Mitigating Climate Change through the Development of Clean Renewable Energy in Southeast Sulawesi, a Developing Region in Indonesia

Ridway Balaka[1a], Aditya Rachman[2a] and Ld Muh. Golok Jaya[3b]

[a] *Department of Mechanical Engineering, Haluoleo University Kampus Hijau Bumi Tridarma Andounohu, Southeast Sulawesi Indonesia*
[b] *Department of Informatics Engineering, Haluoleo University Kampus Hijau Bumi Tridarma Andounohu, Southeast Sulawesi Indonesia*

[+]*Corresponding author email:*[1]*bridway@yahoo.com.au,* [2]*aditya_rchmn@yahoo.com,* [3] *ldmgolok@yahoo.com*

Abstract

Energy plays an essential role in the development of a region. Currently the major source for energy comes from fossil fuel. One of the major unavoidable catastrophic consequences on the utilization of this form of energy is the production of greenhouse gas carbon emission raising the concern about the global challenge of the climate change. The clean renewable power potentially offers a promising solution in delivering clean energy to contribute in the mitigation of the greenhouse gases emissions. The role of developing nations on this mitigation is very important as the major population worldwide lives there. In Indonesia, one of the developing nations, the access of the energy is still becoming a challenge in several of its provinces. Southeast Sulawesi, one of the developing provinces in Indonesia, is still posing the barriers of electricity access for its communities. It is believed that this province has abundant unexplored natural clean energy resources which can be potentially utilized to support the distribution of the energy for the communities as well as to deliver the clean energy in order to contribute in the deceleration on the pace of the greenhouse gas emission. This paper discusses the prospect on the development of the clean renewable power in Southwest Sulawesi. The methodology of generating this paper is literature study of some journal papers, magazines, newspapers and authentic government data. The topic covers the geography-topography and socio-economic condition, the electricity utilization and the problem and the prospect of renewable energy development in Southeast Sulawesi. It is concluded that the natural resources of this province can potentially be harnessed to deliver clean energy in order to cope with its current challenge on the energy distribution for the communities as well as to support the mitigation on the climate change.

Keywords: *Developing region, Climate change, Southeast Sulawesi, Renewable energy*

1. Introduction

Economic growth and improvement of people's living standard are all directly or indirectly related to the increasing utilization of energy [1]. Electricity is one of the energy forms which have been accepted as one of the driving forces of the economic development of all the nations [2]. It is believed that almost 1.6–2 billion people live without access to electricity in which most of them live in the developing countries [3].

It is inevitably that currently the major sources of the energy worldwide come from fossil fuel. Relying merely on the energy based fossil to support the access of the

electricity for the communities in developing countries seems to be less appropriate option as the limitation and, importantly the detrimental environmental impact of the greenhouse gas carbon emission raising the concern on the climate change.

The role of developing nations in the mitigation of the climate change is so indispensable. The condition of the population on these nations can be one of the reasons. Presently, not only the majority of the world's citizens live in developing nations but also the population in these nations is experiencing a higher growth than that of the developed nations. In the middle of 2012, the world population grew to 7 .06 billion after having passed the 7 billion mark in 2011 in which developing countries account for 97 percent for the growth [4]. Another reason for the importance on the role of the developing nations on the mitigation is the condition of the high growth on the carbon emission. Currently even though the major contributor for the catastrophic gas is still the developed nations; the massive growth on the gas emission is surprisingly experienced by the developing nations. A reference [5] shows that between 2006 and 2010, some developed nations experienced declining on the emission, while many developing nations experienced a sharp increase in the emission.

The application of the alternative clean renewable energy technology to support the accessibility of the electricity for the communities in developing nations can be one of the appropriate measures to decelerate the growth of the catastrophic carbon gases emissions in order to contribute to the mitigation of the climate change.

Indonesia is a developing country where many of its regions are still posing to the difficulty in the energy access. In census 2010, the population in Indonesia is more than 200 million in which almost half on them living in rural region [6]. The number of population below the poverty line in Indonesia is 12.4%, at which almost three-fourth of them lives in rural areas [6]. The ratio of electricity in Indonesia is 67%. The rest of this number, equal to 19 million households, is still inaccessible with the power and mostly lives in the east region of Indonesia in which most of the region are developing provinces [7].

