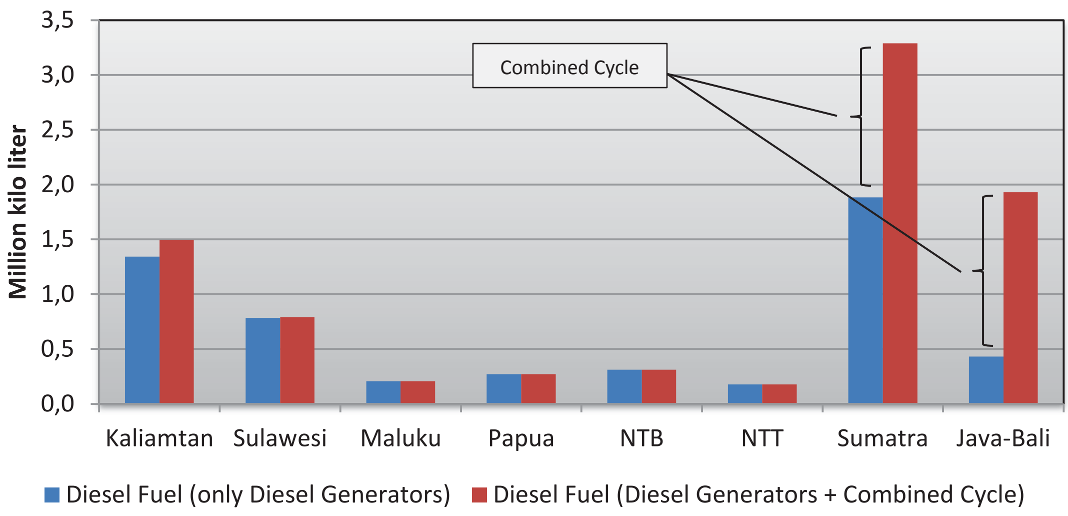

Figure 10: Theoretic Diesel Fuel replacement potential

[19] Including PT PLN Tarakan
[20] Including Bangka Belitung and PT PLN Batam

Compared to Renewable Energy sources provided by constant fuel input and operation such as bioenergy, geothermal and hydropower especially for wind and solar energy the fluctuating and seasonal input affects the power output. This fluctuating power output of PV-systems brings big challenges to local grid-operators to ensure service security both under load- and solar irradiation fluctuations.

In the following the regional technical potential for diesel-fuel replacement using Solar PV is investigated more detailed.

Figure 11 shows exemplarily a typical daily load characteristic (red line). The installed capacity of all generation units in PLN grid is be considered as constant during the interval. In electric power grids, generation units are operated at rated capacities, which is lower than the installed capacities. This is to ensure power generation reserve (frequency control and spinning reserve) in case of fluctuating load behavior to guarantee grid stability.

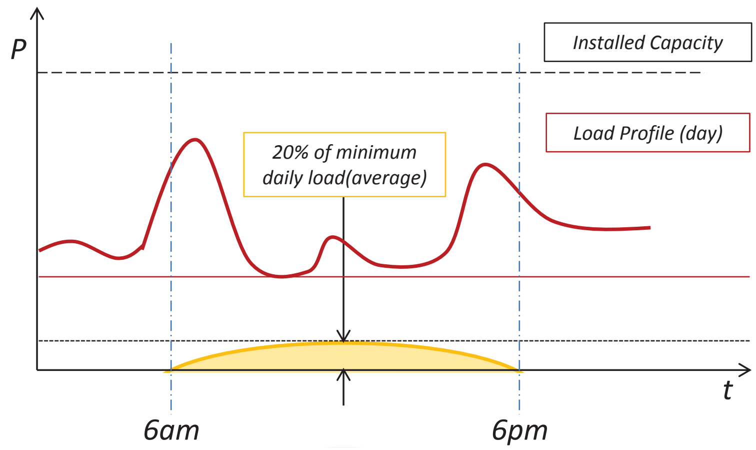

Figure 11: Correlation between Installed Capacity, Load Profile and PV-Penetration potential

In PLN grid, the highest load typically usually occurs in the morning and in the evening. During daytime, the load is usually constantly lower and grid-operators schedule their generation units accordingly.

The capacities of PV-systems, which can be connected to PLN distribution grids depend on several factors. Whereas in larger grids (especially Java-Bali), usually large coal-fired power plants build the majority of power production, in smaller island grids (several) diesel generators are operated. Fluctuating load demand and fluctuating PV power production lead to an imbalance between generated and consumed power. To overcome grid instability, the actual operating generators must provide positive and negative reserve power to guarantee balance and thus grid-stability (spinning reserve).

To overcome grid-instability with increasing share of PV-systems, a control communication between generator and Solar Energy is essential. By balancing the generator output power and respective control of the Solar PV-Systems power output according to the generator operation point (partial load) and current load, a safe and efficient power production can be achieved.

Both to increase and to estimate the maximum level the PV-penetration level, the regional load and generator-management must be evaluated and – in case of increasing PV-penetration – grid management must be optimized. To evaluate the technical implementation potential of grid-connected PV systems into the different province PLN grids, a maximum PV penetration (peak-power) of 20% of the daily minimal load is assumed[21]. This number will deliver a safe approximation regarding grid-stability (frequency control and spinning reserve).

