Global Warming Mitigation Technology Promotion Project, FY2014

"Feasibility Study on Mega Solar, Hybrid Mini Grid and Rural Electrification for Communities by Solar PV System in Federal Democratic Republic of Ethiopia and Republic of Kenya"

March, 2015

Ministry of Economy, Trade and Industry (METI)

NTT Data Institute of Management Consulting, Inc.

CONTENTS

1 Overview of the study

1.1 Background and Objective of the Study

In this project, we conducted a feasibility study for the following three projects utilizing solar power generation which are to be covered by the Joint Crediting Mechanism (JCM) in the Federal Democratic Republic of Ethiopia (hereinafter referred to as Ethiopia) and Republic of Kenya (hereinafter referred to as Kenya) .

[Theme 1] : “Mega solar project” in Ethiopia
[Theme 2] : “Hybrid mini-grid project” that combines diesel and solar power in Kenya
[Theme 3] : “Rural Electrification for Communities by Solar and Micro Hydro Power” in Ethiopia

1.1.1 Background of the study

NTT Data Institute of Management Consulting, Inc. conducted the study over the past three years on the theme of local electrification utilizing renewable energy in Ethiopia and Kenya through the NEDO “Global Warming Mitigation Technology Promotion Project” in fiscal year 2011 and fiscal year 2013 and the “Global Warming Mitigation Technology Promotion Project” of the Ministry of Economy, Trade and Industry in fiscal year 2012. Although there are still several problems, the conclusion they obtained from these studies is that there is a big chance in the electricity business that utilizes Japanese renewable energy technologies.

Table 1 Renewable-energy related businesses that utilize Japanese technologies

	Capacity of RE	Target	Business	Proposal from Japan
Ⅰ	＞1MW	➢National Grid ➢Isolated Large Grid	➢”Mega Solar” Project ➢Large scale rural electrification	➢Large scale project (Solar, Wind, Geo thermal and so on)
Ⅱ	100kW～1MW	➢Isolated Mini Grid	➢Rural Electrification (Small Town, Administrative center)	➢Hybrid Mini Grid (Conventional Diesel generators and Renewable energy)
Ⅲ	10kW～100kW	➢Isolated Nano/Pico Grid ➢Electrification for village and community	➢Rural Electrification (Village, Community)	➢Micro Hydro Generator ➢Micro Hydro + Solar Hybrid system
Ⅳ	Personal	➢Electrification in House hold	➢BOP project (Solar lantern etc)	➢Solar lantern

It seems that there are business chances for electricity business utilizing renewable energy in Africa in the four areas as shown in Table 1, depending on the output scale of renewable energy[1]. When applying them to Ethiopia, Kenya and other East-African countries, we consider that each area has a great potential for different types of project as follows: for Area I, "Large-scale projects such as geothermal power generation and mega solar projects"; for Area II, "Local electrification with hybrid mini-grid" that controls a grid through output stabilization and grid management technologies combining diesel power generation and wind power generation or solar power generation of 1MW or smaller; for Area III, "Electrification of the community with low head micro hydro power generation"; for Area IV, "BOP business with solar lantern, etc."

Especially in Kenya and Ethiopia, where the electrification rate stays at about 20%[2] respectively, most of the local communities do not have a connection to grid power source. In addition, it is thought that there will continue to existing areas and communities in the both countries where residents are left behind the rapidly advancing expansion of grid-connected power or are not able to use grid-connected power actually, as they cannot pay connection fee, even though they are formally covered by the system. It can be said that we have great business chances in these areas.

1.1.2 Objective of the study

In this study, aiming at the business deployment by Kyocera Corporation (Kyocera) on the basis of the past studies, we conduct the study to seek for projects that utilize solar power generation technologies in each area, targeting mega solar in Ethiopia in Area I, hybrid mini-grid in Kenya in Area II, and the development of communities with the combined use of low head micro hydro power and solar power in Ethiopia in Area III.

The solar power generation technology has high applicability compared to wind power and biomass power generation technologies, because Kenya and Ethiopia are both close to the equator and have many areas that are located high above sea level. Moreover, the geographic/climatic conditions, such as low latitudes, high above sea level and stable temperature in the 20 degrees are idealistic for solar power generation, and the power generation efficiency in the both countries is estimated to improve by nearly 30% compared to the actual intensity of solar radiation in Japan according to the estimate made by Kyocera.

As to the project, we provide strategic engagements and policy proposals for business

deployment, appealing that the progress of this project with Japanese low-carbon technologies is in consistent with the environmental and energy policies of the both countries that have already signed the bilateral document on JCM.
We also consider the emissions reduction methodology that is applicable at the implementation of the project and make a trial calculation of estimated amount of emissions reduction using a considered methodology.
We utilize the solar power generation technologies owned by Kyocera Corporation, aiming at the future realization of the project in which Kyocera will play a leading role.

What are to be covered by the study are the assumed projects based on the three themes as mentioned above. We aim at business deployment of the projects based on the transition to the pilot verification utilizing the schemes of New Energy and Industrial Technology Development Organization (NEDO) and United Nations Industrial Development Organization (UNIDO) after implementing the projects.

1.2 Overview of each study

1.2.1 Outline of each study

For three themes around which we aim to implement a project, we summarize backgrounds and objectives of the study for each as follows.

[Theme 1] "Mega Solar Project" in Ethiopia

According to the final report of electric power supply master plan published in September 2014 by EEP of Ethiopia (Ethiopian Electric Power, which was established when the former Ethiopian electric power public corporation EEPCo was divided into EEP, the electric power provider, and EES, the electric power transmission and distribution company in December 2013), solar power generation plants of totally 1,264MW will be established by 2025 at a maximum, and those of totally 2,356MW will be established by 2035 at a maximum for solar power generation with a connection to the grid (Mega solar plants of 100 to 300MW), based on the electric power demand projection of the country. As a specific action, construction of mega solar power plants of 300MW (100MW x 3 locations) is planned to start in 2016. It is decided that these mega solar plants of 300MW are to be constructed by American companies supported by the "Power Africa" project led by President Obama of America, under which private and public sectors of America will fund 7 billion dollars collectively to double the electric penetration rate in Sub-Sahara Africa.
In this project, we consider the participation in the mega solar project in Ethiopia,

including utilization of ODA, in response to “resuming of yen loan and the progress of JCM,” which was clearly announced by Japanese Prime Minister Abe when he visited Ethiopia in January 2013.
In considering the participation, we seek for projects as business, utilizing knowledge about the mega solar projects Kyocera had worked on home and abroad, while providing recommendations on project environment. The government of Ethiopia is planning to introduce the Feed -In Tariff (FIT) soon. In line with such a policy, we make policy recommendations on the implementation of mega solar projects.

[Theme 2] ”Hybrid Mini-Grid Project” that combines diesel and solar power in Kenya

NTT Data Institute of Management Consulting, Inc. received entrustment of the Global Warming Mitigation Technology Promotion Project of the Ministry of Economy, Trade and Industry in fiscal year 2012 and conducted the “Study for composing the local electrification project with hybrid mini-grid utilizing renewable energy in Republic of Kenya.” Hybrid mini-grid is not to extend the national grid, but to construct an independent mini-grid for cities and towns with the demand for electricity to supply electric power using diesel power generation and generation with renewable energy. The scale of power generation plant that supply electricity to the mini-grid is specified as several hundreds watt to 1MW. Kenya aims to supply 30% of the total output of hybrid mini-grid (combining diesel and renewable energy) with renewable energy centered on solar power generation, and has developed a plan to introduce renewable energy of 8MW (in the medium-term) to 15MW (in the medium- to long-term) in total. The cost of introducing renewable energy is estimated to be 12 to 20 billion yen.
The Government of Kenya had negotiations with various donors in implementing this project to eventually receive 30 million euro (approximately 4 billion yen) with a low-interest rate loan from AFD (French Agency for Development) in 2013 for 23 locations of the hybrid mini-grid stations. For solar power generation systems and wind power generation systems for those 23 locations, equipment and technologies to be used are decided by bidding conducted by the Rural Electrification Authority. Delivery of solar power generation system with the total capacity of 3.7MW as shown in this plan will be potential of the hybrid mini-grids for the time being.

From a technical viewpoint, the Government of Kenya assumes a system that uses storage batteries in introducing the hybrid mini-grid system. According to the study by Kyocera, stable supply of electric power to mini-grid is possible without using storage batteries, if the ratio of output of diesel power generation to solar power generation is one to 0.5 to 0.6. In Kenya, the use of renewable energy accounts for 30% in the hybrid mini-grid. Although Japanese solar power generation facilities are regarded as high performance but high price, we can reduce the initial cost and battery replacement cost by proposing a solution without storage batteries, which is expected to ensure our advantage in the market.

Hybrid mini-grid systems are currently procured with the BT (Build and Transfer) system by the Rural Electrification Authority. However, the Ministry of Energy and Petroleum hopes that special purpose companies and independent power providers (IPP) will operate hybrid mini-grid with the BOO (Build, Own, Operation) system in the future.

Based on the above, we conduct the feasibility study of the business and make policy recommendations, assuming that Kyocera would participate in the hybrid mini-grid project and the project would be covered by JCM. In the short-term, we will provide policy recommendations targeting at increase in orders with the BT system, utilizing the technological feature of Kyocera, i.e. introduction of renewable energy without using batteries. We are planning to make technological and policy recommendations based on the experience of introducing the solar power generation system of 160kW in Tajikistan, which has the similar capacity as the hybrid mini-grid system, as well as conduct the study of business environment around the sites, including procurement and construction.

In the medium- and long-term, we will make recommendations with a view to the improvement of the Feed In Tariff (FIT) to encourage entries of private providers.

The Government of Kenya, especially the Ministry of Environment, Water and Natural Resources, which is responsible for the JCM system, has recognized that the hybrid mini-grid project is a candidate for JCM coverage through the project in fiscal year 2012. In this study, we provide effective policy recommendations to the Kenya side, based on the assumption that the project is a business deployment by a provider, Kyocera.

[Theme 3] "Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia

NTT Data Institute of Management Consulting, Inc. received entrustment of the Global Warming Mitigation Technology Promotion Project of NEDO in fiscal year 2013 to conduct the "Study for exploring Rural Electrification for Communities by Solar and Micro Hydro Power in the Federal Democratic Republic of Ethiopia and Republic of Kenya." They investigated the electrification project using ultra low head micro hydro power system with the output of 10kW for the community that was located in the off-grid area to find that there was a potential for introducing micro hydro power system of 83MW in Ethiopia. However, they also found that Ethiopia has the problem of seasonal fluctuation in quantity of water between the rainy season and the dry season. In the discussions with the Ministry of Water, Irrigation and Energy of Ethiopia and the local government, they argued expected future issues in responding to the seasonal fluctuation through a combination of micro hydro power with other renewable energy, especially with solar power.

We obtained the following comment from the director who was in charge of electric power supply planning at the Ministry of Water, Irrigation and Energy: even if the national grid is extended in the future, electric power will be supplied through an independent power generation system for approximately 20% areas in Ethiopia in the medium- and long-term, and: electric power supply with renewable energy, not with diesel power generator, is expected. It is clear that the renewable energy market will expand as an independent power source in the future, and the model that combines micro hydro power with solar power generation will be able to respond to such needs.

Kyocera Corporation has implemented the solar power generation system donation projects to the schools in non-electrification areas in Uganda and Tanzania. The Company has accumulated experiences of installation of the system in non-electrification areas through the projects, and will be able to apply knowledge obtained from such experiences to community electrification.

In addition, community electrification with micro hydro power system is recognized also by the Government of Ethiopia as a specific project to be covered by JCM. We make recommendations also about the model that combines micro hydro and solar power generation as an expanded/developed version of the community electrification with micro hydro power system.

1.2.2 Study Items

We conducted the study on the following items. We visited Ethiopia and Kenya to do interviews and field studies three times in total in September and November 2014 and January 2015. In February 2015, we held workshops with the purpose of reporting outcome of the study and proposing the project in the both countries.

Study item	Overview/Target
(1) Recommendations about policies related to	<u>[Theme 1] : Recommendations about the “Mega Solar Project” in Ethiopia</u>

JCM of partner countries (Technological standards and financial supporting measures for low carbon technologies/products)	・ Creation of requirements that incorporate 20-year performance warranty based on the long-term operation experiences ・Recommendations for the FIT system to activate the participation of private providers ・Project composition that utilizes ODA from Japan <u>[Theme 2] : Recommendations about "Hybrid Mini-Grid Project" that combines diesel and solar power generation in Kenya</u> ・Proposal of hybrid mini-grid without using storage batteries and incorporation of it into the plan ・ Creation of requirements that incorporate 20-year performance warranty based on the long-term operation experiences ・Recommendations for the FIT system to activate the participation of private providers <u>[Theme 3] : Recommendations about the "Rural Electrification for Communities by Solar and Micro Hydro Power "in Ethiopia</u> ・ Technological proposal of "Rural Electrification for Communities by Solar and Micro Hydro Power" ・Recommendation to make the technology a part of the electrification plan ・Proposal of community electrification promotion support policies to Rural Electrification Promotion Center of the Ministry of Water, Irrigation and Energy
(2) Consideration of specific plans to implement a project utilizing policies in (1)	<u>[Theme 1] : Implementation of "Mega Solar Project" in Ethiopia</u> ・Study on electric power related policies ・Study of project environment (legal systems and electric power policies, bidding system, environmental laws and regulations, financing, customs clearance procedure) ・Seek for local partners (constructor, etc.)

	・Consideration of project deployment [Theme 2]　: Implementation of "Hybrid Mini-Grid Project" that combines diesel and solar power generation in Kenya ・Consideration of system ・Consideration of price ・Consideration of matters required for implementation of project ・Project deployment with the BT system ・Toward the future scheme (B00) [Theme 3]　: Implementation of the "Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia ・Consideration of system ・Consideration of price ・Consideration of project partners ・Consideration of project deployment
(3) Consideration of emissions reduction methodology that is applicable when the project is implemented, trial calculation of estimated emission reduction amount when the methodology is used	- Development of methodology according to the "guidelines for methodology development" - Trial calculation of estimated emissions reduction of the three project using a created methodology
(4) Analysis of economic effect in case of implementation of the project	- Create a project deployment plan utilizing technologies and systems considered in (2) based on (1). - Analyze the economic effect based on the project deployment plan.
(5) Tour of related facilities in Japan by government officials of partner countries or holding seminars, etc. for government officials of partner countries	- For Ethiopia, conduct both of "tour of related facilities in Japan by government officials of partner countries" and "holding seminars, etc. for government officials of partner countries." - For Kenya, hold "seminars, etc. for government officials of partner countries."

1.3 Structure of the Study

The project was mainly implemented by NTT Data Institute of Management Consulting, Inc. The future main implementation body will be Kyocera Corporation. Three researchers from Kyocera were in charge of the study, specifically consideration of technologies and systems and trial calculations. In addition, two employees from Ingerosec, which had an experience of engaging in an overseas project as a construction consultant when Kyocera implemented the project overseas, also participated in the investigation of the project environment, including the survey for procurement and construction circumstances and the consideration of environment and society. Both Kyocera and Ingerosec accompanied NTT Data Institute of Management Consulting, Inc. on the field study conducted twice.