Currently the major energy sources in Indonesia come from fossil fuel [8]. As a consequence, the contribution of the nation to the global carbon emission is obviously unavoidable. In this nation, the average carbon dioxide emission from the energy sector increased by almost five percent annually over the last decade. The emission of the carbon dioxide in 2000 was almost 250 million ton and increased to almost 380 million ton in 2010. The carbon dioxide emission from the power plant sectors in 2000 reached roughly 60 million ton and increased to almost 102 million ton in 2010 [8].

Southeast Sulawesi is one of the developing provinces in east region of Indonesia. The access of electricity for communities seems still to be a challenge in several regions in this province. It is believed that this province has potential natural resources which can be utilized to support the development of clean renewable energy technology.

This paper discusses the prospect of the development of renewable resources for delivering clean energy in Southwest Sulawesi. The methodology of generating this paper is literature study of some journal papers, magazines and authentic government data such as the Statistical Centre Bureau (BPS) and the Department of Energy and Mineral Resources (ESDM).

2. Geography-Topography and Socio-Economic Condition

Southeast Sulawesi lies on the southeast peninsula of Sulawesi. Geographically, it is located in the southern part of the equator, between 02°45' and 06°15' south latitude, and between 120° 45' and 124°45' east longitude. The larger part of this region is water

(sea) (74% or 110.000 km²). The land (26%) consists of the main island and several smaller islands with the total area of approximately 38.140 km². This province is divided administratively into ten districts, namely Buton, Muna, Konawe, Kolaka, Konawe Selatan, Wakatobi, Bombana, Kolaka Utara, Buton Utara and Konawe Utara, and two cities, namely Kendari and Bau-Bau. The total number of villages is more than two thousands in which almost 40% of them locates in coastal regions [9].

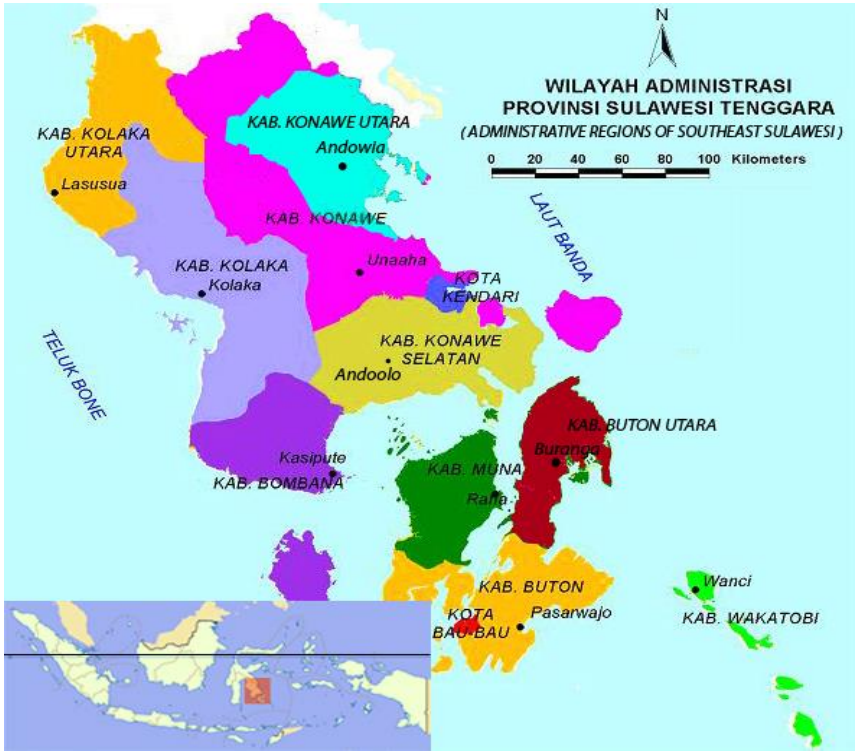

Figure 1. Administrative Regions in Southeast Sulawesi
Source: BPS Sultra (2010) [9]

Topographically, Southeast Sulawesi has a mountainous and undulated soil surface characteristic. The up-mountain range which accounts for 1,868,860 ha, is mostly located at an altitude ranging from 100 to 500 meters with the slopes of 40 degrees [9].