Under real situations given in regional PLN grids, the technical potential might be higher. Especially in smaller island grids which are mainly exclusively operated by diesel-generators, the relative PV penetration potential is higher, as the response time of diesel generators to increase/decrease power production to ensure power balance is faster compared to larger power plants. As detailed information on smaller province grids is not available, the calculations are based on province level.

To calculate the solar energy yield – and thus the diesel-fuel replacing potential – regional solar irradiations are considered. The calculation is done under the following assumptions:

Calculation parameters for PV-potential

1. Maximum **PV-capacity** per province is assumed to be **20% of the daily minimal load**
2. The **daily minimal load** is assumed to be **30% of the installed capacity**
3. Different solar irradiations on province level
4. Same system efficiency for all provinces (Table 3)
5. Each kWh solar energy will replace each kWh diesel fuel generated energy
6. Constant diesel generator efficiency [22] for diesel-fuel calculation

Under these assumptions, at least 2,000 MWp grid-connected Solar PV systems can be installed in PLN grid without any grid or load management

The theoretic solar energy generation can be calculated using the peak power of the technical possible PV capacity, the active module surface multiplied with the average annual solar irradiation on the horizontal surface. Furthermore, temperature losses due to increasing module temperature and solar irradiation losses (reflection / mounting angel differs from zero) are taken into account.

Based on the assumptions and calculations mentioned above, the possible solar energy generation is shown in Table 4 on province level. The regional data is attached in the Appendix.

The technical potential for GHG-emission reduction potential can be calculated using

$$CO2\ [kg] = 2.68\ kgCO2/l.$$

[21] Rule-of-Thumb based on experiences on grid-operators and system integrators
[22] Generator operation stability issues and reduced generator efficiency in partial load in the calculations neglected

Monthly Averaged Insulation on Horizontal Surface	kWh/m2/day
PV-module surface	7 m^2/kWp[23]
Losses Solar Irradiation	10%[24]
Losses due to module efficiency	85%
Temperature and Electrical losses	20%[25]

Table 3: Assumptions for calculating Solar Energy yield

The expectable energy output is 2,800 GWh/year and respectively 2.16 MtCO2/ year can be saved! From the table below it can be seen that the highest potential is in Java-Bali with 80 % and Sumatra with 12 %. In both provinces the electrification rate and grid availability is high (> 85%).

Table 4: PV capacities, solar irradiation and resulting annual solar energy yield and GHG-Emission reduction potential

	Daily Minimum Load[26] (30% of Installed Capacity)	PV Capacity[27] (20% of minimum load)	Solar Irradiation (average)	Solar Energy Yield	GHG-Emission reduction
	MW	MWp	kWh/m2/day[28]	GWh/year	MtCO2/year
Kalimantan	291	58	4.8	77	0.059
Sulawesi	293	59	5.3	83	0.064
Maluku	54	11	5.4	16	0.013
Papua	40	8	4.9	11	0.008
NTB	44	9	5.4	13	0.010
NTT	45	9	5.9	15	0.011
Sumatra[29]	1366	273	4.6	345	0.264
Java-Bali	7737	1,548	5.3	2,259	1.730
Sum		1,975	-	2,819	2.16

The total expectable energy yield from 2,000 MWp PV capacity amounts to 2,800 GWh per year. 9.5% for the electric energy could be replaced.

Main Findings Technical Potential
(static, without energy demand increase)

- At least **2,000 MWp can be installed** in PLN grid without any grid or load management
- **2.8 TWh** electric energy can be produced all over Indonesia using Solar PV systems
- **9.5% of diesel-fuel can be replaced**
- **850,000 kilo liter diesel** fuel can be saved
- The **GHG** reduction potential more than **2 MtCO2/year**

[23] Polycrystalline Panel 230 Wp / 1.6 m^2
[24] Based on simulations of a 100 kWp System in Maumere, Flores (Mounting angel 10 Degrees, 5.92 kWh/m^2/day)
[25] Based on simulations of a 100 kWp System in Maumere, Flores
[26] 30 % of installed capacity assumed
[27] Based on assumption of 20% PV-penetration potential of average load during daytime
[28] Average values. Based on NASA Surface Meteorology and Solar Energy
[29] Including Bangka-Belitung and Batam

6. Electricity Generation Costs for Grid Connected Solar PV

This chapter shows the calculation of electricity costs or PV systems in different regional conditions. The *Levelised Costs of Energy* (LCOE) for Solar PV-Systems can be calculated as follows:

$$LCOE = \frac{\sum \frac{(I_t + OM_t)}{(1+d)^t}}{\sum \frac{(E_t)}{(1+d)^t}}$$

- I_t are the annual expenditures for investment
- OM_t are the annual operation and maintenance costs
- E_t is the annual expectable energy yield
- *d* is the discount factor.

Both the financial parameters and the annual expected energy yield are weighted with the discount factor *d*. In this case, the discount factor is approximated using the WACC (Weighted Average Capital Costs).