As to the consideration of JCM methodology and amount of emissions reduction, Japan Quality Assurance Organization (JQA) conducted validation. JQA attended the field study once to interview candidates for counterparts in partner countries.

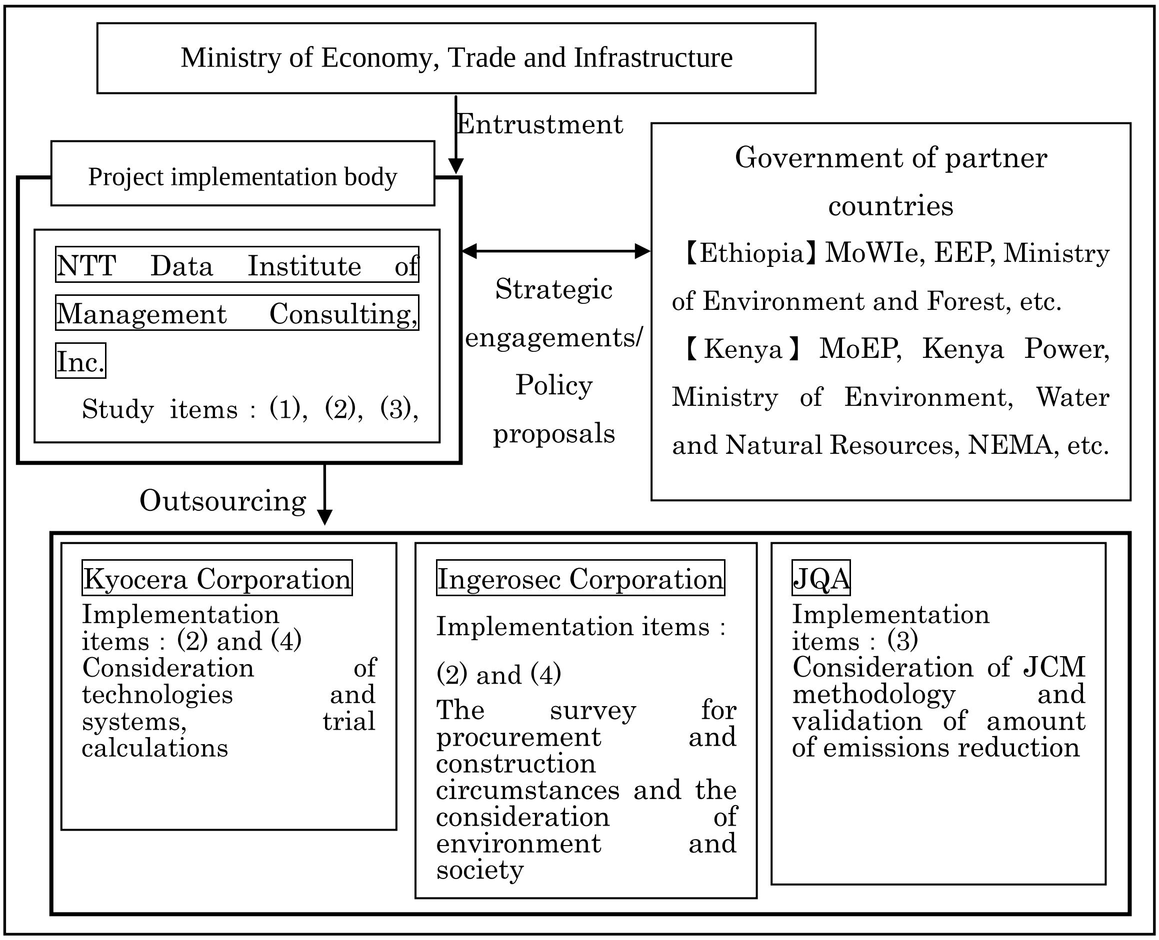


Figure 1 Project organization

1.4 Applied Technology

Kyocera Corporation has engaged in a lot of residential/industrial solar power generation projects as a leading solar power battery manufacturer in Japan. Especially in the industrial projects, the Company has established a reputation through introducing the most appropriate system that achieves consistency in the entire EPC (engineering, procurement and construction) and operation/maintenance, in addition to the development and sales of high-quality solar battery modules. Also, it promoted the solar power generation project through managing total power generation projects that covered power purchase agreement (PPA) with electric utilities, acquisition of land and permits and approvals, and fund raising. Such a business deployment with a view to the entire solar power generation project enables the Company to promote its business without participating in a "grueling price war of equipment" also in foreign countries.

1.4.1 Quality Assurance and Long-term Reliability

Kyocera's high-efficient polycrystalline silicon solar battery module itself also has an established reputation for high quality, long-term reliability, as well as stable supply capability. The Company received a certification for the long-term sequential test by Tuv Rheinland of Germany, the third party testing body that provides certification on safety and quality of products, for the first time in the world. This test is known for being very strict. As shown in the figure below, the usual international standard test allows to use different modules for each kind of test, whereas the long-term sequential test by Tuv Rheinland allows only one module for all the tests.

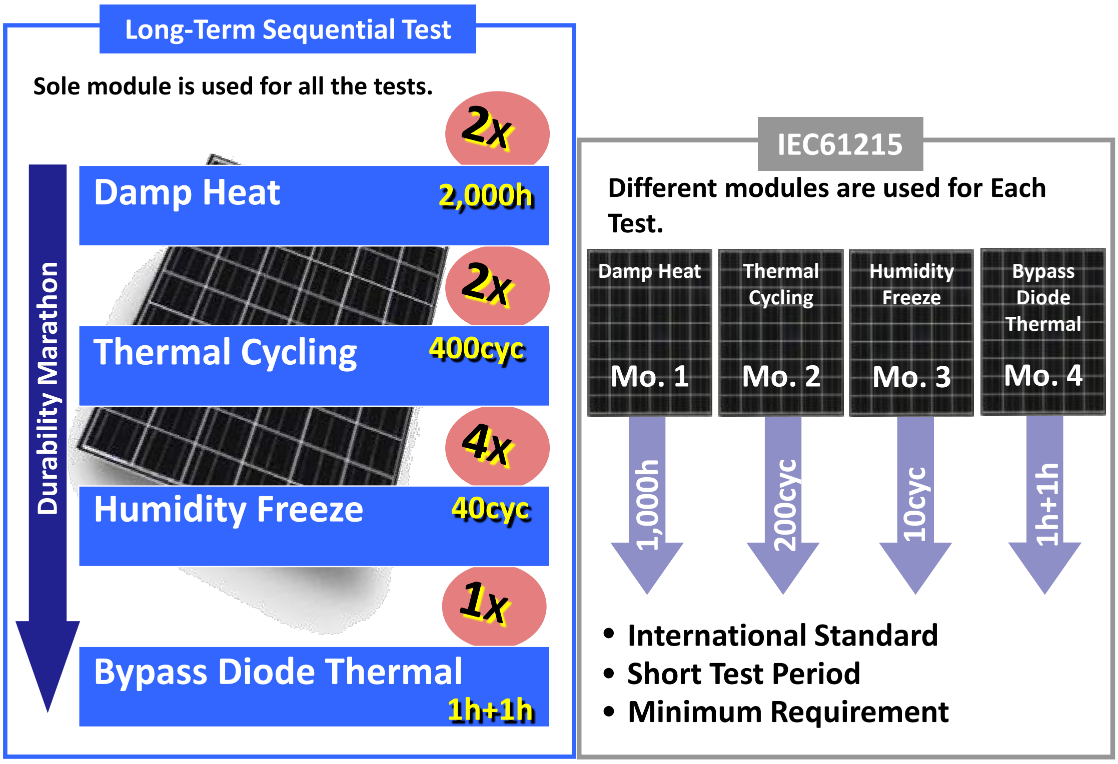


Figure 2 Comparison between the long-term sequential test of Tuv Rheinland and the usual international standard test for the quality assurance

Moreover, its solar power module was one of the four modules without power reduction in the "PID-resistance test," which was conducted on the products of 13 major module manufacturers in the world by Fraunhofer Center for Silicon Photovoltaics CSP, a German international research institution.

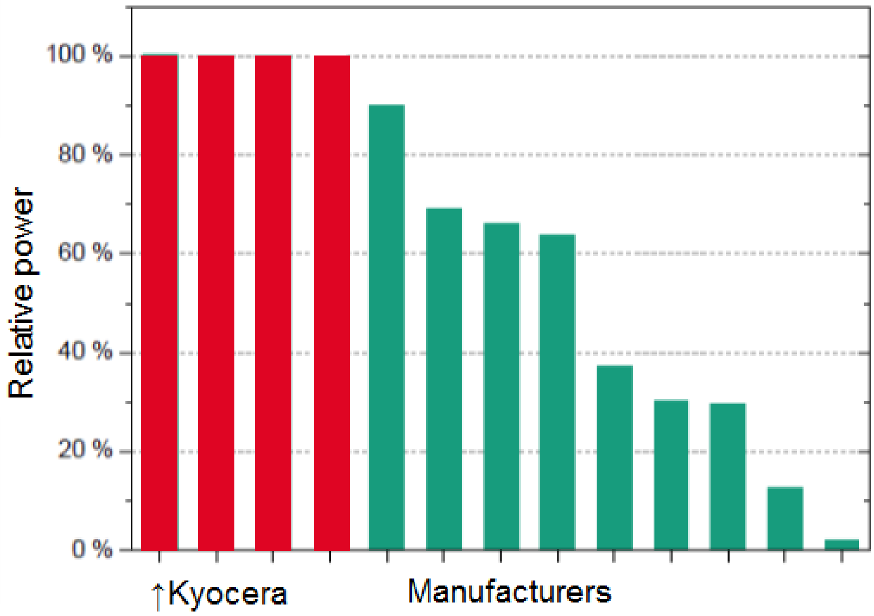


Figure 3 PID test results

In recent years, there has been an increased number of the cases of international procurement by the United Nations and ODA in which the “record of manufacture and sales of solar power generation systems over 20 years” is required in addition to the “guarantee for power capacity (10% for 10 years and 20% for 20 years).” In this context, the domestic and international records of Kyocera are expected to lead to an advantage in the international procurement. Especially for the guarantee for power capacity, the solar power system installed at Sakura Solar Energy Center of Kyocera in Chiba prefecture has been in operation for more than 30 years since 1984 and the power capacity degradation record show only as small as 9.6% after 25 years operation. It means that Kyocera is one of the few companies in the world which can show long-term reliability with the real record data.

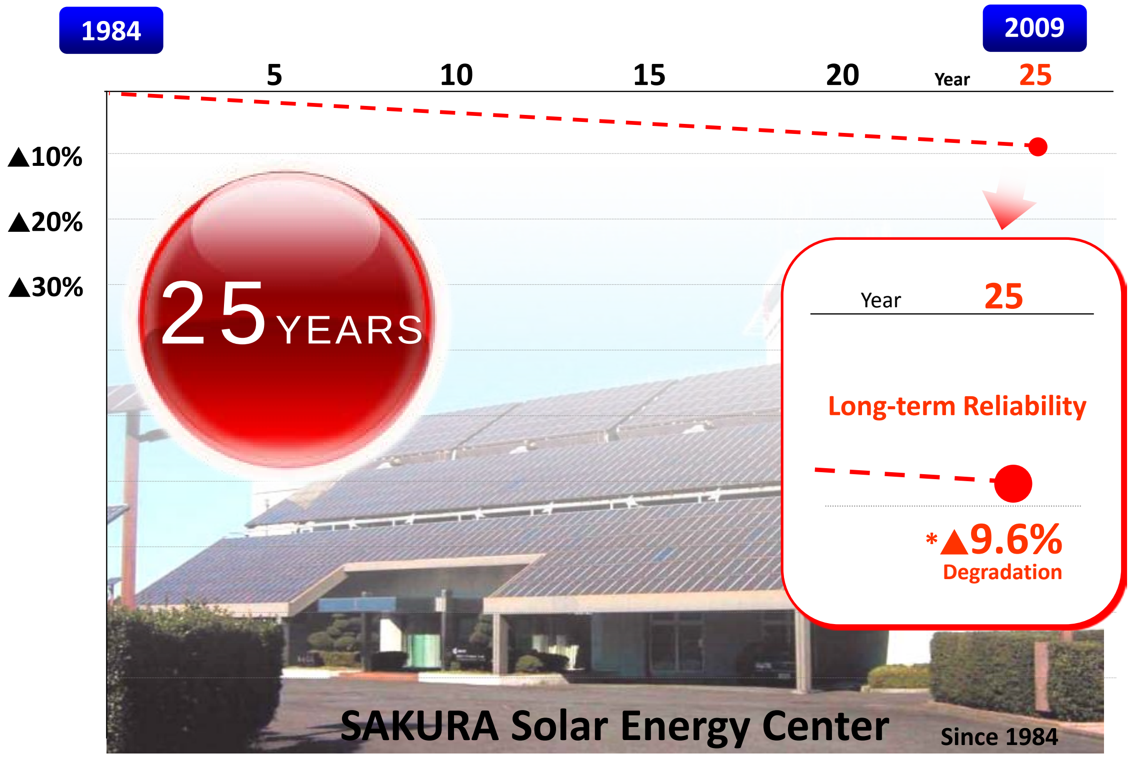


Figure 4 Record data of power capacity guarantee for the long-term operation

1.4.2 Overseas Business Development

“Photovoltaic modules” are produced at two domestic facilities, Shiga Yokaichi Plant and Shiga Yasu Plant. “Solar battery modules” are produced at four facilities in Japan, China and Mexico, which allows business deployment in various regions.

As to the overseas deployment, Kyocera has experiences of providing solar battery modules to Spain (Samalanca: 13.8MW, Dulcinea: 28.8MW) and to Thailand (257kW) as mega solar project .

As to the solar power generation project, the Company delivered the solar power generation system of 160kW in total in 2012 to the hospital in Republic of Tajikistan. It provided equipment, design and system operation techniques in this project.

In addition to the above, Kyocera have supplied solar power generation systems of over 3,000kW in total under more than 40 ODA projects to many areas in Asia Pacific region and across the countries in Africa since it first supplied solar batteries under the ODA project for developing countries in 1984. The table on the next page shows the

Company's record of providing solar power related products since 2009. In most of the cases of the project of less than 1MW, it introduced solar power generation systems that do not use storage batteries.

Table 2 Kyocera's past record of providing solar power related products overseas

Year	Client / Project	Supplied product	Capacity	Facility/ Location	Country	Remarks
2009	Avanzalia	Solar battery module	28.8MW	Dulcinea solar power generation plant/Cuenca	Spain	Avanzalia supplied battery modules to the solar power generation plants of 10.5MW and 13.8MW, in addition to the plant described on the left.
2010	Solar Power	Solar battery module	257MW	Solar power generation plant	Thailand	Solar Power is planning to supply solar battery modules to a large-scale solar power plant in Southeastern Asia, in addition to the plant described on the left.
2011	ODA Project	Solar battery module	453kW	Airport	Mongolia	Grid system/Chinggis Khaan International Airport
2011	ODA Project	Solar battery module	104kW	Street lamps	Syria	Off-grid system
2011	ODA Project	Solar power generation system	238kW	Airport	Palau	Grid system/Palau International Airport
2011	ODA Project	Solar power generation system	312kW	Research center	Djibouti	Grid system
2011	ODA Project	Solar power generation system	395kW	Public facilities	Maldives	Four systems at four locations including the office of President of Maldives
2012	ODA Project	Solar power generation system	211kW	National hospital	Marshall Islands	Grid system
2012	ODA Project	Solar power generation system	164kW	National hospital	Tajikistan	Grid system
2013	LS Power	Solar battery module	24MW	Arizona	U.S.A.	Covers 20% of the total project scale (127MS)
2013	Yokoray	Solar power generation system	64kW	Warehouse/Wang Noi	Thailand	Installed on walls

Figure 5 Left/Solar power generation system delivered to Republic of Tajikistan (160kW), Right/Dulcinea Solar Power Generation Plant in Spain (28.8MW)

In addition to the projects included in the above record, Kyocera made various efforts in Africa on their own: the Company donated devices and equipment, including solar power generation systems, storage batteries, lightings, TV sets and radios, to 35 schools that were located in the non-electrification areas in Tanzania and Uganda in East Africa over 5 years from 2009. The Company has come to aspire the deployment into African market when the time is ripe as a result of such efforts.