In census 2010, the number of population in this province is more than 2.2 millions [10]. The majority of the population lives in Kolaka and Kendari (see Figure 2). The percentage of people living in poor condition in this province is 14.61% and more than 90 % of the poor community lives in rural regions [10]. The Gross Domestic Product (GDP) is roughly 400 dollars with the major contributor from the agriculture sector (Indonesia; 2400 dollars) [6]. The Human Development Index (HDI) in this province is 69 (Indonesia; 71.17), the adult literacy rate is 93.6% & 86.6% for both man and woman respectively (Indonesia; 94.3% and 87.5 % respectively) and the life expectancy is 70.4 year (Indonesia; 70.9) [6].

3. Electricity and Problem

The communities in Southeast Sulawesi use the electricity which is generally obtained from the State Electricity Company (PLN), while rural communities with no

access to the electricity network use non-PLN electricity and kerosene lamps [12]. In 2009, the total amount of the electricity consumption is roughly 356 GWH [12], equal to the electricity per-capita of 50 watt (In 2009, the total electricity consumption in Indonesia is 155 TWH, equal to the electricity per-capita of 174 watt [14]).

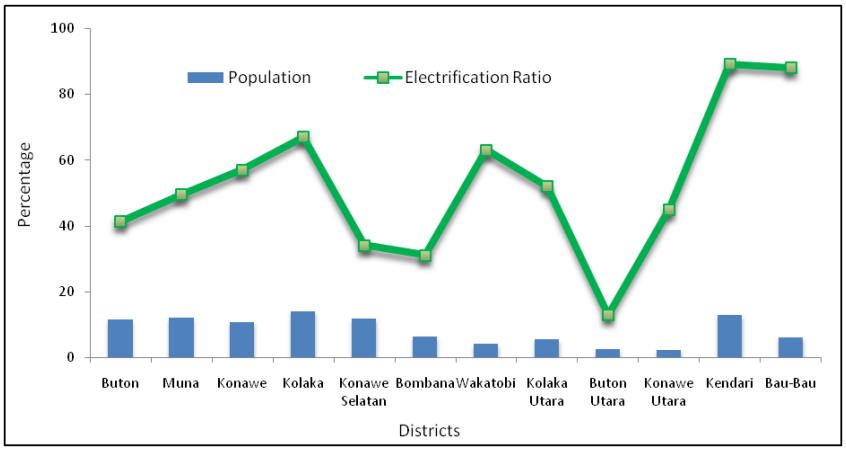

Figure 2. The Distribution of Population and the Electrification Ratio in Southeast Sulawesi

This province has the electricity ratio of 56 % [15]. On this percentage, the number of households with the electricity connection is 307.531 of the total of 547.924 households and the number of villages with the electricity connection is 1440 of the total of 2196 villages [15].

Apart from above facts, the inequality electricity distribution among the districts in this province apparently exists. Figure 2 compares the electrification ratio and the population distribution in all districts/cities in Southeast Sulawesi. The data of the electrification ratio is derived from the Department of Energy and Mineral Resources of Southeast Sulawesi [15] and the data of the population is derived from the Statistical Centre Bureau of Southeast Sulawesi [10]. A highlight reveals that Kendari and Bau-Bau have the highest proportion of the energy. It can be seen from the graph that the electricity ratio of these cities is almost 100%. In contrast, in some regions such as Konawe Selatan, Bombana and Buton Utara, the electricity ratio is less than 40%.

4. Prospect of Renewable Energy Development

Southeast Sulawesi is believed to have the potential clean natural resources to be developed as renewable power. The following paragraphs present some potential clean renewable resources in this province.