The WACC is calculated using

$$WACC = (1 - I_T) \cdot C_D \cdot S_D + C_E \cdot S_E$$

Where I_T is the income tax, S_D and $_S$E is the share of debts and equity and C_D and C_E are the Costs of Debt respectively Cost of Equity. The Costs of Debt is assumed to be the credit interest rate and Costs of Equity is set to 20%.

To calculate the LOCE under given solar irradiation and specific investment costs, the following financial parameters are chosen to be constant. A detailed of the LCOE calculation is exemplarily shown in the Appendix.

Table 5: Values for calculation of the Levelized Cost of Electricity (LCOE) for a 1 MWp-System

System Parameters		**Financial Parameters**	
Operation and Maintenance	30 USD/kWp/ a	Loan / Equity	80% / 20%
Degradation Output	0.5% p.a.	Interest rate	10%
		Income tax	25%
		Inflation rate	7%

The results of the LCOE calculation high and low solar irradiations are shown in Figure 12, by varying the specific investment costs.

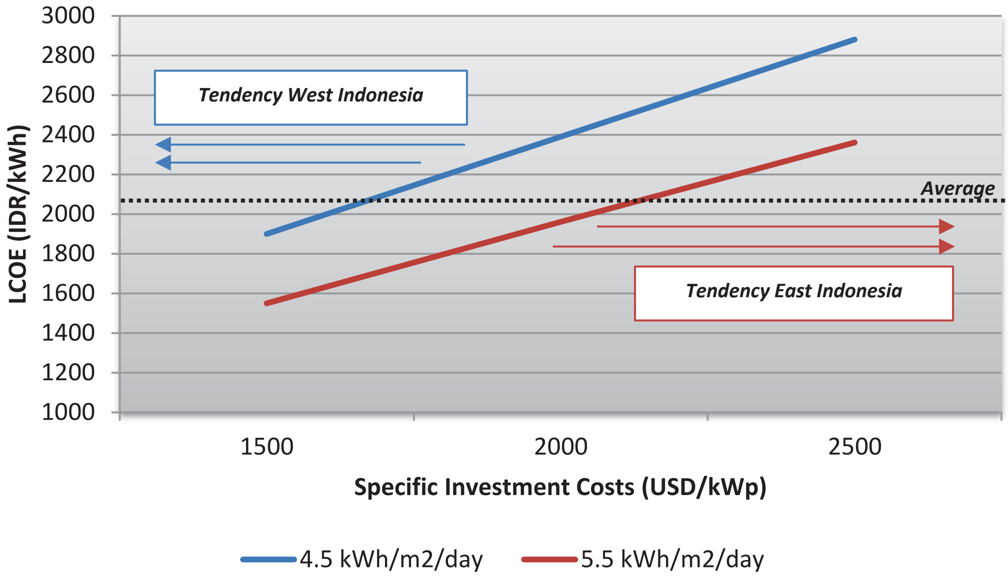

Figure 12: LCOE as a function of different specific investment costs and solar irradiation

LCOEs for PV-systems range from 1500 – 3000 IDR/kWh[30] with an average LCOE of around 2000 IDR/kWh. The tendencies for LCOE vary besides the specific investment costs also on the solar irradiation. Whereas in the Western part of Indonesia compared to the Eastern part generally lower solar irradiation is given, the specific investment costs are expected to be lower due to easier accessibility for installation, operation and maintenance. In contrast, in the Eastern part the specific investment costs are higher due to higher transportation costs and worse accessibility. Compared with Figure 12 and the tendencies mentioned above, an average LCOE in Indonesia in the range of 2000 – 2200 IDR/kWh can be seen as realistic.

7. Economic Potential and Outlook to 2020

This chapter investigates the investment costs of a step by step installation of grid-connected PV and the resulting fuel costs savings for PLN. Thus the economic impact of diesel-fuel replacement by PV is evaluated in this chapter.

According to PLN Statistics 2012, the average annual diesel fuel price for PLN power production in 2012 was 8229 IDR/l. Under assumption of an annual average price increase for diesel fuel of 10% per year, the average diesel fuel price will exceed 10,000 IDR/l in 2015, leading to an average diesel generator electricity generation costs of 4,000 IDR/kWh[31].

[30] 1 USD = 10,000 IDR
[31] Assumption: 30% generator efficiency, 30% additional costs for operation and maintenance etc.

Implementation -Scenario until 2020:

- **350 MWp initial implementation** in 2014
- Annually **50%** PV capacity **increment per year** compared to the previous year until the technical potential is fully implemented in 2020
- The **technical potential** increases with 9.5% per year due to energy demand increase and leads to a technical potential of **4 GWp in 2020**.
- **After 2020, 9.5% additional** PV capacity per year
- **10% diesel-fuel costs increase per year**
- **No new diesel generators** are installed

In 2014 an initial implementation of 350 MWp is assumed with an annual additional implementation of Solar PV systems of 50% per year (compared to the previous year) until the maximum technical potential (blue dot-line) is reached in 2020 (4 GWp). After reaching the maximum technical potential, the PV capacity implementation increases with the annual energy demand increase (9.5%) assuming an equal extension of power plants allover Indonesia (Figure 13 a)

Figure 13 b) shows the economic impact replacing diesel-fuel with solar energy. The generation costs for Solar Energy are assumed to be 2000 IDR/kWh resulting from the averaged calculated LCOE in Chapter 6. This number can be interpreted both as electricity generation costs by PLN itself and as off-taker from IPPs. The implementation of 350 MWp in 2014 results in 500 GWh produced energy by grid-connected PV and thus generation / purchase costs of around 100 Million USD.