Figure 6 Left/Solar batteries installed in the school in Uganda, Right/Ceremony for donation of solar power generation system in Tanzania

As to mega solar, Kyocera is in charge of management of a power generation company for Kagoshima Nanatsu-jima Mega Solar Power Plant (70MW), which is one of the biggest solar power plants in Japan, as well as of part of construction and operation and maintenance. The Company can utilize such experiences in Japan from construction to operation of mega solar plant in foreign countries.

1.4.3 Technology Applied for the Hibrid Mini-grids

Generally, when connecting with a system that mainly uses a diesel generator, we have to design the capacity of the photovoltaic power generation system at 20% or less of that of diesel generator at a maximum. This is to prevent burnout of the diesel generator caused by reverse flow of output current of the photovoltaic power generation to the diesel generator. Moreover, if the load becomes excessive low as a result of photovoltaic power generation when looked from the diesel generator, that could not only reduce power generation efficiency (fuel efficiency) but also generate soot and smoke due to imperfect combustion eventually, resulting in more frequent maintenance work. To solve these problems and increase the interconnection capacity of the photovoltaic power generation system, we can consider the use of a storage type storage battery. However, the introduction cost of storage batteries, including lithium ion batteries and lead acid batteries, is high, and they need to be replaced every 5 to 10 years due to their useful life, although depending on how to control discharge and charge. Therefore, it is difficult to find a positive economic effect from the long-term view.

Therefore, we apply a technology that can improve the introduction rate of photovoltaic power generation to diesel generator up to 60% at a maximum without introducing storage batteries. Specifically, we efficiently reduce the amount of fuel used for diesel generator by monitoring the balance between the generated power on the side of the generator and the demand power on the load side and controlling the output of photovoltaic power generation. This system is also characterized by elimination of modification and replacement of existing power generation facilities, as what is controlled is on the side of photovoltaic power generation.

Examples of Kyocera's experience in the introduction of the hybrid system of diesel and photovoltaic power are as follows.

- 10kW system for a public facility in Republic of Maldives through a Non-Project Grant Cooperation project in 2006 (Countermeasures against damages by Off Sumatra Earthquake and Indian Ocean Tsunami)
- 3kW system for a fishery facility in Micronesian Yap Island through a fishery grant cooperation in 2008

Utilizing those experiences and knowledge, Kyocera develops and proposes the hybrid system in Ethiopia and Kenya.

Figure 7 Installation of the hybrid systems at a public facility in Maldives (left) and at a fishery facility in Micronesia Yap Island

1.4.4 Future Direction for the Business Development

Summarizing the above, we have developed a business deployment model utilizing the following three strong points for the Kyocera's project in Africa and decided to implement this project to promote the future business deployment.

1) A project model that covers the polycrystalline silicon solar battery module achieving high efficiency and long useful life and the entire solar power generation system.
2) Experiences in a wide range of project deployment overseas from mega solar to 100kW class and the electrification of non-electrification areas.
3) Past experiences and sales networks in Africa and a project vision for the future as a company.

2 Background Information and Business Environment

2.1 Background Information and Business Environment

2.1.1 General Information about Ethiopia

<u>Geography and Climate</u>

The Federal Democratic Republic of Ethiopia (Ethiopia) is an East-African country of multi ethnic groups. There are nine regions (Afar, Amhara, Benishangul-Gumuz, Gambela, Harari, Oromia, Somali, Southern Nations, Nationalities, and Peoples', and Tigray) and two autonomies (Addis Ababa and Dire-Dawa). The capital city is Addis Ababa. The administrative divisions are regions, zone, woreda and kebele being the smallest division.

Ethiopia is a landlocked country and bordered by Eritrea to the north and northeast, Djibouti and Somalia to the east, Sudan and South Sudan to the northwest, and Kenya to the south. The Ethiopian Highlands cover most of the country. Addis Ababa is situated on the foothills of Mount Entoto, at an elevation of around 2,400 m. There are many water systems in the north. The Ogaden region in eastern Ethiopia stretches from the Ethiopian Highlands to desert in Somalia. The Afar Region in northern Ethiopia has the Afar Triangle, which is geologically important lowland. The Great Rift Valley runs from Tanzania and Kenya.

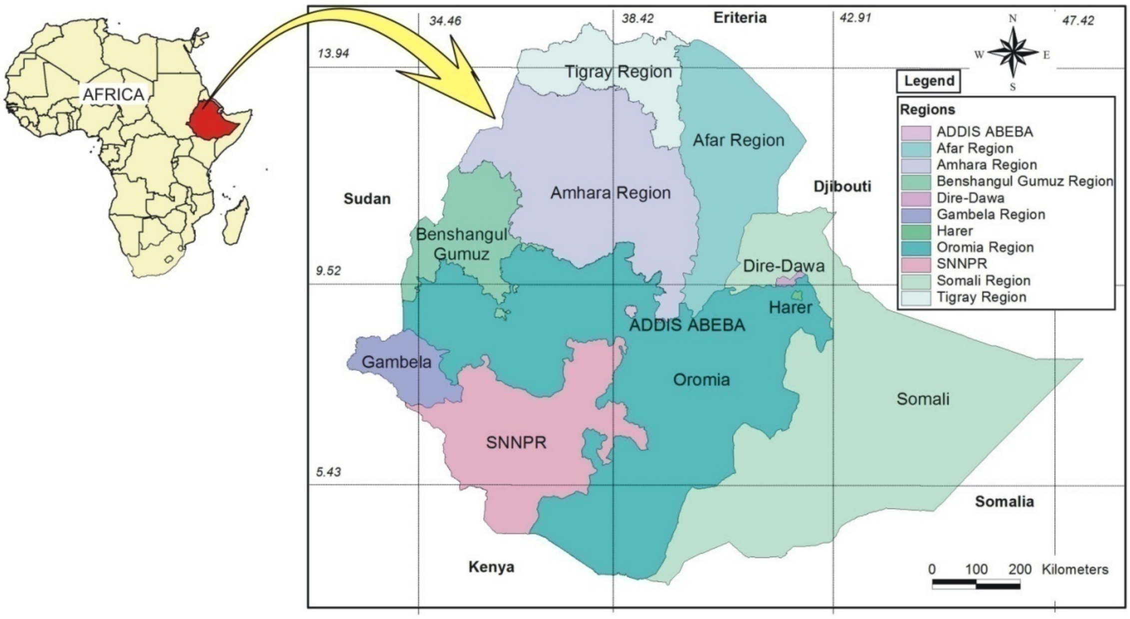


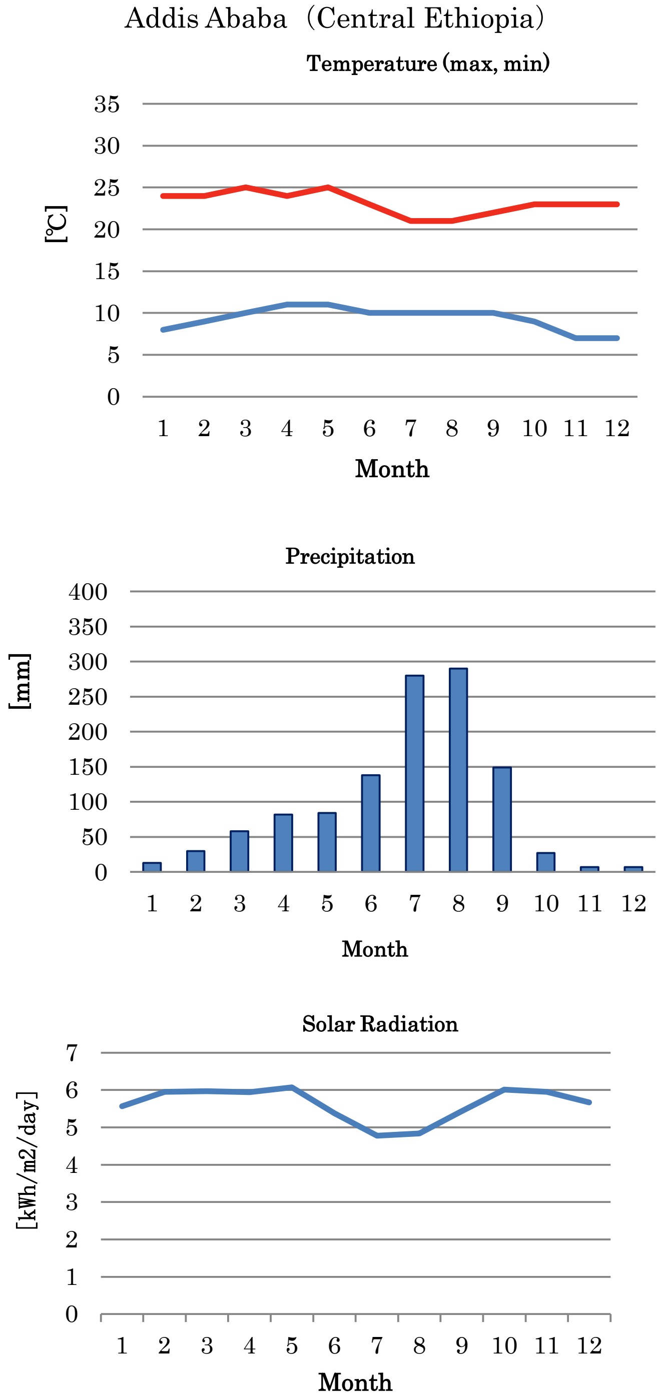
Figure 8 Location map and administrative regions in Ethiopia (Source: MoWIE)

<u>Solar radiation in Ethiopia</u>

Ethiopia is in a low latitude region with approximately perpendicular incidence of sunshine so that, in general, it is very rich in solar radiation resource. Solar radiation resources are distributed differently in different regions with the change of terrain height and weather conditions. In Ethiopia, the solar radiation resource is highest in the north highland, the mid-south, and the east Somali regions. Ethiopia experiences the highest levels of solar irradiation during the months November to March. The lowest solar irradiation levels are observed during the months June to September. The peak season for solar generation occurs during the dry season, which is also when reservoir levels, and hence hydro generation, are at their lowest. The variation in monthly energy production of solar, wind, sugar and biomass plants has been modeled in Aquarius optimization runs and in the generation planning programs WASP and EPSIM. They exhibit "complementarily" with the hydro system in that at times of maximum rainfall their production is at a minimum. Generating electricity from solar sources in a hydropower dominated system such as that of Ethiopia thus complementary. The complementarities of solar, wind and hydro generation are taken account of in the generation planning studies

Results of the daily analysis are consistent with those found from the monthly distribution and, as we would expect, levels of solar irradiation peak at noon (12:00). Obviously, solar energy is not generated once the sun has set and cost effective energy storage systems do not yet exist. We note that electricity generated from solar PV would therefore be ineffective in its contribution to meeting Ethiopia's peak demand, which occurs around, or just after 19:00 as levels of irradiation are very low at this time. However, with the large hydro energy storage of the Ethiopian system, this is not of great significance in that energy generated during the day can be stored and hydro generation can then be used in the peak and overnight hours.

The highlands of Ethiopia have abundant precipitation of more than 1,200 mm in a year. This abundant precipitation results in rich vegetation and flows down into rivers, to water surrounding arid areas. The eastern plateau divided by the Great Rift Valley is dry. The Ogaden region run to Somalia is hotter and drier. There are variations in seasons in different areas. The climate pattern in the central area has a dry season for October-March, light rain season for March-May and heavy rain season for June-September. Figure 4 shows monthly average temperature and precipitation in Addis Ababa, Jimma and Bahir Dar.



Source: Edited based on data of World Meteorological Organization (2013), NASA Langley Research Center and Atmospheric Science Data

Figure 9 Average temperature, precipitation and solar radiation in Addis Ababa, Ethiopia

<u>Basic Data</u>

The population of Ethiopia was 91.7 million in 2013, which was the 13^{th} biggest population in the world. According to the UN World Population Prospects (2012), it will be double by 2050 and become the nine-most populated country with180 million inhabitants in the world.

Ethiopian economic has been affected by the decline in agricultural production due to drought and the continual influx of refugees from Eritrea, Somalia, and North and South Sudan due to the conflicts. Yet, economic growth has been remarkable in recent years, recording an average 10.6% for eight years between 2004/05 - 2011/12. The GNI was 410 USD in 2012, however, which is still within the level of the least developed countries. About 90% of working population engages in agriculture, whose GDP accounts for about 50%. However, agriculture including teff cultivation, which is the most important staple crop, is very vulnerable against drought, because it is depending on rainfed agriculture by small-scale farmers (about 95% of all farmers). Furthermore, the Ethiopian government has depended on food imports and food aid due to chronic food shortages.

The Ethiopian government claims in the Growth and Transformation Plan (GTP 2010/11-2014/15) that it aims at development to become a middle-income country by 2020 to 2023. In that process, it aims to alleviate poverty by developing electric power infrastructure as well as road networks and water supply systems.