4.1 Biomass

Some important sources of biomass in Indonesia can be obtained from residues of paddy rice, oil palm, sugar cane, coconut, forestry and waste wood processing result, and other agricultural and animal farm [16]. Southeast Sulawesi has also potential for

the development of renewable energy based biomass as the availability of the abundant vegetative natural resources.

The potential of renewable resource based biomass of this province is 800 MW [17]. This condition is supported by the major land utilization for plantations. The forest dominates the land utilization by almost 2 million ha. The estate land (658,186 ha) is in the second, followed by wasteland/garden land (209,068 ha), wooded land (158,731 ha) and temporarily fallow land (132,299 ha). Of these land utilizations, there are at least seven types of food crops cultivated, namely: paddy, maize, cassava, sweet potato, peanut, soybean and bean. Indeed, there are still many other plantation crops, including coconut, coffee, kapok, pepper, nutmeg, clove, cashew nut, candle nut, cocoa, sugar-palm, vanilla, areca nut, tamarind, tobacco, hybrid coconut, cotton, sugarcane, ginger and sago [18].

Instead of the energy from the vegetative sources, energy based biogas can be another potential renewable resources for this province. This province has the potential of renewable resources based biogas of 10 MW [17]. This is supported by the condition that this province has commodity of animal products, including the large livestock (cow, buffalo and horse), the small livestock (goat, sheep and pig) and the poultry (native chicken, broiler and duck) [18].

4.2 Solar

Most of Indonesian archipelagos lie in equator line. This enables the nation to receive high intensity of the sunlight. In a report of the Department of Energy and Mineral Resources in 2002, the potential of the energy sources based solar in Indonesia is more than 1 billion MW [19]. Southeast Sulawesi is one of the regions in Indonesia potential for the development of renewable energy based solar as geographically the location is around the equator line. A study of assessment of solar radiation intensity in [20] shows that the annual solar radiation in Southeast Sulawesi is roughly 1985 KWH/m^2 (or 5.57 KWH/m^2/day).

4.3 Hydro

Indonesia is believed to have the potential hydro power of 75 GW which is one of the largest hydroelectric reserves in Asia [21]. Much of this potential is spread across more than 1300 possible locations where different size and types of schemes can be built. About half of Indonesia's hydropower potential could be exploited by building large scale hydroelectric schemes exceeding 100MW installed capacity and the rest can be developed by building smaller schemes including mini and micro hydro projects.

Table 1. Some Rivers Potential for the Development of Renewable Power in Southeast Sulawesi

No	River	District	Capacity (MW)
1	Newijo	Konawe Utara	2
2	Lasolo	Konawe Utara	100
3	Lalindu	Konawe Utara	60
4	Konaweha	Konawe Utara	200
5	Lansilowo	Konawe	3
6	Mosolo	Konawe	4
7	Lampeapi	Konawe	10.5
8	Lawey Roraya	Konawe Selatan	10
9	Ngari-ngari	Buton	0.25
10	Winto Winning	Buton	10
11	Kabungka	Buton	2
12	Sampolawa	Buton	2.3
13	Lakaritsu	Buton	0.2
14	LakangBola	Buton	3.1
15	Lakawa	Bombana	0.2
16	Emoiko	Bombana	0.375
17	Sangkona	Bombana	0.375
18	Labuhan	Buton Utara	0.3525
19	Langkoroni	Buton Utara	0.21
20	Pohoroa	Buton Utara	0.24
21	Langkumbe	Buton Utara	0.42
22	Ronta	Buton Utara	0.17
23	Towor	Muna	6
24	Katangana	Muna	2
25	Toki	Muna	0.76
26	Latobera	Muna	0.15
27	Lantowu	Kolaka Utara	2.2
28	Alawatu	Kolaka Utara	20
29	Tamboli	Kolaka	4.5
30	Mangolo	Kolaka	0.8
31	Oko-Oko	Kolaka	1.6

Source: ESDM Sultra (2011) [22]

Southeast Sulawesi with the mountainous and hilly land characteristic and the existence of many rivers is very potential for the development of the renewable hydro power. This is supported by the condition that, several of the rivers flow across almost in every district/city in this province [12]. The potential of the rivers in generating power is more than 800 MW which can be built in large, mini and micro schemes [17]. Table 1 shows some potential rivers for the hydropower in Southeast Sulawesi.