The energy production of 20,000 GWh[32] by diesel fuel costs 5.97 Billion USD. An energy production of 500 GWh using Solar PV results in a decreased diesel fuel demand (19,500 GWh) in 2014. The expenditures for diesel fuel amount respectively to 5.82 Billion USD leading to reduced diesel fuel costs of 150 Million USD.

In year 2014, the costs for reimbursement for the LCOE / purchase costs amounted to 100 Million USD. The effective savings in the year 2014 respectively result in 50 Million USD (savings due to reduced diesel fuel consumption and costs on Solar Energy). In the following years, the savings will increase due to a drastic diesel fuel price increase and increasing share of PV capacities.

Increasing Solar Energy share and diesel fuel price result in higher annual saving potential. In 2020, the annual savings reach 2 Billion USD per year leading to an accumulated value of around 4 Billion USD (Figure 13 b) and an theoretic diesel fuel replacement of around 30% compared to the baseline of 20,000 GWh in 2013 (c).

[32] Assumption for 2013 based on 18.912 GWh in 2012, for economic calculation and theoretical expenditures diesel fuel, the energy production in 2013 is taken as a baseline weighted with an increasing diesel fuel price

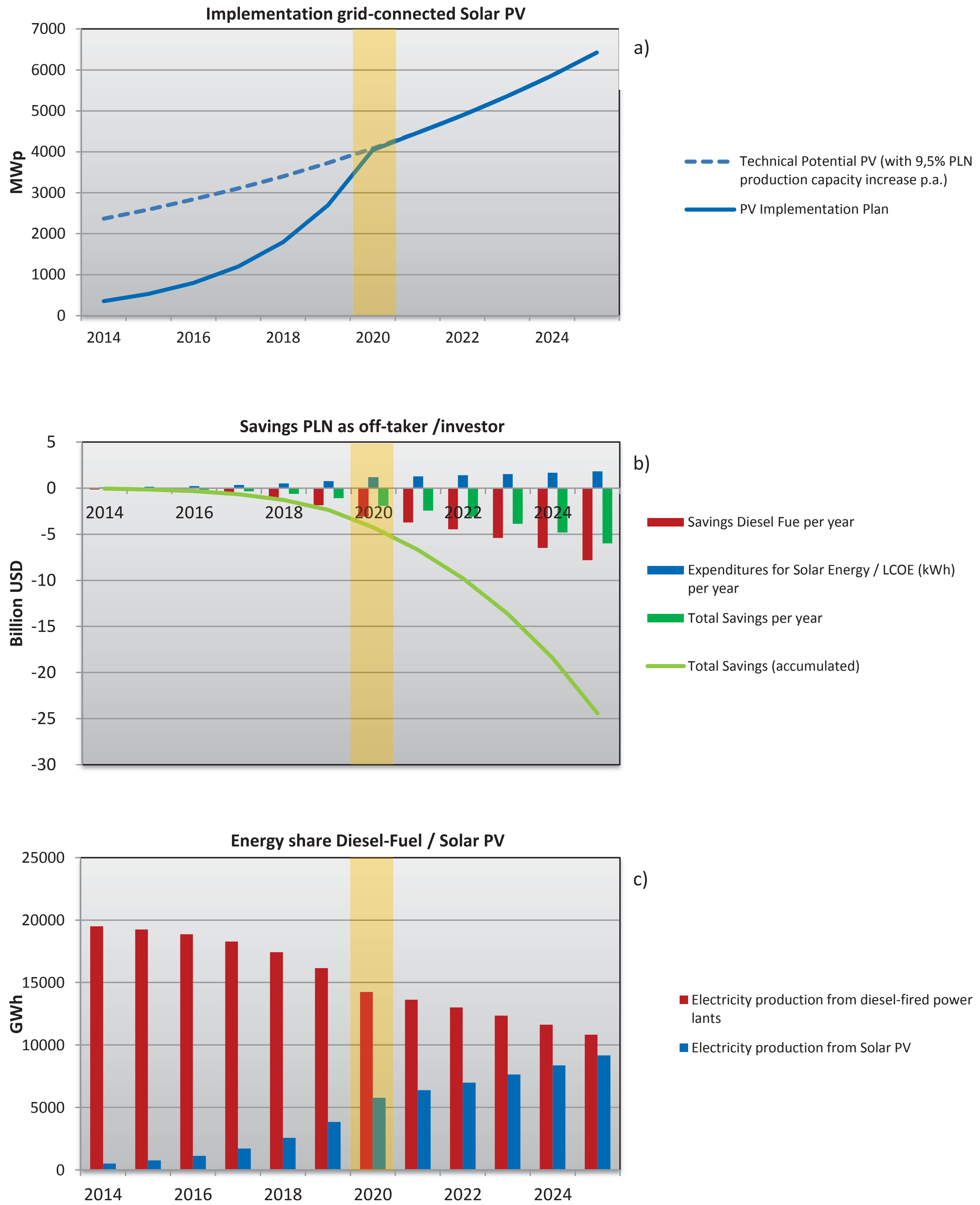

Figure 13: Technical potential grid-connected Solar PV and observed implementation scenario (a), Economic Potential replacing diesel fuel (b) and Energy Production share using diesel-fuel and Solar PV generated energy (c)

The initial implementation expenditures amount to 700 million USD (350 MWp, assuming 2000 USD/kWp). In 2020, the total cumulated costs of realizing the PV potential and the implementation scenario amounts to 8 billion USD.