Table 3 Ethiopia basic data

General Information	Area	1,097,000 sq. km (three times bigger than Japan)
	Population	91,728,849 (World Bank, 2013) Population growth rate: 2.61% (World Bank, 2013)
	Capital	Addis Ababa
	Ethnic groups	Oromo, Amhara, Tigray and others about 80 ethnic groups
	Languages	Amharic and English
	Religions	Ethiopian Orthodox, Muslim and others
Government	Government type	Federal republic
	Chief of state	President MULATU Teshome Wirtu (since October 7, 2013 for a six-year term)
Economy (US$)	Major industries	Agriculture (cereals, pulses, coffee, oilseed, cotton, sugarcane, potatoes, khat, cut flowers; hides, cattle, sheep, goats; fish)
	GNI	$37.4 billion (World Bank, 2013)

	GNI per capita	$410 (World Bank, 2012)
	GDP growth	8.5%(World Bank, 2012)
	Inflation	22.8%(World Bank, 2012)
	Unemployment rate	17.5%（2012 年：IMF）
	Total trade	(1) Exports $3.109 billion (2) Imports $9.498 billion (2012)
	Commodities	(1) Exports: coffee, khat, gold, leather products, live animals, oilseeds (2) Imports: petroleum and petroleum products, chemicals, machinery, motor vehicles, cereals, textiles
	Partners	(1) Exports: China 13%, Germany 10.8%, US 7.9%, Saudi Arabia 7.8%, Belgium 7.7%, (2012) (2) Imports: China 13.1%, US 11%, Saudi Arabia 8.2%, India 5.5% (2012)
	Currency	BIRR
	Currency rate	$1= 19 BIRR (July, 2014)
Economic Cooperation	Japan's economic cooperation	(1) Loans (FY2012, E/N base) 3.7 (2) Grants (FY2012, E/N base) 101.005 (3) Technical Cooperation (FY2012, JICA base) 33.601 (billion yen)
	Donor countries	US: 706.66, UK: 552.25 Japan: 119.70, Canada: 118.64, Germany: 101.21 (million dollars, 2011)

Source: Ministry of Foreign Affairs of Japan (Accessed in September, 2014)
http://www.mofa.go.jp/mofaj/area/ethiopia/data.html

2.1.2 Current Situation of Electric Power

Rural Electrification

MoWIE is in charge of rural electrification in Ethiopia. There is a rural electrification master plan, called "Universal Electricity Access Program (UEAP)", under which EEP (current EEP) has proceeded with grid expansion. Regarding the grid extension, EEP published in September 2014 a master plan study "Ethiopian Power System Expansion Master Plan Study –Final Reportt". It covers 2013-2037, where the ambitious plan aims at 95% electrification rate and an upgrade of the power capacity by 20 times by 2037. Reference plan combined hydropower, renewable energy, and thermal power generation is derived as a generation planning. Historically, hydropower is the main electricity power source, accounting for 86% as of 2008; however, the cost of hydropower plant construction has been rising, while other renewable energy sources such as geothermal, wind and solar have recently become more attractive.

Currently, there are many off-grid areas, where people use small scale diesel generation and hydropower generation as a self contained system (SCS). The total SCS capacity is 34MW, among which 6.2MW is from small hydropower. The grid network has been progressing to include those current off-grid areas. On the other hand, MoWIE and Oromia government clearly mentioned that there will remain off-grid areas in the future as well and they even have a plan to cover 20-25% of electricity demand by isolated grids. STREAMs should be suitable for those isolated grid power sources.

The Rural Electrification Fund (REF) of MoWIE is in charge of rural community electrification. It is, however, dependent on foreign support, such as GIZ, from Germany. The basic policy of electrification in the country is to increase the capacity of power generation and to give priority of grid extension to urban areas and public facilities. On the other hand, rural electrification is given low priority as it is considered that there is little demand of electricity in rural communities. Thus, progress of rural electrification by the Ethiopian government is unlikely in the near future.

Solar (Photo-voltaic)

The non-hydro power plant options that have been considered, with the nominal sizes used for planning is Solar (photovoltaic) with an average annual load factor of 20%. Electricity may be generated by harnessing the sun's energy with solar photovoltaic (PV) modules. The technology is simple with no moving parts or environmental emissions during operation8 and grid connected systems have been in operation for twenty years. The technology is becoming increasingly attractive as the PV module price reduces - the price of solar PV panels has fallen 75 per cent since 2008. Alternative solar technologies such as concentrated solar power, which use using thermal systems, are more expensive compared to the reduced cost of PV modules. The storage capabilities of some CSV technologies are not of significant benefit in Ethiopia, which inherently has storage capacity. Maximum annual generation planting for solar has been set to 10% of the overall demand including exports in any given year. Therefore, a generic solar park model of 300 MW capacity or split into nominal 100 MW units are able to establish. Solar photovoltaic parks have a relatively small footprint, though about 50% larger than a wind farm and the land cannot be used other purposes. The typical land take for a 300 MW solar park would be 390 ha, assuming flat land (possibly slightly south facing) and no obstacles (trees, houses, fences etc.).

Ethiopia is one of the few countries in Africa to have a green energy plan – the Climate Resilient Green Economy Strategy10 (CRGE). However, due to the economic situation in the country it is unlikely that Feed in Tariffs (FiTs) incentives will be available. FiTs have the effect of incentivizing renewable technologies by offering a 'higher than market price' for their electricity. The lack of FiTs would ordinarily present a barrier to entry for PV schemes; however, the price of modules has fallen so much that grid parity for PV generation will soon be reached. The CRGE should however encourage the installation of sustainable, efficient energy generating capacity as opposed to inefficient systems with a lower capital cost (CRGE, 2011). This is supported by the Ethiopian government's announcement of a goal to source 20 per cent of the country's capacity from solar energy in the five years from 2012, although the generation planning based on economic pricing of the various alternatives does not support such a rapid penetration.

According to the master plan of EEP, developed by Parsons Brinckerhoff, current deployment of PV in Ethiopia extends only to off-grid systems, predominantly to support telecommunications equipment in remote areas. Some off-grid rural electrification schemes also exist; however, there are currently no grid connected schemes. No plants have been committed.

The Ethiopian company METEC (Metals and Engineering Corporation) has recently completed a 20 MW PV module turnkey assembly line in Addis Ababa in collaboration with international companies Spire Corporation and SKY Energy International, Inc. This should help reduce the cost of PV installations in Ethiopia. Several local companies are interested in developing solar power. Taking into account the above considerations, the installed price, excluding interest during construction, has been set at $US 1.8/kWp or $US 1800/MWp, as shown in the table below. The capital includes the cost of the modules, inverters, balance of system and installation costs (including civil work, labor costs etc.). The operational cost, estimated as US$ 25 /kWp/year, reflects the operation and maintenance costs as well as the cost for on-site security guards.

Small Hydropower Generation

MoWIE conducted a potential assessment survey for the small hydropower generation, and it identified 40 sites. For those sites, STREAM turned out to be not applicable, because they have heads with more than tens of meters in height, for which other technology is suitable. There are also cases of community development supported by GIZ using a micro hydropower system near Awasa in central Ethiopia. They just started in 2012 receiving the support from GIZ for the initial cost coverage including the installation of generators. They aim at starting an operation committee to maintain and manage the generators and to collect fees from users as well as building capacity in the community. Their unique point is that GIZ lets the community itself develop the methodology of utilization of electricity for sustainable development, instead of imposing them "best practices" from the beginning. Another unique point is that the community has to bear the initial cost partially, for example for the construction of canals as an "in kind contribution".

2.1.3 Environmental Policy in Ethiopia

The competent Ethiopian government agency that controls affairs on climate change and in the environmental field is the Ministry of Environment and Forest (MEF). This ministry was established in July 2013 after part (forest field) of the Ministry of Agriculture and Forest and the Environmental Protection Authority (EPA) under the umbrella of the Ministry of Water, Irrigation and Energy were consolidated.

EPA was established in 1995. EPA has been playing a role of DNA (Designated National Authority) of Ethiopia in CDM (Clean Development Mechanism) which has been initiated by the United Nations Framework Convention on Climate Change (UNFCCC). Japan and Ethiopia singed in May 2013 the bilateral document pertaining to the Joint Crediting Mechanism (JCM). MEF is a member of the Joint Committee (JC) where the Chair on the Ethiopian side has been assumed by Director General Mehari Wondmagegn (as of February 2015). The first JC meeting was held in August 2013 towards early implementation JCM projects in Ethiopia.

The issues cited as cross-cutting subjects in the national five-year "Growth and Transformation Plan (GTP)" (2010-2014) of Ethiopia are the environment and climate change. To build a Green Economy that is also resilient to climate change, the issues refer to the significance of measures against climate change and of alleviation of greenhouse effect gas.

For a measure pertaining to climate change, "Climate Change National Adaption Programme of Action (NAPA) of Ethiopia" was drawn up in 2007. NAPA cites 37 options as potential adaptive measures of high priority. Many of the options are related to agriculture but include no specific measures of alleviation in the energy field.

In addition to NAPA, the Government of Ethiopia drew up the Climate Resilience Green Economy (CRGE) in 2011. CRGE has introduced the Green Economy Plan based on the four pillars stated below which aims to realize sustainable economic development and bring up Ethiopia to a middle income country by 2025.

① Improvement in production methods of farming and livestock farming;

② Forest preservation and forestation;

③ Expansion of power generation from renewable energy sources; and

④ Expansion of application of advanced energy-saving technology in transportation, industries, and buildings.

In addition, as comprehensive policy pertaining to the environment and natural resource control, "Environmental Policy of Ethiopia (EPE)" was adopted in 1997. The policy details measures for environmental and natural resource control in the following areas.

(a) Soil control and sustainable agriculture;
(b) Forest, forest land, and wood resource;
(c) Biodiversity of genetic inheritance, seeds, and ecosystems;
(d) Water resource;
(e) Energy resource;
(f) Mineral resource;
(g) Populated places, urban environment, and public sanitation;
(h) Control of hazardous material and contamination originating from industrial waste;
(i) Air pollution and climate change; and
(j) Culture and natural heritage.

(e), Energy resource, refers to cutting fossil fuel through promotion of renewable energy, while (i), Air pollution and climate change, refers to promotion of natural energies, including solar energy, that produce no greenhouse effect gas.

Furthermore, EPE refers to implementation of Environment Impact Assessment (EIA) as a cross-cutting policy.

A legal obligation in Ethiopia has required implementation of EIA since 2002, which is under control of MEF (former EPA). According to the "Environment Impact Assessment Procedural Guideline series 1 (November 2003)," projects to be implemented in Ethiopia are required to implement an EIA and submit a Study Report (Environmental Impact Statement (EIS); if a project is under control of the federal government or involves in more than one region, the project is required to submit an EIS report to the federal government (EPA); other projects are required to submit an EIS report properly to the local governments concerned. For implementation of EIA, projects are classified as stated below. Projects in each field consist of three types (① project that is required to implement EIA throughout all the project phases because it may have serious impact on the environment; ②project that may have serious impact on the environment, depending on the type, scale, or other features but submission of an EIS report is considered unnecessary; and ③project that is considered to have no impact on the environment and therefore that is required to conduct no EIA).

（1） Social infrastructure and services

(a). Region, supply of urban water, and sanitation

(b). Waste processing

(c). Urban development

（2） Economic infrastructure and services

(d). Traffic

(e). Energy

（3） Production fields

(f). Agriculture

(g). Irrigation and drainage

(h). Forest

(i). Livestock

(j). Fishing

(k). Mineral extraction and processing

(l). Oil

(m). Industry

（4） All projects concerning environmental improvement programs

Basic EIA steps in Ethiopia are indicated in the following figure.

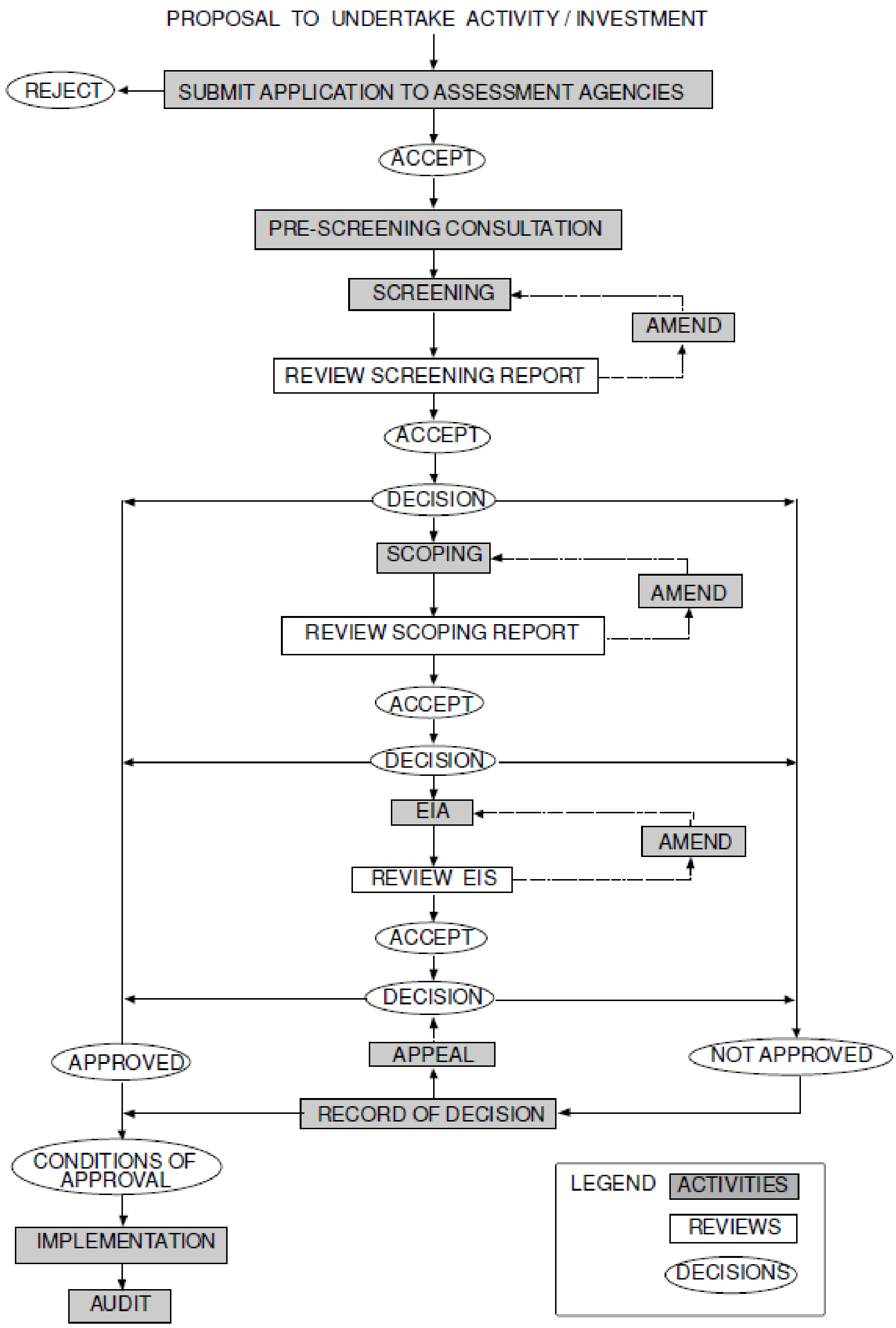


Figure 10 EIA Steps

Source: EPA, "Environmental Impact Assessment Guideline Document"

Other legal systems relating to the environment include "Environmental Pollution Control Proclamation," which pertains to control of air pollution and water quality, etc., and "A PROCLAMATION TO PROVIDE FOR THE CONSERVATION,

DEVELOPMENT AND UTILIZATION OF FORESTS," which involves in forest conservation.

2.1.4 Business Environment in Ethiopia

1) Customs duties and systems

Ethiopia has exempted the entire custom duties on the import of capital goods, including plants, machinery, and construction material, to activate investment in the private sector. Furthermore, income tax is exempted on newly established corporations to encourage investors into capitalizing in production business, agriculture product processing business, power generation, and power supply, etc.

In addition, since Ethiopians have no private right to own land, almost all of the land is owned by the government. Such land lots are available for lease for a long period (15 to 99 years).

2) Transportation environment

When overseas material and equipment, etc. procured are imported into Ethiopia, the equipment usually arrives at the port of Djibouti, a neighboring country, before trucks transport the cargo into Ethiopia on land. The roads from the port of Djibouti through the city of Addis Abeba are paved. In addition, since the tolled expressways run between the city of Addis Abeba and Mojo, a major industrial area in Ethiopia, and between Djibouti and Adama, efficient and smooth transportation is available.