4.4 Geothermal

It is believed that Indonesia has the largest potential resources of geothermal energy in the world [8]. The potential of the geothermal energy in this nation is equivalent to 29,028 GW of electricity (GWe). In this amount, 12,756 GWe is confirmed as probable

reserve, 823 MWe as possible reserve and another 2,288 GWe as proven reserve. The remaining 13,171 MWe are still speculative and estimated resources [8].

Table 2. Some Locations Potential for the Development of Geothermal Power in Southeast Sulawesi

No	Location	District	Capacity (Mwe)
1	Lainea	Konawe Selatan	60
2	Pancasila	Konawe Selatan	15
3	Sonae	Konawe Selatan	10
4	Lampeapi	Konawe	10
5	Wongkolo	Konawe	5
6	Abuki	Konawe	20
7	Kaendi	Konawe	30
8	Landai	Konawe	20
9	Puungkolo	Konawe	15
10	Pebuinga	Konawe	10
11	Osuntunduho	Konawe	10
12	Nambomopula	Konawe	10
13	Pudonggala	Konawe	10
14	Lemomole_lembu	Konawe	10
15	Lamopula	Konawe	10
16	Matandahi	Konawe	20
17	Anggolom Baebia	Konawe Utara	10
18	Bahomokule	Konawe Utara	30
19	Wawolessea	Konawe Utara	10
20	Manggolo	Kolaka	50
21	Sampolawa	Buton	5
22	Kabungka	Buton	10

Source: ESDM Sultra (2011) [23]

The potential of geothermal energy in Southeast Sulawesi is 380 MWe [23]. Table 2 shows some locations potential for the development of renewable power based geothermal in this province.

4.5 Other potential renewable energy resources

Instead of biomass, solar, hydro and geothermal, there are other natural sources can be potentially harnessed to deliver clean renewable energy in this province. Wind can be the potential alternative energy resources for communities in coastal regions. The average wind speed in most of these coastal regions accounts for 3-5 m/s [17]. Sea, the majority part of this province, can be the other option for the alternative power sources by the utilization of the wave energy converter technologies, the tidal energy converter technologies and the sea current energy converter technologies.

5. Discussion

It is obvious that in Southeast Sulawesi, one of the developing regions in Indonesia, the communities in many regions still have a difficulty in accessing the energy. It can be seen that the electricity ratio in this province is only 56%, slightly below the average

of the electricity ratio of Indonesia (65%). This is supported by the condition of the low electricity per-capita and the inequality of power distribution among regions in this province.

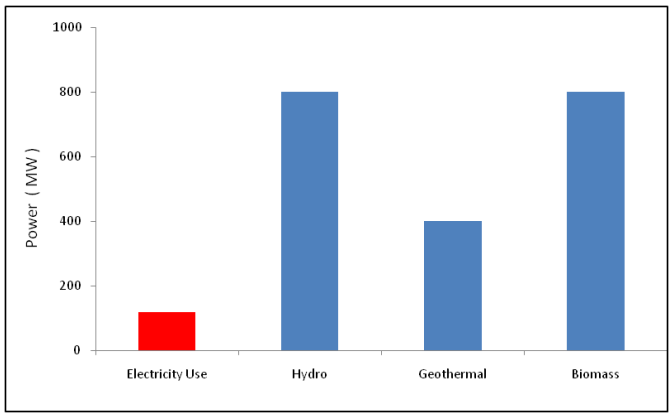

Figure 3. Present Utilization on Electricity and Some Potential of Renewable Energy Resources

Solution solely on the power based fossil fuel in dealing with the challenge on delivering the energy access for the communities in several regions in this province seems to be less appropriate option as the availability is so limited and importantly, the detrimental environmental impact of the greenhouse gas fuel is obviously unavoidable. Thus, delivering the clean decentralized renewable power can be more appropriate option in dealing with the challenge of providing the energy for communities.