Besides the huge economic saving potential there is also a diesel fuel and GHG-emission reduction potential as shown in Figure 14. Once implemented the full technical potential by 2020 (4 GWp), the annual diesel fuel saving will reach 1.7 billion liter replaced with 5,800 GWh Solar Energy. Until 2020, the diesel fuel saving would accumulate to 4.8 billion liter. The replaced diesel fuel will reduce the GHG-emission by 13 MtCO2 in 2020 (accumulated). Compared to Indonesia's goal to reduce GHG-emissions in 2020 in the Energy and Transport sector by 38 MtCO2, grid-connected photovoltaic systems can contribute with 34% (13 MtCO2).

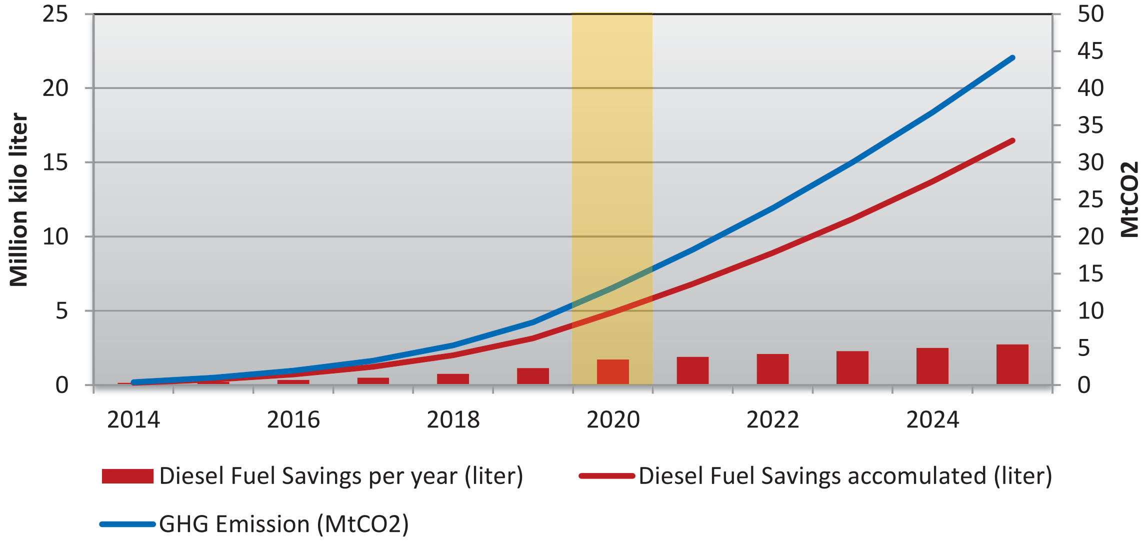

Figure 14: Diesel Fuel and GHG-emission

Main Findings Implementation -Scenario until 2020:

- **In 2020**, the **technical potential** for grid-connected PV systems reaches **4 GWp**
- **By 2020 at least …**
  - ✓ 30% of the diesel-fuel produced energy can be replaced compared to 2013
  - ✓ 4 Billion USD savings through diesel-fuel replacement possible
  - ✓ 4.8 Billion liter diesel-fuel can be saved
  - ✓ 13 MtCO2 GHG can be reduced
  - ✓ 34% can be contributed by Solar PV to Indonesia's climate goal (reduction by 38 MtCO2 in 2020)

Appendix

Table 6: Installed Capacity and Number Generation Units

	Installed Capacity	Overall	Overall Number		
	MW	GWh	Number	Number	% Diesel
		own production	Gen. Units	of Diesel Gen	of Gen. Units
Outside Java-Bali / Sumatra					
Region of West Kalimantan	222,41	1829,58	462	453	98,05%
Region of South Kalimantan	310,92	2088,28	116	110	94,83%
Region of Central Kalimantan	79,01	611,26	286	286	100,00%
Region of East Kalimantan	356,6	2243,14	326	310	95,09%
Region of North Sulawesi	220,6	1314,7	157	137	87,26%
Region of Central Sulawesi	133,68	554,49	268	260	97,01%
Region of Gorontalo	29,11	208,77	24	22	91,67%
Region of South Sulaeesi	460,41	1831,57	101	75	74,26%
Region of West Sulawesi	6,39	7,68	37	37	100,00%
Region of Southeast Sulawesi	125,4	629,23	183	174	95,08%
Region of Maluku	135,06	608,88	393	392	99,75%
Region of North Maluku	44,6	107,89	204	201	98,53%
Region of Papua	88,8	664,61	171	161	94,15%
Region of West Papua	44,17	294,64	158	156	98,73%
Region of NTB	147,3	1094,08	163	155	95,09%
Region of NTT	151,19	628,31	557	549	98,56%
Java Bali / Sumatra					
Region of Aceh	141,78	473,95	229	225,00	98,25%
Region of North Sumatra	12,64	99,65	26	26,00	100,00%
Region of West Sumatra	32,83	165,82	101	96,00	95,05%
Region of Riau	177,31	1165,93	381	380,00	99,74%
Region of South Sumatra	42,27	129,43	98	96,00	97,96%
Region of Lampung	4,79	1,26	38	38,00	100,00%
Power Production S. Sumatra	1902,14	10294,55	100	47,00	47,00%
Power Production N. Sumatra	2048,63	10599,97	76	29,00	38,16%
Sumatra overall	4554,7	24464,05	1145	1032,00	90,13%
Java Overall	25791,29	110573,81	297	66,00	22,22%