The cargo railway from Djibouti to the city of Addis Abeba is currently under construction with the aid from China. The railway is scheduled to be opened in 2015. After it is opened to traffic, railway transportation time is likely to reduce by 7 to 8 hours, compared with road transportation time.

3) EPC contractor

The local EPC contractors who are likely to actually undertake the solar power generation project are as follows. Among other likely contractors, Alphasol Modular Energy has rich experience in undertaking renewable energy projects including solar power generation and hydropower generation.

- Alphasol Modular Energy
- National Consultants Engineering
- Tropics consulting Engineers P.L.C
- Tekleberhan Ambaye Construction P.L.C

4) Feed in Tariff: FiT

The FiT of Ethiopia is currently under deliberation at the Ethiopia Parliament. It is expected to take one year or longer before the subject is settled. The Government of Ethiopia arranged a draft of "Feed-in Tariff Proclamation No ---/2012" in 2012 and has intention to introduce the FiT to promote power generation based on renewable energy. According to the draft, FiT on solar power generation (continuous power) is set up as listed in the following table.

Table 4 FiT Price on Solar Power Generation (continuous power)

Megawatt (MW)	FiT (US cents/kWh)
0.01 – 0.1	10
0.1 – 0.5	9.5
0.5 – 2.5	9
2.5 – 5	8.5
5 – 10	8

Source: Ethiopian Electric Agency, "Feed-in Tariff Proclamation No ---/2012"

2.1.5 Issues in Terms of Project Implementation

<u>Mega Solar Project in Ethiopia</u>

- Project Partners

<Government agencies>

If a mega solar project is to be implemented in Ethiopia, it will be appropriate that the project is implemented as an ODA project when the size of the present economy of Ethiopia is taken into consideration.

The government agency that controls electricity projects, including mega solar projects, is the Ministry of Water, Irrigation, and Energy (MoWIE), while the agency for implementing national grid projects is Ethiopian Electric Power (EEP) under the umbrella of MoWIE. When a mega solar project is to be implemented, the operator of the project should consult with those 2 agencies as partners and jointly consider the project before requesting that the project be received as an ODA project by the Embassy of Japan or JICA in Ethiopia.

<EPC contractor>

As the local partner in Ethiopia who will undertake EPC for the mega solar project, Alphasol Modular Energy, who is referred to in the section 2.1.4, is considered as the most likely partner.

As is stated in that paragraph, the company has rich experience in undertaking EPC in renewable energy related projects in Ethiopia. Meanwhile, since the company has no experience in implementing large-sized projects, like the mega solar project, it is essential that an appropriate corporation, like a Japanese corporation who has experiences in this field, becomes representative of the project for smooth execution of the project.

- Legal Issues

In our hearing to the Ministry of Environment and Forestry (MEF) on implementation of the mega solar project as an Ethiopian JCM project, it was found out that the project needs no EIA but is required to submit an "Impact Assessment Report" to MEF. However, since this project case is currently under consideration in the government, the form, requirements, and other details are scheduled to be specified in future.

In addition, the place designated to the site for the solar power generation facility stated in this report is currently used as farmland. As is mentioned in the section 2.1.4, Ethiopia has no private ownership of land. The entire land is owned by the government. Therefore, if the government determines to implement the mega solar project in the designated site, the government is supposed to make land arrangements, including the expropriation of the site.

Furthermore, as stated in the same section 2.1.4, customs duties on the import of the facilities necessary for this project are exempted.

<u>Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia</u>

- Project Partners

<EPC contractor>

Like what is mentioned in the last section of the Mega Solar Project, Alphasol Modular Energy is the most likely partner who undertakes EPC services to the community electrification project in Ethiopia in which micro hydro power and sunlight are combined.

As is mentioned in the abovementioned paragraph, since this company has past experiences in undertaking a wide variety of EPC services to renewable energy related projects in Ethiopia, the company is likely to contribute to smooth execution of this project.

- Legal Issues

The community electrification project where micro hydro power and solar power are combined is required to submit an Impact Assessment Report to MEF if the project is to be implemented as a JCM project. Details, including the form and requirements, of such Impact Assessment Report are scheduled to be specified in future.

Moreover, since the place designated to this solar power generation facility stated in this report is in no use currently, the project has no problem pertaining to the utilization of the land.

Furthermore, as is mentioned in the section 2.1.4, customs duties on the import of facilities necessary for this project are exempted.

2.2 Background information and Business Environment in Kenya

2.2.1 General Information about Kenya

Geography and Climate

Kenya is a Republic country located in the East of Africa. It was independent from the United Kingdom in 1963 and shifted to a republican government in 1964. Jomo Kenyatta is a first President of Kenya. It is one of the countries of the British Commonwealth. It was administratively divided in eight provinces until 2010. However, these divisions were abolished in the new constitution, which reorganized the country into 47 administrative regions (counties) since 2013. Counties are subdivided into Wards, and subsequently into Locations.

Kenya lies on the equator with the Indian Ocean to the southeast, Tanzania to the south, Uganda to the west, South Sudan to the north-west, Ethiopia to the north and Somalia to the northeast. Most of the land is a mountainous plateau with an elevation of 1100m-1800m. The site of the highest point in Kenya is Mount Kenya, which reaches 5,199 m and lies on the equator.

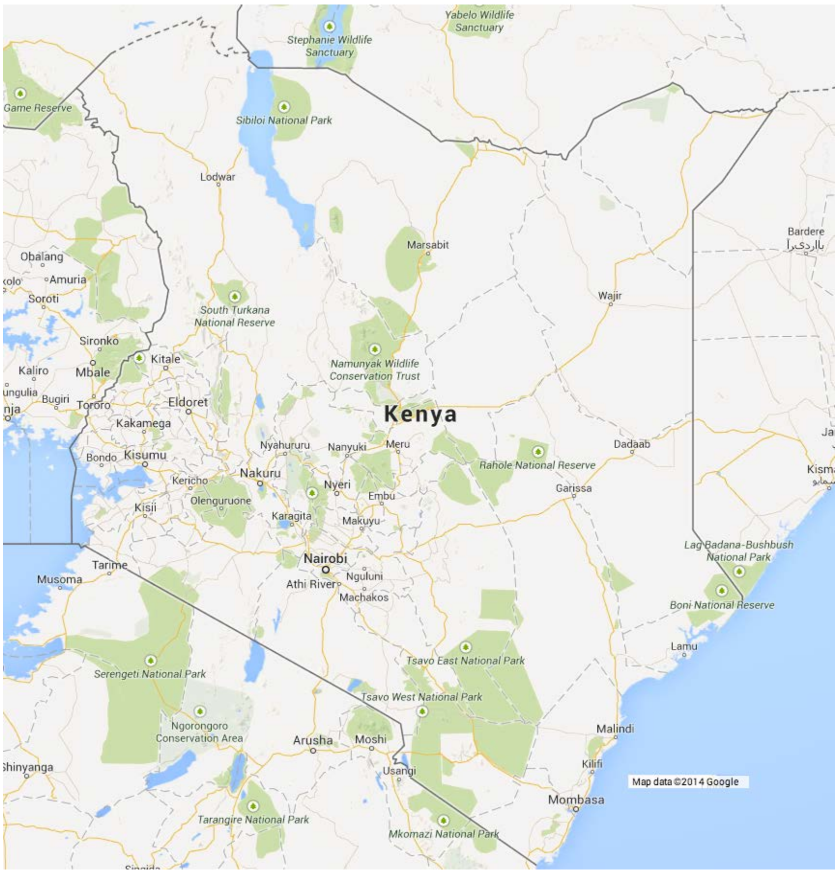
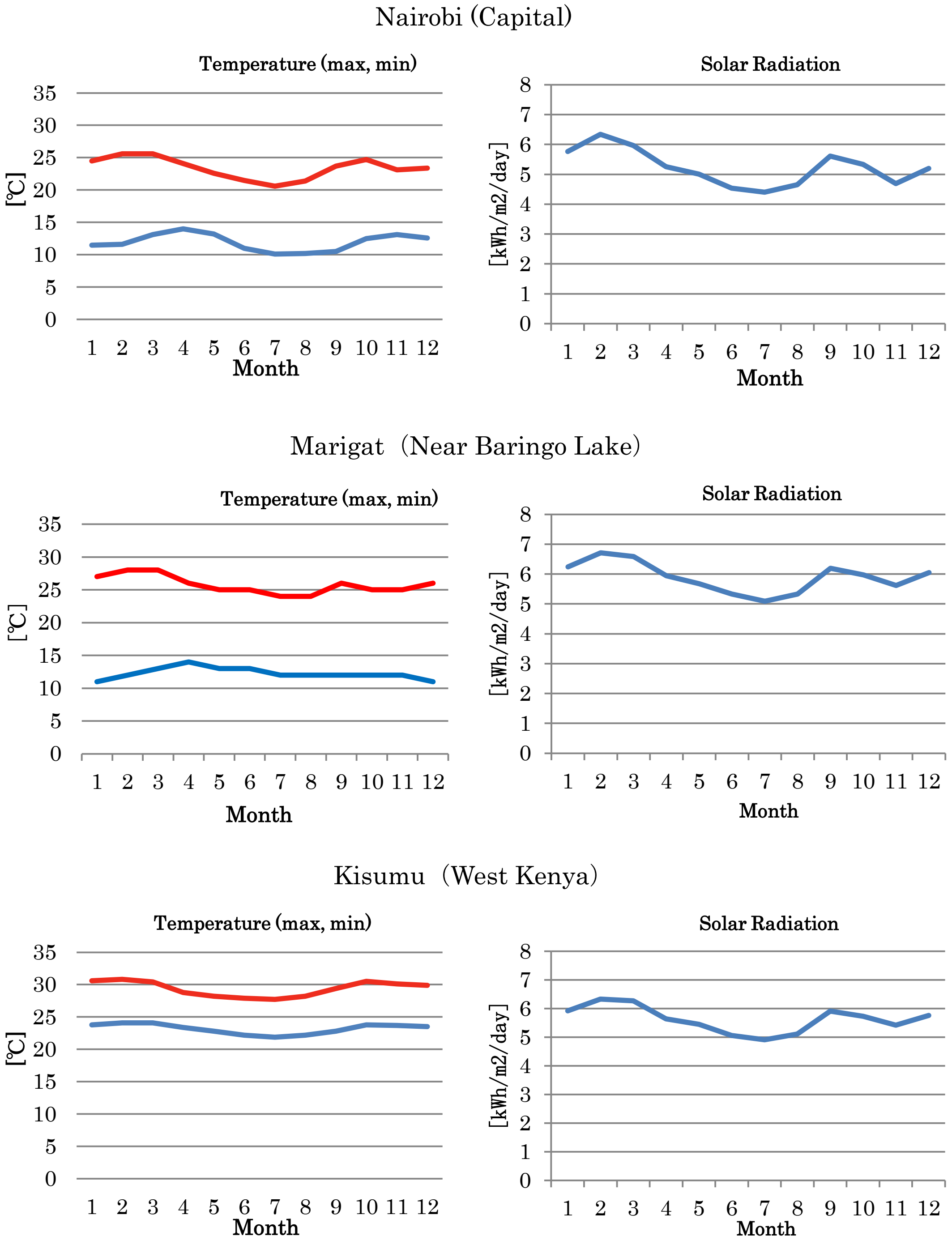


Figure 11 Kenya map

The climate is mostly that of a dry plateau savanna. Seasonal winds blow from November to March (northeast monsoon) and from May to September (southeast monsoon). Due to the influence of the southeast monsoon, there is heavy rain between March and May and lighter rains between October and December. The highland region in the center of the country is where it rains the most. However, the climate is rather cool, due to high altitude. The regions of Lake Victoria and the coast of the Indian Ocean have a weather of tropical rain. The north and northeast of Kenya are very hot and dry. On the other hand, Mount Kenya has a glacier holding perpetual snow and there is frost in altitudes above 2500m. Figure 6 shows temperature and precipitation for three cities near candidate areas for the implementation of this project.



Source: Edited based on data of World Meteorological Organization (2013), NASA Langley Research Center and Atmospheric Science Data Center (2013)

Figure 12 Figure 6: Average temperature and solar radiation in Nairobi, Marigat and Kisumu, Kenya

Basic Data

In 2011, the population of Kenya was about 41.6 million. According to estimates in the 2012 edition of the "World Population Outlook" of the United Nations, it is expected to reach more than double, at about 97 million by 2050. The main industry is agriculture including coffee, tea and horticulture. Agriculture accounts for 25% of GDP and is the main activity of about 60% of the working population. Industrialization is relatively high, in comparison with other African countries. It displays an important presence in Eastern Africa.

The national plan "Vision 2030" was formulated in 2008 with the aim of enabling Kenya to become a middle-income country by the same year denoted by its name. Electrification of 100% is one of the objectives stated in the plan. The REA wants to achieve 65% electrification by 2022.

The establishment of a new constitution was decided in the referendum of 2010. In contrast with the constitution that was established after the independence from British colonial rule in 1963, the new constitution strengthened the separation of powers by the reduction of presidential authority. It promoted decentralization through the transfer of authority to the County. Thus, it is estimated to further promote democratization. The new Constitution came into force after the general election in 2013.

Table 5 Kenya Basic Data

General Information	Area	583,000 sq. km (1.5 times bigger than Japan)
	Population	44,350,000 (World Bank, 2013)
	Capital	Nairobi (about 3.1 million inhabitants) (Kenya National Bureau of Statistics, 2009)
	Ethnic groups	Kikuyu, Luhya, Kalenjin, Luo and others
	Languages	Kiswahili and English
	Religions	Christian, Muslim, and Traditionalists
Government	Government type	Republic
	Chief of state	President Uhuru KENYATTA (since 9 April 2013 for a five-year term)
Economy (US$)	Major industries	Agriculture: coffee, tea, horticulture, sisal, cotton, corn, and pyrethrum Manufacture: food processing, beer, cigarettes, cement, oil refining, and sugar Mining: soda ash and fluorite
	GDP	44.1billion USD (World Bank, 2013)

	GNI per capita	$950 (World Bank, 2013)
	GDP growth	4.7% (World Bank, 2013)
	Inflation	9.4%(World Bank, 2013)
	Unemployment rate	Unknown
	Total trade	2.1643 trillion KSH (EIU, 2013)
	Commodities	(1) Exports: 611 billion KSH tea, horticultural products, textiles, accessories, coffee, cigarettes and its manufacturing products, and steel (2) Imports: 1.553,4 trillion KSH petroleum products, machinery and transportation equipment, oil, and motor vehicles (EIU, 2013)
	Partners	(1) Exports: Uganda, UK, Tanzania, Netherlands, US (2) Imports: UAE, India, China, South Africa, Japan, Saudi Arabia, Indonesia (Kenya National Bureau of Statistics, 2012)
	Currency	Kenyan Shilling (KSH)
	Currency rate	$1= 88KSH (September, 2014)
Economic Cooperation	Japan's economic cooperation	(1) Loans (FY2013, E/N base): 298.513 billion yen (2) Grants (FY2013 E/N base): 119.310 billion yen (3) Technical Cooperation (FY2013, JICA base): 104.715 billion yen
	Donor countries	(1) US (817.8) (2) UK (161.3) (3) Germany (157.0) (4) Japan (132.07) (5) France (89.9) (million dollar, 2012)

2.2.2 Current Situation of Electric Power

Rural Electrification

Rural electrification falls under the responsibility of the Rural Electrification Authority (REA), an executive agency under the umbrella of the Ministry of Energy and Petroleum (MoEP). As the source of funds for the REA, 5% of all sales by Kenya Power, which exclusively controls the power transmission and distribution business, are devoted for rural electrification development. However, at the present time, the capacity to promote rural electrification at the REA is insufficient in teams of personnel, quality and funds. Furthermore, the priorities for rural electrification are low outside of schools, hospitals and commercial facilities. This is due to perceived low demand, which results in very limited funds being allocated.