Southeast Sulawesi has advantages of the abundant natural resources for the development of the decentralized clean renewable power technologies. The position around the equator line benefits the province in receiving relatively high annual solar energy intensity. Indeed, the condition of mountainous and hilly land, the existence of many rivers and the abundant plantation supported by the tropical condition (location around equator line) enables the regions obtaining the renewable clean decentralized resources for the power generation based hydro and biomass. Indeed, geothermal source, extensively available in some districts the province, can also be alternatively utilized to bring the power locally and environmentally for the communities.

Figure 3 illustrates a rough figure on the comparison of current electricity utilization and some of the potential of the natural resources for the development clean decentralized renewable power in this province. It can be seen that the amount of natural renewable resources are much higher than current power utilization in this province. Thus, the initiative on the development of the renewable sources in this province is so imperative.

The Indonesian government has enacted the energy policies, under the Presidential decree of 5/2006 and the Law of 30/2007. These policies aim to expand the development of renewable energy technologies using local natural resources to support the sustainable development and to reduce the dependence on the fossil fuel which currently becomes the major sources of foreign exchange as well as social and economic development and to ensure the national energy security and the environment sustainability. In addition, the law (UU 30/2007) is designed to encourage the effort in increasing the energy access for the community in remote regions in order to support the development in order to enhance the living standard and the prosperity.

6. Conclusion and Recommendation

Southeast Sulawesi is a developing region in which the access of the electricity for communities is still becoming a challenge in many of its region. Relying on the exhaustible and unclean fossil energies on delivering a solution for the energy access for the communities seems to be less appropriate options as the limitation and the detrimental environmental impact of the global climate change. Since this province has still many unexplored potential clean renewable energy resources such as river, solar, geothermal, wind, biomass and sea, the development of clean renewable power technology can be one of the appropriate solutions in dealing with the power distribution challenge with clean and sustainable solution.

The Indonesian government has enacted the policies aimed at promoting renewable energy to support the effort on the reduction on the dependency on fossil fuel to ensure environment sustainability. The introduction of the policy also aims to support the effort on enhancing the accessibility of the electricity for community in remote regions. So it is essential to make public conscious on the importance of the utilization of the clean decentralized renewable resources for the power generation. The role of university institution to make the public awareness is very potential. This is because that the institution has the responsibility in transferring knowledge into students, in delivering research, and in contributing in empowering communities. The importance of the renewable energy utilization can be immersed into the responsibility to enhance the student knowledge, to create research which relates to the renewable power development and to contribute into community development by informing and, if it is possibly, by applying the renewable energy technologies for the communities.

References

[1] K. Q. Nguyen, "Alternatives to Grid Extension for Rural Electrification", Decentralized Renewable Energy Technologies in Vietnam, Energy Policy, vol. 35, **(2007)**, pp. 2579–2589.
[2] D. Kaundinya, P. Balachandra and N. H. Ravindranath, "Grid-connected Versus Stand-alone Energy Systems for Decentralized Power: a Review of Literature", Renewable and Sustainable Energy Reviews, vol. 13, Issue 8, **(2009)**, pp. 2041-2050.
[3] A. Zahnd and H. M. Kimber, "Benefits from a Renewable Energy Village Electrification System", Renewable Energy, vol. 34, no. 2, **(2007)**, pp. 362-368.
[4] C. Haub, "Fact sheets; World Population Trends in 2012", **(2012)**, www.prb.org/publication/datasheet/2012/world-population-data-sheet/fact-sheet-world-population.aspx.
[5] R. Rapier, "Climate Change and Developing Countries", Energy Bulletin, **(2012)**, www.energybuletin.net/stories/2012-08-09/climate-change-and-developing-countires.
[6] Statistical Centre Bureau (BPS), "Trends of the Selected Socio-Economic Indicators of Indonesia", **(2010)**.
[7] Department of Energy and Mineral Resources of Indonesia (ESDM), "The Government Will Focus on the Electricity Distribution in the East Regions of Indonesia", **(2011)**, http://www.esdm.go.id/news-archives/323-energi-baru-dan-terbarukan/4256-pemerintah-akan-fokus-aliri-listrik-wilayah-timur-indo.
[8] Center for Data and Information on Energy and Mineral Resources Ministry of Energy and Mineral Resources (KESDM), Indonesia Energy Outlook 2010, **(2009).**
[9] Statistical Centre Bureau of Southeast Sulawesi (BPS Sultra), Southeast Sulawesi in Figure 2010: Geography, **(2010)**.
[10] Statistical Centre Bureau of Southeast Sulawesi (BPS Sultra), The Results of the Census in Population in 2010: the Data of Aggregate in Every District/city in Southeast Sulawesi, Press conference, **(2010)** August 16.
[11] Statistical Centre Bureau of Southeast Sulawesi (BPS Sultra), The Profile of the Poverty in Southeast Sulawesi, **(2011)** September.