Table 7: Diesel Generators (installed and energy production) and Diesel-Fuel

	Diesel Generators			Diesel Fuel (Deisel Gen + CC)		
	MW installed	GWh own	GWh rented	GWh total	Total GWh	Price IDR/l
Outside Java-Bali / Sumatra						
Region of West Kalimantan	186,32	433,50	1295,59	1729,09	1823,31	8370
Region of South Kalimantan	129,92	177,43	721,86	899,29	952,15	9004
Region of Central Kalimantan	79,01	100,08	511,18	611,26	611,26	9004
Region of East Kalimantan	230,22	401,04	1055,58	1456,62	1840,44	8498
Region of North Sulawesi	103,59	124,98	465,98	590,96	590,95	9065
Region of Central Sulawesi	125,13	145,91	387,53	533,44	533,44	9065
Region of Gorontalo	27,91	29,38	174,79	204,17	204,17	9065
Region of South Sulaeesi	74,61	94,05	751,34	845,39	865,61	8760
Region of West Sulawesi	6,39	7,42	0,26	7,68	7,68	8760
Region of Southeast Sulawesi	96,61	144,30	421,48	565,78	565,8	8760
Region of Maluku	134,94	158,77	450,05	608,82	608,82	9195
Region of North Maluku	43,00	54,30	53,14	107,44	107,44	9195
Region of Papua	84,86	183,10	472,06	655,16	655,16	9159
Region of West Papua	42,17	80,13	210,25	290,38	290,38	9159
Region of NTB	145,23	253,54	838,26	1091,80	1091,8	8938
Region of NTT	146,74	247,79	374,62	622,41	622,41	9150
Java Bali / Sumatra						
Region of Aceh	140,03	88,92	379,83	468,75	468,75	9136
Region of North Sumatra	12,64	15,30	84,36	99,66	99,65	9408
Region of West Sumatra	31,98	36,45	128,81	165,26	165,26	8917
Region of Riau	163,31	206,27	959,32	1165,59	993,3	9238
Region of South Sumatra	40,67	37,92	89,67	127,59	127,6	9135
Region of Lampung	4,79	1,26	0,00	1,26	1,26	8738
Power Production S. Sumatra	133,73	70,33	643,79	714,12	879,85	8937
Power Production N. Sumatra	119,36	85,17	2761,57	2846,74	7961,88	8536
Sumatra overall	838,78	722,27	5865,44	6587,71	11511,51	
Java Overall	103,21	126,46	1379,16	1505,62	6758,25	7843

Table 8: Solar Irradiation on Province Level

	E/W	N/S	kWh/m2/year
Outside Java-Bali / Sumatra			
Region of West Kalimantan	110,0	0,0	4,78
Region of South Kalimantan	115,5	-3,0	4,84
Region of Central Kalimantan	113,5	-1,5	4,84
Region of East Kalimantan	116,0	1,5	4,84
Region of North Sulawesi	125,0	1,0	6,68
Region of Central Sulawesi	120,0	0,0	5,10
Region of Gorontalo	112,5	1,0	5,90
Region of South Sulaeesi	120,0	-4,0	4,95
Region of West Sulawesi	119,3	-2,3	5,37
Region of Southeast Sulawesi	122,0	-3,5	4,93
Region of Maluku	129,0	-3,0	5,64
Region of North Maluku	128,0	1,0	5,25
Region of Papua	138,5	-5,0	4,67
Region of West Papua	132,5	-1,5	5,09
Region of NTB	116,0	-8,5	5,40
Region of NTT	122,5	-8,5	5,92
Java Bali / Sumatra			
Region of Aceh	97,0	4,2	4,51
Region of North Sumatra	99,5	2,0	4,47
Region of West Sumatra	100,5	-0,5	4,90
Region of Riau	102,0	0,5	4,61
Region of South Sumatra	104,5	-3,0	4,66
Region of Lampung	105,0	-5,0	4,83
Power Production S. Sumatra	104,5	-3,0	4,66
Power Production N. Sumatra	99,5	2,0	4,47