Hybrid Mini-grids

"Rural Electrification Master Plan (2009)" mentions the importance of "use of renewable energy resources for rural electrification" and "hybrid scheme."

> Delivery of fuel oil [for diesel power generation] in many remote rural areas in North-Western, Northern and North-Eastern Kenya and along the Coast is a serious issue especially during the rainy season. [...] fortunately, the renewable resource base in these areas permits erecting triple-hybrid generation plants, combining renewable wind and solar energy with diesel fuel supplied by trucks.

"Scaling-up Renewable Energy Program (SREP)" of Climate Investment Funds proposes "SREP Investment Plan for Kenya (September, 2011)" to the Kenyan government and uses the term of "Hybrid Mini-grids."

According to the investment plan, "Hybrid Mini-grids" Project proposes to increase the proportion of renewable energy (solar and wind) in existing and plansned mini-grids to 30%. Specifically, the project proposes to install 3 MW of renewable systems (solar and wind) in hybrid with the existing diesel generators in 12 isolated mini-grids with a total installed capacity of 11MW. Further, the Kenyan government intends to construct 27 additional isolated mini-grids with an installed capacity of 13 MW.

2.2.3 Environmental Policy in Kenya

The Kenyan government agencies that control affairs on climate change and in the environmental field is the Ministry of Environment, Water, and Natural Resources (MEWNR) (policy determination body) and the National Environment Management Authority (NEMA) (implementation body). MEWNR was established in 2013 when the Ministry of Environment and Natural Resources and the Ministry of Water were consolidated as part of ministerial reorganization. NEMA was established in 1999 as a body of the Kenyan government that implements environmental policy based on

"Environmental Management and Co-ordination Act No. 8 of 1999 (EMCA)." NEMA is also the designated national agency (DNA) for Clean Development Mechanism in Kenya.

The Government of Kenya announced "National Climate Change Action Plan" in 2013, which refers to alleviation measures and indicates the direction of promoting renewable energies including geo-thermal power generation in electrification in rural areas.
Japan and Kenya signed the bilateral JCM documents in June 2013. JCM Chair on the Kenyan side is Dr. Alice Kaudia of MEWNR. The initial Joint Committee (JC) meeting was held in August 2013 towards early implementation of projects.

Projects in Kenya are required to implement an Environmental Impact Assessment (EIA) in advance, depending on the field. EIA is controlled by NEMA. The projects that are required to implement EIA are as follows:

（１） General;
（２） Urban development;
（３） Transportation and traffic;
（４） Dam, river, water resource;
（５） Aerial spraying;
（６） Forest related;
（７） Agriculture;
（８） Production and processing industries;
（９） Power supply infrastructure;
（１０） Waste processing;
（１１） Natural preservation areas; and
（１２） Nuclear reactor;

Normal EIA steps are shown in the figure below. Approval will be granted normally within 45 days after the required documents are submitted to NEMA. If a project is turned down and a review is necessary, EIA process will be discontinued until the project is revised. However, such approval will be granted normally within 45 days including the period of revision days. The cost for such application will be either 0.1% of the amount necessary for the project or 10,000 Kenya shilling (ksh).

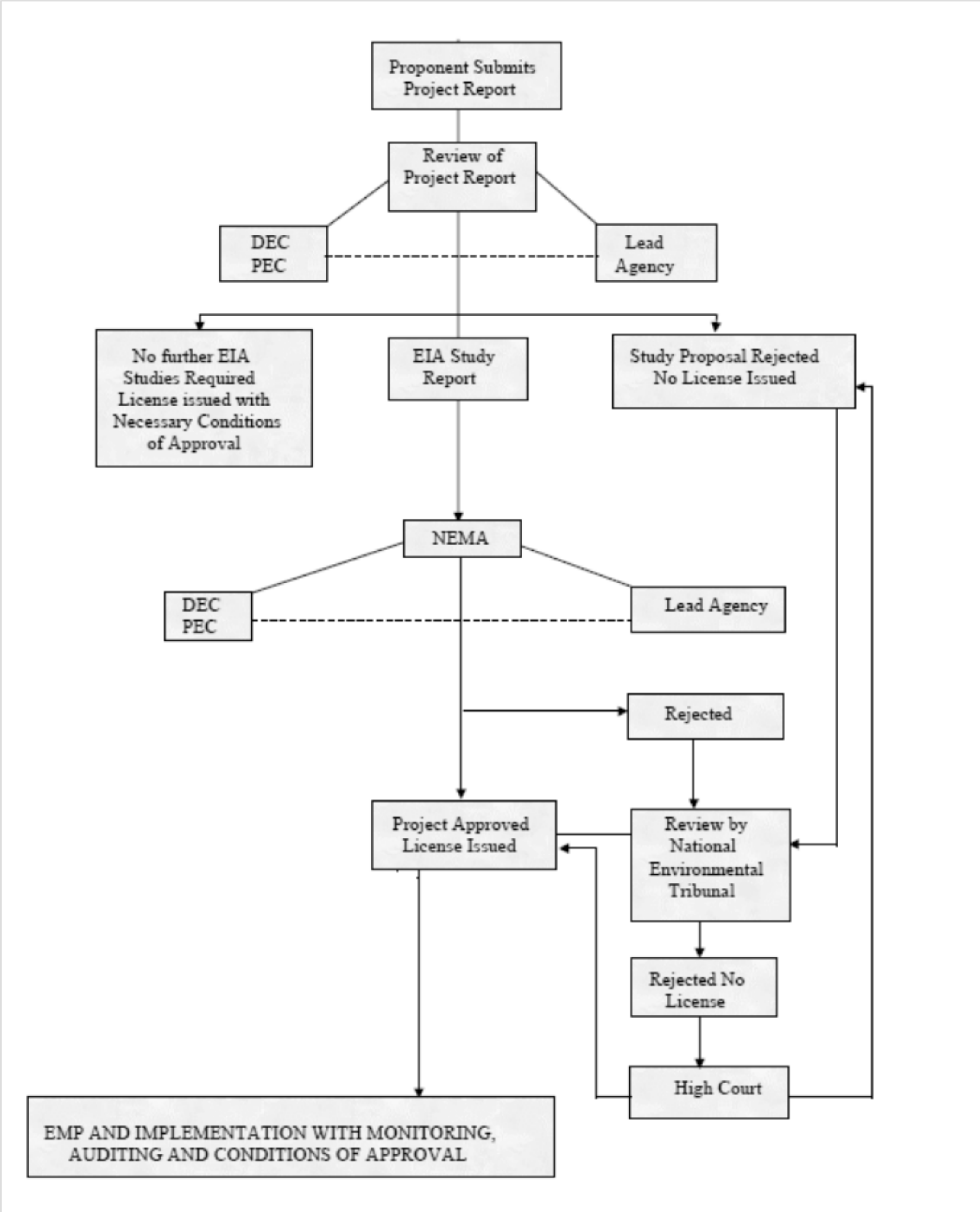


Figure 13 EIA Steps Source: NEMA, "Environment Impact Assessment Guidelines and Administrative Procedures"

2.2.3 Business Environment in Kenya

1) Customs duties

Since Kenya has exempted customs duties on import pertaining to solar generation systems, solar power generation equipment can be imported with no customs duties.[1] When a solar power generation project is implemented, relevant taxes are listed in the following table.

Table 6 Taxes Relating to Implementation of Project in Kenya

Type of tax	Tax rate/Description	Applied law
Corporation tax	30% (37.5% on foreign corporation)	Income Tax Act
Withholding tax	5%, 15%, or 20% on local, regional, and international services	Income Tax Act
Compensation tax	When there are no dividends	Income Tax Act
Undercapitalization	When the liability of a foreign corporation exceeds three times the equity capital	Income Tax Act
Investment allowance	150% on EPC expenditure	Income Tax Act
Excise duty	N/A	Customs & Excise Act
Stamp tax	4% on real estate in autonomous regions, 2% on real estate outside autonomous regions, and 1% on increase of authorized capital.	Stamp Duty Act
Railway development tax	1.5% on the price of import goods	The Finance Act, 2013

2) Transportation environment

Overseas material can be imported into Kenya by means of marine transportation or air transportation.

In case of marine transportation, cargo arrives at the port of Mombasa, from which the cargo is transported on land by railway or truck into the project site. The port of Mombasa is linked through Mombasa Road (paved road) to Nairobi in the distance of six hours or so.

There are many airports in Kenya. Thus, overseas cargo can be sent by air to a Kenyan airport nearby the project site, from which the cargo can be transported on land by

[1] "East Africa Community Customs Management Act," Value Added Tax Amendment Act No.7 of 2014

truck to the project site.

3) EPC contractor

Local EPC contractors who can undertake the solar power generation project are as stated below. These contractors have experiences of undertaking many sunlight projects. Among others, Socabelec has a wide variety of experience in undertaking sunlight and wind power generation projects and the like. Furthermore, for hybridization, this company can design mini-grids, etc. Since the other contractors have undertaken introduction of sunlight systems only, it could be said that Socabelec is superior in technology. For an outline and past achievements of this company, refer to the attached document

- Socabelec East Africa
- Power Point Systems (E.A) Limited
- Solar Works (E.A) Ltd
- Center for Alternative Technologies Ltd

4) Feed in Tariff (FiT)

The Ministry of Energy and Petroleum (MoEP) of Kenya has drawn up "Feed-in-Tariffs Policy on Wind, Biomass, Small-Hydro, Geothermal, Biogas and Solar Resource Generated Electricity[2]" in 2008. The ministry has introduced the Feed in Tariff (FiT) system that buys solar electricity at fixed prices as listed in the following table.

【Case where installed capacity is 10 MW or less】

	Installed capacity (MW)	Standard FiT (US$/kWh)	Variable portion	Minimum capacity (MW)	Maximum capacity (MW)
Grid connection	0.5-10	0.12	8%	0.5	10
Off grid	0.5-10	0.2	8%	0.5	1

2

【Case where installed capacity is over 10 MW】

	Installed capacity (MW)	Standard FiT (US$/kWh)	Variable portion	Minimum capacity (MW)	Maximum capacity (MW)	Maximum cumulative capacity (MW)
Grid connection	10.1-40	0.12	12%	10.1	40	100

In addition, the present environmental law of Kenya has no description pertaining to net metering. However, the National Energy Act 2014 (draft version) has description of net metering as indicated in the table below. The Energy Bill 2014 (draft version) also has description of net metering. It could be thus said that the Government of Kenya has set up a policy of promoting net metering in future.

Table 7 Description of Net Metering in the National Energy Law 2014 (draft version)

【Definition】

"Net metering" is a system that operates concurrently with public power distribution systems to measure electricity supply with one or more measurement devices. The system will become an incentive for consumers of power to sell generating electricity from renewable energy sources to retailers and distributors.

【Summary】

- The Government of Kenya considers "net metering" as a policy and a strategy of dealing with issues that sunlight and wind force energies are facing. The government also intends to adopt "net metering" that will provide a framework that enables to connect electricity, generated from sunlight and wind power, to the national or independent grids, through direct sale or net metering.
- The government is also preparing the arrangement of customs duties on net metering of electricity originated from renewable energy from consumers of power. To this end, the government is considering the preparation as the strategy for handling issues around introduction of domestic renewable energy.
- Action agenda of the policy, made by the government, has aimed to prepare a legal system necessary for "net metering" in the short period (2012-2016).

Table 8 Description Relating to Net Metering in Energy Bill 2014 (draft version)

➢ Under the Ministry of Energy, a secretariat will be set up that will be in charge of net metering. ➢ Definitions of "net metering system" and "net metering system agreement" ➢ The upper limit of electricity from renewable energy that is applied to net metering shall be 20 KW.

2.2.4 Issues in Terms of Project Implementation

Hybrid Mini-Grids Project in Kenya

➢ Project Partners

<EPC contractor>

As the partner in Kenya who undertakes a hybrid mini-grids project, Socabelec is considered as the most likely partner, as mentioned in the section 2.2.4.

As is mentioned in that paragraph, since Socabelec has rich experience in constructing solar power generation projects, the company is expected to contribute to smooth execution of the project. Our hearing to Socabelec has found out that the company is interested in this project and that the company is eager to undertake EPC services when the project is implemented.

➢ Legal Issues

Solar power generation projects in Kenya are not included in the fields that require EIA. However, in the case of a project that is included in "General (size or structure that is not harmonious with the surrounding environment, or a significant change is expected in the current use of the land)," the project is subject to EIA. It is unlikely that the site designated to this solar power generation facility reported in this report is subject to EIA.

In addition, in our hearing to the local EPC contractor (Socabelec), the company told us that the company had no experience of trouble pertaining to EIA in its many construction projects in the past. Unless this project is to be implemented in farmland, etc., the project will have no problem relating to EIA.

Furthermore, as is mentioned in the section 2.2.4, customs duties on the import of facilities are exempted if they are utilized for solar power generation projects in Kenya. However, it should be noted that payment of taxes, including railway tax, on such facilities is required.

3 Consideration of specific plans

3.1 "Mega Solar Project" in Ethiopia

3.1.1 Examination and selection of mega solar project site

We provide site selection criteria and select a potential site.

Site selection criteria

① The capacity of a photovoltaic generation system shall be large (Conditions of site: broad land, flat land, etc.).

② It shall be able to serve as a model case in introducing a mega solar system into other sites.

③ The reliability of supply of transmission line shall not be low and the transmission line shall be located in a close area.

(Areas covered by the investigation)

We checked the location of the site that had been designated by EEP to find that it didn't satisfy several conditions: We cannot secure the area of 1km square and a route for bringing in equipment.

Figure 14 Candidate site in Nuraera area

After the investigation team and local related parties had checked and examined nearby areas, we decided to conduct a system design for the following site that is located along a main road and has a relatively flat ground and a transmission line nearby that can be connected to the system.