[12] Statistical Centre Bureau of Southeast Sulawesi (BPS Sultra), Southeast Sulawesi in Figure 2010: Industry, Mining, Electricity and Water Supply, **(2010)**.
[13] Department of Energy and Mineral Resources of Southeast Sulawesi (ESDM Sultra), The List of the Ratio of Electrification and the Ratio of the Village with the Electricity Connection in the province of Southeast Sulawesi, **(2011).**
[14] EIA, Heat/Electricity in Indonesia in 2009, **(2012)**, http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=ID.
[15] Department of Energy and Mineral Resources of Indonesia of Southeast Sulawesi (ESDM Sultra), The list of the ratio of electrification and the ratio of the villages with the electricity connection in Southeast Sulawesi December 2011, **(2011)**.
[16] ZREU, German Energy Saving Project, **(2000)**.
[17] Department of Energy and Mineral Resources of Southeast Sulawesi (ESDM Sultra), Renewable Energy in Southeast Sulawesi, **(2011).**
[18] Statistical Centre Bureau of Southeast Sulawesi (BPS Sultra), Southeast Sulawesi in Figure 2010: Agriculture, **(2010)**.
[19] C. O. P Marpaung, A. Soebagio and R. M. Shresta, "The Role of Carbon Capture and Storage and Renewable Energy for CO_2 Mitigation in the Indonesian Power Sector", The 8th International Power Engineering Conference (IPEC), **(2007)**.
[20] B. Sudia, A. Rachman and Kadir, "The Assessment of Solar Radiation Intensity in Southeast Sulawesi Based on the Relative Position of the Sun", Journal of Metropilar, vol. 9, (**2011)**, pp. 115-120.
[21] D. Hayes, "Asian Renewable South East Asia regional overview", Re-Focus, **(2004).**
[22] Department of Energy and Mineral Resources of Southeast Sulawesi (ESDM Sultra), The Potentiality of Rivers as Power Production, **(2011)**.
[23] Department of Energy and Mineral Resources of Southeast Sulawesi (ESDM Sultra), The Potentiality of the Geothermal Rnergy in Southeast Sulawesi, **(2011)**.

Authors

Ridway Balaka

He was born in Kendari Indonesia 20th March 1959. He received his Bachelor of Mechanical Engineering degree from Hassanudin University Indonesia in 1986 and his Master Engineering from Asian Institute University Thailand in 1993.

He is a senior lecturer in Mechanical Engineering Department of Haluoleo University Indonesia. He is interested in the research relating to the development of river current energy technology and the energy policy. He has published some papers in some national and international conferences and international journals.

Aditya Rachman

He was born in Surakarta Indonesia 11st April 1979. He received his Bachelor of Mechanical Engineering degree from Gadjah Mada University Indonesia in 2003 and his Master Engineering degree from the Engineering Faculty of Wollongong University, Australia in 2010.

He is a lecturer in Mechanical Engineering Department of Haluoleo University Indonesia. He is interested in the research relating to the development of small wind and river current energy technologies. He has published some papers in some national and international conferences and international journals.