Table 9: Solar Potential and expectable Energy Yield

	Base Load		Solar PV			
	MW	MWp	kWh/m2/day	GWh/year	equals fuel	MtCO2e
	% of inst. C ap.	20% of Dily-Avg.	NASA		kilo liter	
Outside Java-Bali / Sumatra	30%				35%	2,68 kg / liter
Region of West Kalimantan	66,7	13,3	4,78	17,60	5029	0,013
Region of South Kalimantan	93,3	18,7	4,84	24,91	7119	0,019
Region of Central Kalimantan	23,7	4,7	4,84	6,33	1809	0,005
Region of East Kalimantan	107,0	21,4	4,84	28,58	8164	0,022
Region of North Sulawesi	66,2	13,2	5,68	20,75	5927	0,016
Region of Central Sulawesi	40,1	8,0	5,10	11,29	3225	0,009
Region of Gorontalo	8,7	1,7	5,90	2,84	812	0,002
Region of South Sulaeesi	138,1	27,6	4,95	37,73	10781	0,029
Region of West Sulawesi	1,9	0,4	5,37	0,57	162	0,000
Region of Southeast Sulawesi	37,6	7,5	4,93	10,24	2924	0,008
Region of Maluku	40,5	8,1	5,64	12,61	3603	0,010
Region of North Maluku	13,4	2,7	5,25	3,88	1108	0,003
Region of Papua	26,6	5,3	4,67	6,87	1962	0,005
Region of West Papua	13,3	2,7	5,09	3,72	1064	0,003
Region of NTB	44,2	8,8	5,40	13,17	3763	0,010
Region of NTT	45,4	9,1	5,92	14,82	4234	0,011
Java Bali / Sumatra						
Region of Aceh	42,5	8,5	4,51	10,59	3025	0,008
Region of North Sumatra	3,8	0,8	4,47	0,94	267	0,001
Region of West Sumatra	9,8	2,0	4,90	2,66	761	0,002
Region of Riau	53,2	10,6	4,61	13,53	3867	0,010
Region of South Sumatra	12,7	2,5	4,66	3,26	932	0,002
Region of Lampung	1,4	0,3	4,83	0,38	109	0,000
Power Production S. Sumatra	628,3	125,7	4,66	161,59	46169	0,124
Power Production N. Sumatra	614,6	122,9	4,47	151,61	43318	0,116
Sumatra overall	1366,4	273,3		344,57	98448	0,263841287
Java Overall	7737,387	1547,5	5,29	2258,89	645396	1,7297

Table 10: Calculation Diesel-Fuel replacement and Economic Impact (2014 – 2025)

Year	Diesel		Diesel Costs	Diesel Costs	Savings	Savings	Savings	Savings	Savings	PV	PV	PV	PV	PV	PV
			Replacement	*No replacement*		*Diesel Fuel*	*GHG-Emission*	*Diesel Fuel acc.*	*GHG-Emission acc.*	*Max Potential*	*Implementation*	*Yield*	*Investment*	*Generation Costs*	*Generation costs acc.*
	GWh	IDR/l	Bil USD	Bil USD	Bil USD	Kilo Liter Saved	MTCO2	Kilo Liter.	MtCO2	MWp	MWp	GWh	Billion USD	Million USD	Million USD
2013	20000	9052	5,43	5,43	0,00										
2014	19493	9957	5,82	5,97	-0,15	152121	0,41	152121	0,41	2367	355	507	0,71	101	101
	19239	10953	6,32	6,57	-0,25	228182	0,61	380303	1,02	2592	533	761	1,07	152	254
2016	18859	12048	6,82	7,23	-0,41	342273	0,92	722577	1,94	2838	799	1141	1,60	228	482
	18289	13253	7,27	7,95	-0,68	513410	1,38	1235987	3,31	3108	1198	1711	2,40	342	824
2018	17433	14578	7,62	8,75	-1,12	770115	2,06	2006103	5,38	3403	1797	2567	3,59	513	1.337
	16149	16036	7,77	9,62	-1,85	1155173	3,10	3161276	8,47	3726	2696	3851	5,39	770	2.108
2020	14224	17640	7,53	10,58	-3,06	1732759	4,64	4894036	13,12	4080	4044	5776	8,09	1.155	3.263
	13619	19404	7,93	11,64	-3,71	1914248	5,13	6808284	18,25	4468	4468	6381	8,94	1.276	4.539
2022	13013	21344	8,33	12,81	-4,47	2096102	5,62	8904387	23,86	4892	4892	6987	9,78	1.397	5.936
	12349	23478	8,70	14,09	-5,39	2295232	6,15	11199619	30,01	5357	5357	7651	10,71	1.530	7.466
2024	11622	25826	9,00	15,50	-6,49	2513279	6,74	13712898	36,75	5866	5866	8378	11,73	1.676	9.142
	10827	28409	9,23	17,05	-7,82	2752040	7,38	16464939	44,13	6423	6423	9173	12,85	1.835	10.977

Diesel Price Increase	10%	*Per year*
Energy Demand Increase	9.5%	*Per year*
PV Implementation in year 2014	355 MWp	*Of technical potential*
Solar Implementation Increase	50%	*Per year until technical potential is reached*
FIT / LCOE	2000	*IDR/kWh*
Diesel Price year 2014 (average)	9900	*IDR/l*

Table 11: Calculation of LCOE (solar irradiation 5.50 kWh/m2/day and 2000 USD/kWp specific investment costs)