Merqasa：Located at latitude 8°46’56” north and longitude 39°38’55” east

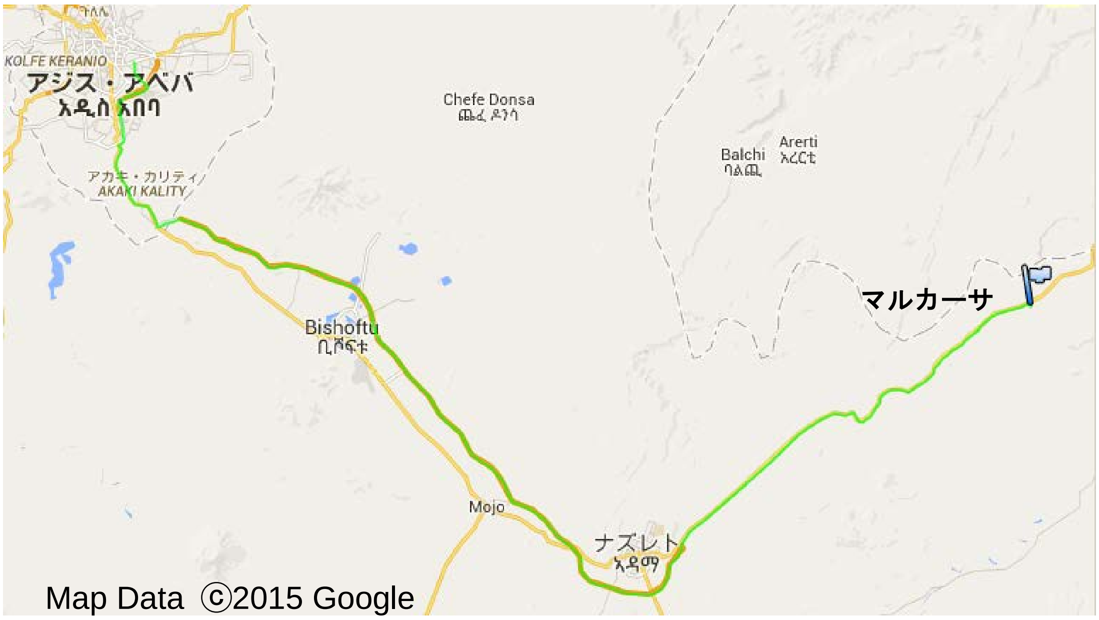


Figure 15 Positional relation of Merqasa with other cities

3.1.2 Examination of the system

1) Scale of photovoltaic plant

Although EEP expects a project with a scale of 50 to 100MW, we have decided the scale of the project is 10MW, which is a minimum unit, and will reconsider the scale when necessary. Since the scale of the project is set also depending on the capacity of a transmission line that is connected to the system, we have decided the scale of the system for conducting the FS is 10MW.

2) Information about the site

The area of Merqasa is located along a main road, named Awash-Assab highway, and is currently out of cultivation. Since transportation of a large amount of materials and equipment is required for the construction of mega solar plant, including photovoltaic modules, it is essential to select the land that has a secured bringing-in route in order to reduce the construction cost. In addition, as shown in Figure 16, the ground is relatively flat and there is no obstacle in the surrounding area. That means this site is suitable for installation of a photovoltaic generation system. Therefore, we selected this land as the site for FS.

Figure 16 Landscape of Merqasa area

3) System structure

We decided that the scale of the photovoltaic generation system is 9.98MW in total, using 38,400 units of 260W photovoltaic modules. We assumed the area required for installation of the system, including photovoltaic array and power conditioning system (PCS), is about 260m by 500m. The project layout is shown in Figure 17 and the system block diagram is shown in Figure 18.

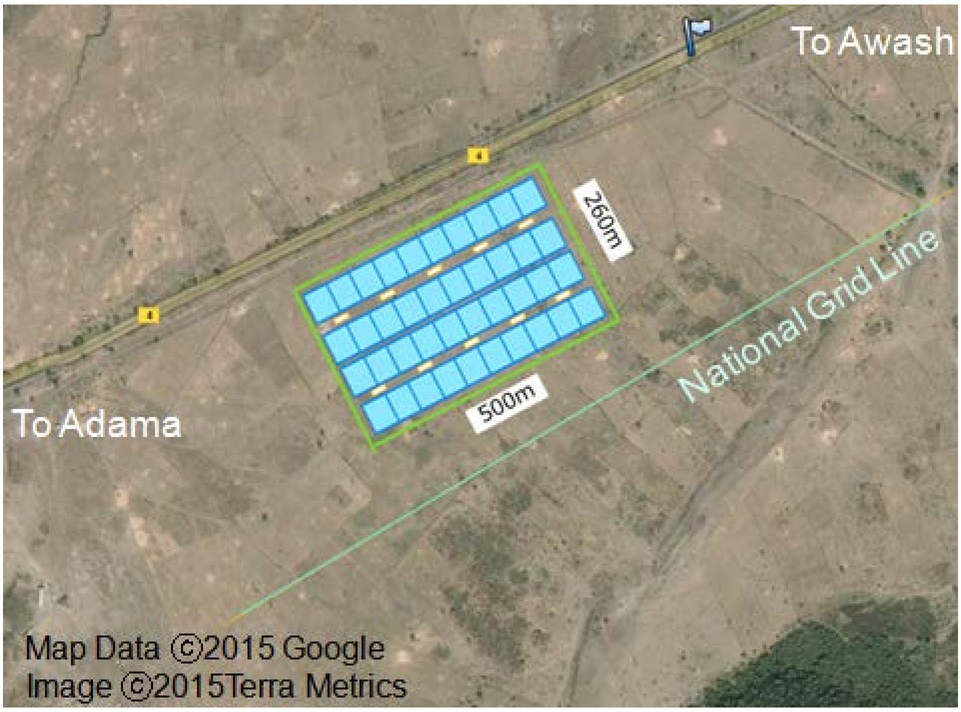


Figure 17 Site layout chart

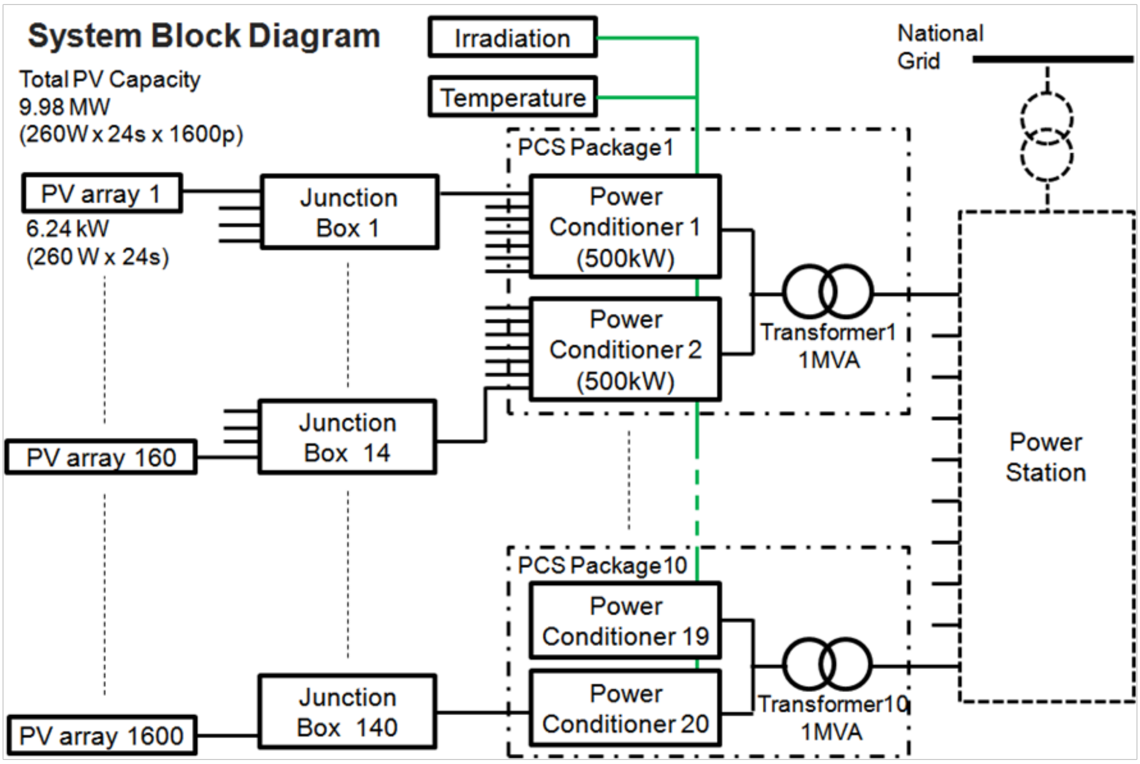


Figure 18 System block diagram

Our plan is to simplify constituting equipment and reduce the space of PCS through making one package by connecting two units of rated power of 500kW to transformer of 1MVA, as well as to eliminate the building construction and wiring works by using outdoor specifications for the PCS package.

4) Simulation of estimated power generation amount

Table 9shows the result of simulation of estimated amount of the photovoltaic power generation system, utilizing the meteorological data of Metronome. The conditions for estimation include efficiency deviation factor, cell temperature factor, DC cable loss and PCS conversion efficiency.

The annual amount of irradiation is 2,103kWh/m^2 and the amount of estimated annual power generation with this system is 13,958MWh. The value is equivalent to the annual electricity consumption by 2,470 general households in Japan[3].

3

Table 9 Estimated amount of power generation

Name of city	Nazerit		Name of site	Merqasa	
Latitude	8.65 °	N	PV tilt angle	10	deg.
Longitude	39.32 °	E	Array azimuth angle	30	deg.
Elevation	1550	m	PV total capacity	9,984	kWp

Category	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Amount of irradiation (kWh/m^2/day)	6.16	6.68	6.65	6.13	5.65	5.03	4.29	4.45	5.13	6.23	6.70	6.13
Amount of irradiation (kWh/m^2/month)	191	187	206	184	175	151	133	138	154	193	201	190
Average temperature (℃)	23.6	25.6	25.2	23.7	24.3	23.0	21.6	22.0	22.8	23.4	21.8	23.0
Design coefficient	0.664	0.658	0.659	0.664	0.662	0.666	0.671	0.669	0.667	0.665	0.670	0.666
Total power generation (MWh)	**1,267**	**1,228**	**1,355**	**1,220**	**1,157**	**1,004**	**891**	**922**	**1,025**	**1,281**	**1,345**	**1,264**

[1)] Average annual electric power consumption by general household, Guidelines for Indication (FY 2014), Japan Photovoltaic Energy Association

5) Consideration of price of the system

In considering the price of the system, we are planning to procure materials and equipment from Japan, because they rely on import to obtain materials and equipment necessary for the photovoltaic power generation system and utilization of local equipment is difficult in Ethiopia. Since “Alphasol Modular Energy,” which is described as a candidate EPC contractor in Chapter 2 (2) 3), has an experience in renewable energy project, we obtained a quotation for the construction cost and estimated the cost assuming that they would implement the project. Items of the project cost are (1) cost of materials and equipment, (2) transportation cost, (3) commissioning cost and (4) construction cost. Total project cost is shown in Table 10 In addition, VAT is added to the total amount.

Table 10 Total project cost (VAT not included)

No.	Description	Qty.	Price
①	Equipment		$ 19,980,400
1	Photovoltaic Module	38,400	
2	Mounting Structure	1	
3	Junction Box	140	
4	1MW Power Conditioner	10	
5	Monitoring System	1	
6	Metrological Equipments	1	
7	Cable & material	1	
②	Transportation cost		$ 4,347,200
③	SV cost		$ 231,900
④	Construction cost		$ 6,608,700
	Total cost		$ 31,168,200

＊ Construction cost of power station is not included.

6) Specific measures toward implementation

FiT of Ethiopia is currently under deliberation a at the Ethiopia Parliament., as shown in Chapter 2. However, since it is estimated that it will take more than 20 years to recover investment with the price of FiT that is under deliberation, even if the mega solar project is rolled out, the project is assumed not to be linked to a significant movement of investors. Temporarily, Table 11 shows the price of FiT that was estimated based on the number of years required for investment recovery.

Table 11 Estimated FiT Price and the number of years required for investment recovery

Year	FiT [USD/kWh]
7	0.32
10	0.25
15	0.17
20	0.13

＊ Estimated by the investigation team

At present, the target number of years for investment recovery is set to be less than ten years for the photovoltaic power generation system (mega solar) in Japan. The following Figure 19 shows the result of estimation when using the FiT price of 0.25USD/kWh that allows investment recovery in 10 years according to Table 11.

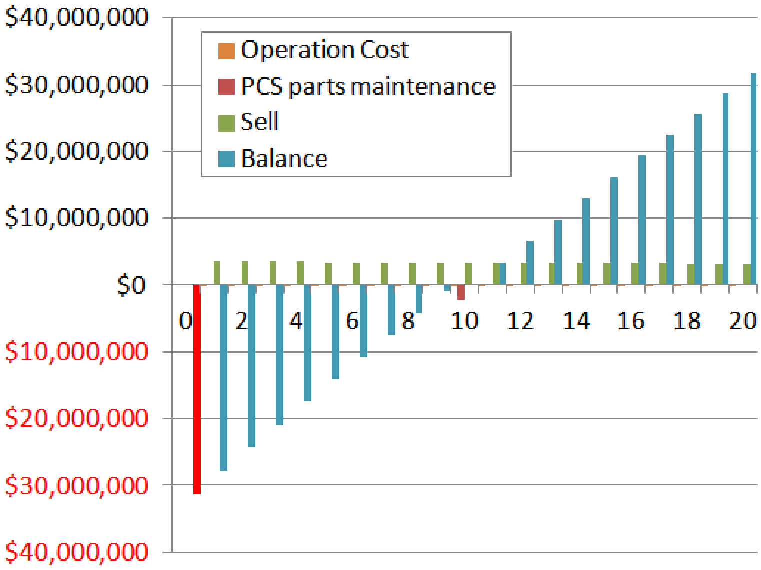


Figure 19 Number of years required for investment recovery and earning and expense for FiT price of 0.25USD/kWh

The estimation shown in Figure 19 includes deterioration of photovoltaic modules and operation and maintenance cost. Specific figures of these items in estimation of the cost are 0.5% for deterioration of photovoltaic module, the maintenance cost of PCS in the tenth year of operation (replacement of equipment), and 0.2% of the initial cost for the annual operation cost of the power plant.

As mentioned above, we form an ODA case based on the electricity master plan in Ethiopia on a short time basis as an effort to implement the mega solar project and will show the superiority of Japanese products. Meanwhile, the improvement of infrastructure as an electricity industry market through implementation of policies, such as premier of FiT price, and the international electricity trading, could accelerate the movement of foreign and domestic investors entering into the project.

3.2 "Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia

3.2.1 Essence of micro hydro hybrid

As to the introduction of ultra-low head micro hydro power generation system in Ethiopia, the following estimation was made in the Report for FY2013: there were 1,558 locations that had a potential of power generation and the total scale of power generation of all projects was 83MW. However, the amount of water of canal irrigations is not necessarily constant: it decreases due to seasonal fluctuation. A shortage of power generation with micro hydro is concerned. To solve these problems, we propose a micro hydro hybrid system that can eliminate a power shortage through a combination of a micro hydropower system and a photovoltaic power generation system, which can use photovoltaic power as independent renewable energy, and realize stable power source supply.

3.2.2 Examination and selection of project site

We provide the site selection criteria and select a potential site.

Site selection criteria

① It is located in the area where the extension of the national grid is not planned.

② It is located in the area where micro hydro power generation is being operated or planned to be operated.

(Areas covered by the investigation)

In the UNIDO project (PROJECT SAP ID 120601), micro hydro power generation is being introduced in Fentale. This project is positioned as a pilot plant of micro hybrid power generation project in Ethiopia, and is also expected to play a role of model project for a hybrid system with photovoltaic power generation, providing a showcase effect.