Investment costs and Energy		
Installed capciy	1000	kWp
Investment costs	2000	USD/kWp
Avg. solar irradtiation	5,50	kWh/m2/d
Annual energy yield	2008	kWh/m2
Losses	23%	
Spec Energy yield	1550,19	kWh/kWp
Safety margin	3,00%	
Energy yield	1.503.686	kWh
Degradation	0,50%	%/a
FIT (1st fpriod)	2500	IDR
FIT (1st period)	0,25	USD
FIT2 (2nd period)	2500	IDR
FIT2 (2nd period)	0,25	USD
FIT2 afer x years	10	a

Operation and mainenance costs		
OM-costs/kWp/a	$30,00	30000

Amortization		
Period	20	a
Amortization	100000	USD/a

Installation costs (rapairment etc.)		
Additional costs:	0	USD
every	5	years

Exchange Rate	10000	IDR/USD

Loan		
Equity	20,00%	400000,00
Loan	80,00%	1600000,00
of total investment costs		
Credit period	10	a
Interest	10,00%	%
Annuity	260393	USD

Taxes and inflation		
Income tax	25,00%	%
Inflation	7,00%	%/a

LCOE	0,196	USD/kWh
WACC	10,00%	
Cost of equity	20,00%	
Cost of Debts	10,00%	

Year	Revenues	OM	EBITA	Amortization	EBIT	Outstanding loan	Interests	Redemption	EBT	Taxes	EAT	Cash Flow	EBITA (acc.)	Cash flow (acc.)	DSCR
0			-2.000.000			-1.600.000						-400.000	-2.000.000	-400.000	1,33
1	375.921	-30.000	345.921	-100.000	245.921	-1.499.607	-160.000	-100.393	85.921	-21.480	64.441	64.048	-1.654.079	-335.952	1,31
2	374.042	-32.100	341.942	-100.000	241.942	-1.389.175	-149.961	-110.432	91.981	-22.995	68.986	58.554	-1.312.137	-277.398	1,30
3	372.172	-34.347	337.825	-100.000	237.825	-1.267.700	-138.918	-121.475	98.907	-24.727	74.180	52.705	-974.312	-224.692	1,28
4	370.311	-36.751	333.559	-100.000	233.559	-1.134.078	-126.770	-133.623	106.789	-26.697	80.092	46.469	-640.753	-178.223	1,26
5	368.459	-39.324	329.135	-100.000	229.135	-987.093	-113.408	-146.985	115.728	-28.932	86.796	39.811	-311.617	-138.412	1,25
6	366.617	-42.077	324.540	-100.000	224.540	-825.410	-98.709	-161.683	125.831	-31.458	94.373	32.690	12.923	-105.722	1,23
7	364.784	-45.022	319.762	-100.000	219.762	-647.558	-82.541	-177.852	137.221	-34.305	102.916	25.064	332.685	-80.658	1,21
8	362.960	-48.173	314.786	-100.000	214.786	-451.921	-64.756	-195.637	150.031	-37.508	112.523	16.886	647.471	-63.772	1,19
9	361.145	-51.546	309.600	-100.000	209.600	-236.721	-45.192	-215.201	164.407	-41.102	123.306	8.105	957.071	-55.667	1,17
10	359.339	-55.154	304.186	-100.000	204.186	0	-23.672	-236.721	180.514	-45.128	135.385	-1.335	1.261.257	-57.002	#DIV/0!
11	357.543	-59.015	298.528	-100.000	198.528	0	0	0	198.528	-49.632	148.896	248.896	1.559.785	191.894	#DIV/0!
12	355.755	-63.146	292.609	-100.000	192.609	0	0	0	192.609	-48.152	144.457	244.457	1.852.394	436.351	#DIV/0!
13	353.976	-67.566	286.410	-100.000	186.410	0	0	0	186.410	-46.603	139.808	239.808	2.138.805	676.159	#DIV/0!
14	352.206	-72.295	279.911	-100.000	179.911	0	0	0	179.911	-44.978	134.933	234.933	2.418.716	911.092	#DIV/0!
15	350.445	-77.356	273.089	-100.000	173.089	0	0	0	173.089	-43.272	129.817	229.817	2.691.805	1.140.909	#DIV/0!
16	348.693	-82.771	265.922	-100.000	165.922	0	0	0	165.922	-41.481	124.442	224.442	2.957.727	1.365.350	#DIV/0!
17	346.950	-88.565	258.385	-100.000	158.385	0	0	0	158.385	-39.596	118.789	218.789	3.216.112	1.584.139	#DIV/0!
18	345.215	-94.764	250.450	-100.000	150.450	0	0	0	150.450	-37.613	112.838	212.838	3.466.562	1.796.977	#DIV/0!
19	343.489	-101.398	242.091	-100.000	142.091	0	0	0	142.091	-35.523	106.568	206.568	3.708.653	2.003.545	#DIV/0!
20	341.771	-108.496	233.276	-100.000	133.276	0	0	0	133.276	-33.319	99.957	199.957	3.941.928	2.203.502	
SUM after 20 years	7.171.793	-1.229.865	5.941.928		3.941.928		-1.003.926	-1.600.000	2.938.002	-734.501			3.941.928	2.203.502	

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