・Fentale：Located at latitude 8°44’05” north and longitude 39°46’43” east

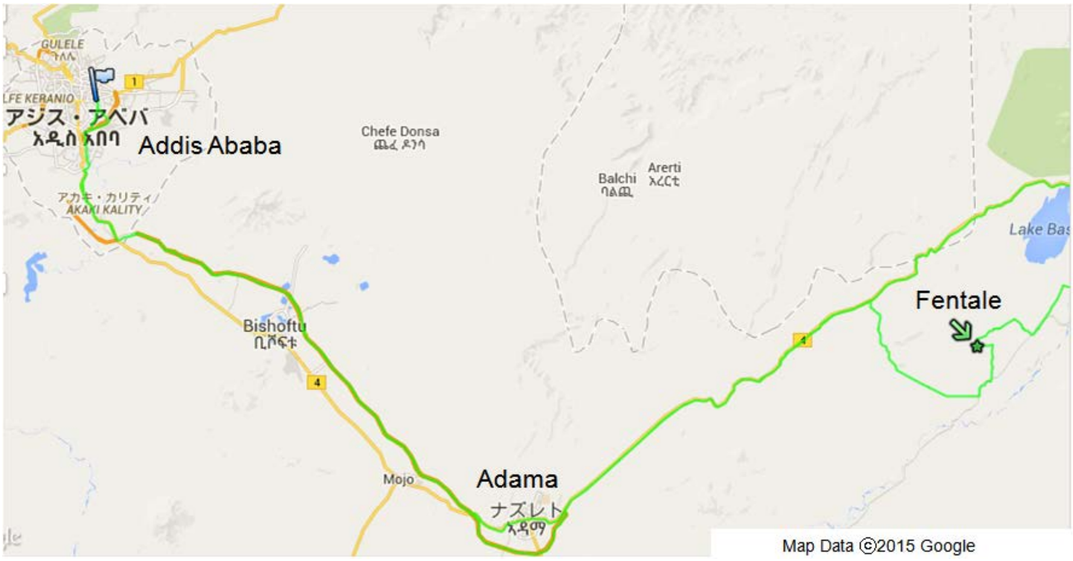


Figure 20 Positional relationship of Fentale area

3.2.3 Consideration of the system

1) Overview of the system and load design

This project is aimed at achieving a stable electric power supply even in seasons with lower water volume by using an ultra-low head micro hydro power generation system, which is to be introduced under the UNIDO project prior to this project, as a base power source in combination with a photovoltaic power generation system. However, it is difficult to make the photovoltaic power generation system a standalone stable power source, because its output fluctuates depending on the weather. For example, the output of photovoltaic power generation system could drop sharply as a result of sudden change in insulation. Under such a circumstance, the load required for the system could exceed the total power generation and cause a decline of system voltage, which may lead to a power failure. To address the problem, we need to take countermeasures to stabilize supply power using storage battery.

It is essential to have a control system that can utilize multiple power sources, i.e. micro hydro, photovoltaic power and storage battery, selectively and efficiently, and a comprehensive micro grid system design is critical. The image of the system is shown in Figure 21.

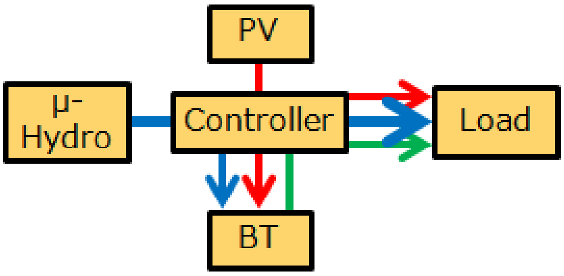


Figure 21 Image of structure of micro hydro hybrid system

2) Information about the site

Fentale area is located to the southeast of Awash-Assab highway along an unpaved road. As shown in Figure 22, the area is plentiful in agriculture utilizing canal irrigations, and the micro hydro power generation system is planned to be installed in such canal irrigation.

Figure 22 Irrigation canal in Fentale area

We searched for a candidate land for installing a photovoltaic power generation system near the planned site where we plan to install a micro hydro power generation system, and selected the land unused by neighboring residents, as shown in Figure 23 as an appropriate site. However, as this unused land is located on a gentle hilly area, we need to select a contractor that owns installation technique to handle such a condition for design and construction of the foundation and the mount of photovoltaic power generation system.

Figure 23 Candidate site in Fentale area

Then, we study load conditions for system design. The residents requested us to ensure lighting of their houses, recharge of mobile phone and operation of refrigerators at stores. In addition, Mr. Amensisa Tsegaye Bedane of Oromia Region Hydraulic Power Mineral Energy Agency pointed out in his request that the introduction of agricultural machinery, such as threshing machines, could significantly improve production capacity and added value for Fentale area where agriculture is a main industry. Taking account of these aspects, we created a load model as shown in Figure 24.

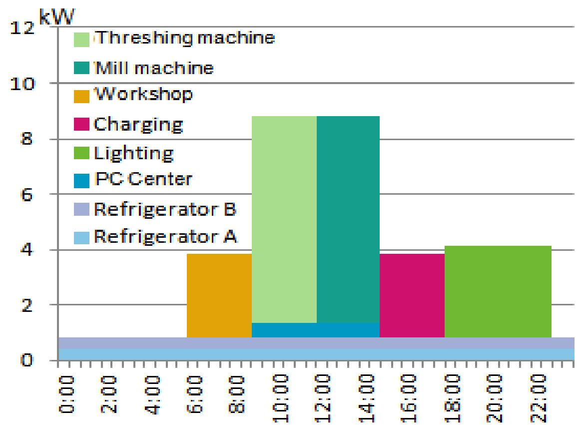


Figure 24 Load model in Fentale area

3) System structure

We have an assumption that the scale of photovoltaic power generation system in Fentale is 12.48kW in total using 48 units of 260W photovoltaic modules. The site layout is shown in Figure 25.

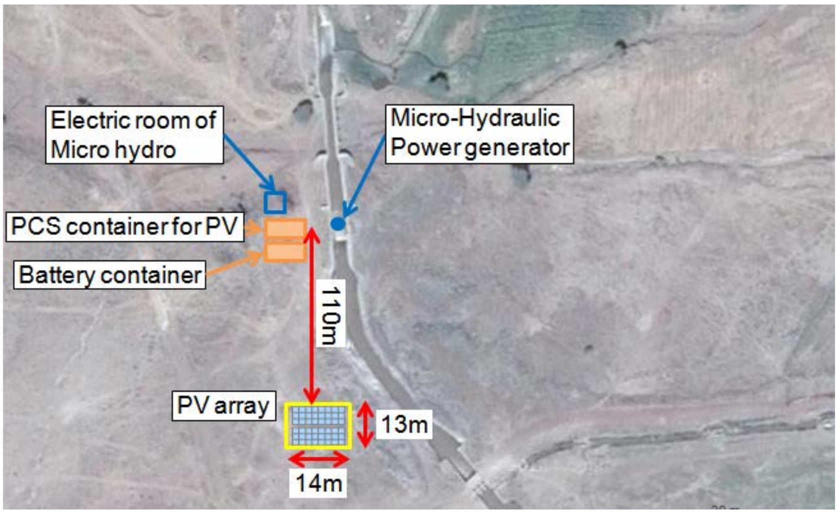


Figure 25 Site layout

The photovoltaic module is assumed to install on a land with relatively gentle slope. We decided to install PCSs and storage batteries in a container-type storage facility. PCS, step-up transformer, grid control unit and measurement PC for data collection are stored inside the container.

Next, the system block diagram is shown in Figure 26.

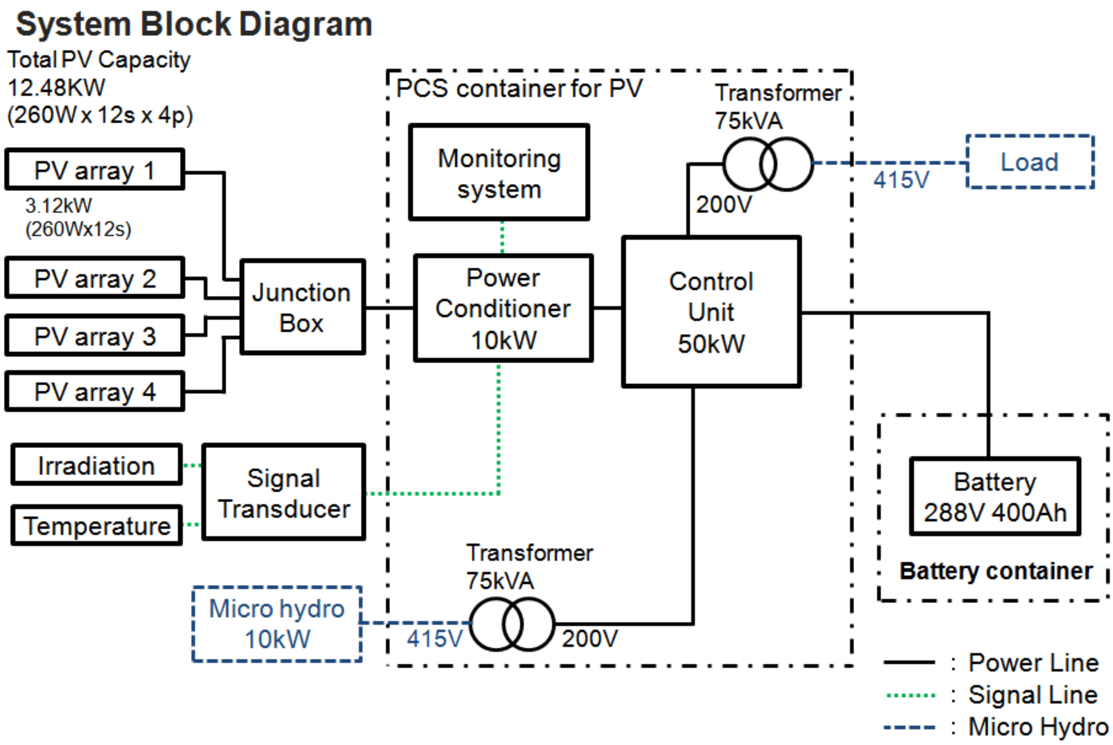


Figure 26 System block diagram

The rated output of PCS should be 10kW and storage battery should be a sealed lead acid battery of 288V400Ah. These power sources are connected to the control unit. The control unit preferentially supplies electric power of micro hydro and photovoltaic power. If surplus electricity is generated, it is used to recharge storage batteries. If there is a shortage in the quantity of water flow or the amount of insulation and a shortage of electric power occurs, we can supply electric power stably by discharging electricity from storage batteries.

The simulation result of operating this system is as shown below. We referred to the data of global irradiance for the amount of insulation necessary for ensuring the amount of photovoltaic power generation, and the amount of water flow required for micro hydro power generation is calculated based on the data of water flow of rivers in Vietnam, which is provided by CLOVER (Copyright © 2009 National Institute of Advanced Industrial Science and Technology (AIST)), with some adjustment considering the data of the amount of precipitation in Ethiopia. The result for the season with least water flow amount is shown in Figure 27. The result of annual basis simulation based on this is shown in Figure 28.

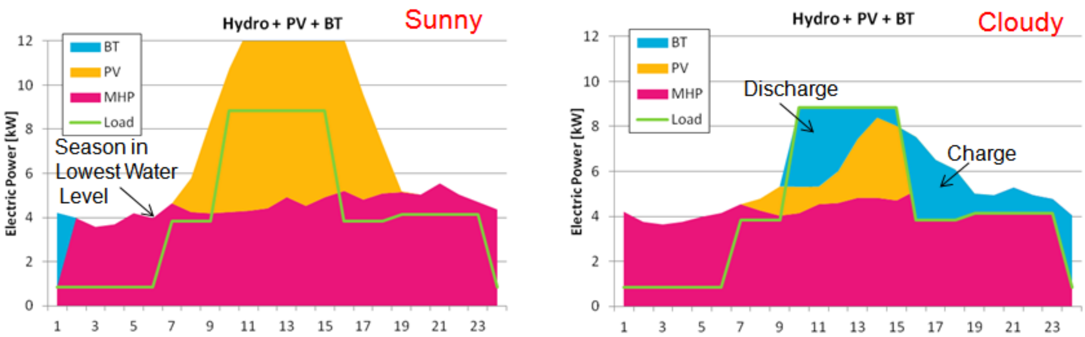


Figure 27 Simulation of system operation

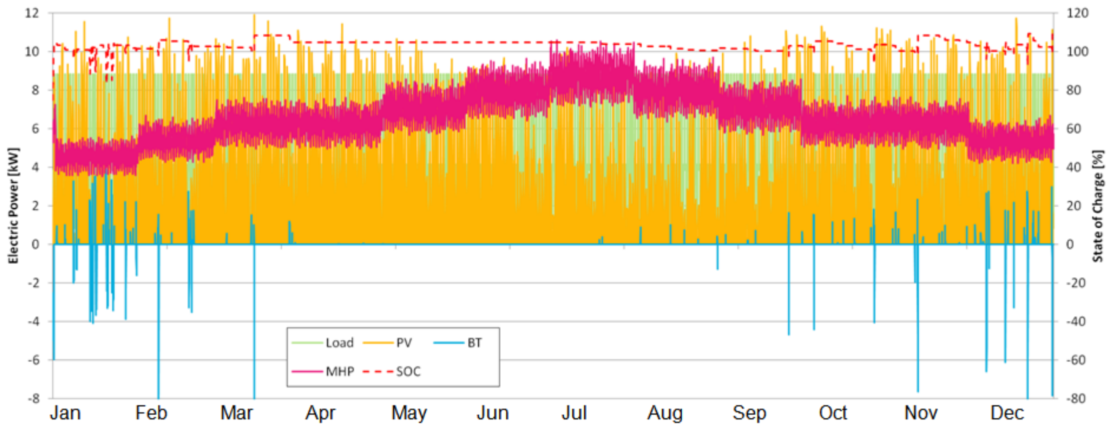


Figure 28 Simulation of annual basis power generation

In Figure 28, positive part of BT shows discharged electricity and negative part shows recharged electricity. SOC (right axis) shows the state of charge of storage batteries. Stable electric power supply is possible, as the rate of power outage is 0% in the simulation as a result of appropriate control of recharged amount of storage batteries.

4) Consideration of the price of the system

In considering the price of the system, we plan to procure technologies to realize a hybrid system with micro hydro power generation from Japan. We also plan to procure materials and equipment required for the photovoltaic power generation system from Japan from a viewpoint of system warranty.

Because Alphasol Modular Energy, which is described as a candidate EPC contractor in Chapter (2) 3), has an experience in renewable energy project and a record of delivery of micro hydro power generation system, we obtained a quotation for construction cost from the Company and made an estimation.

Items of the project cost are (1) cost of materials and equipment, (2) transportation cost, (3) commissioning cost and (4) construction cost. Total project cost is shown in Table 12. VAT is added to the total amount.

Table 12 Total project cost (VAT not included)

No.	Description	Qty.	Price
①	Equipment		$ 363,000
1	Photovoltaic Module	48	
2	Mounting structure	1	
3	Junction Box	1	
4	Power Conditioner	1	
5	Control Unit	1	
6	Transformer	2	
7	Storage Battery	1	
②	Transportation cost	1	$ 105,000
③	SV cost	1	$ 79,000
④	Construction cost	1	$ 122,000
	Total cost		$ 669,000

3.3 ”Hybrid Mini-Grid Project” in Kenya

3.3.1 Essence of hybrid mini-grid

In the areas where the extension of the national grid is difficult, the mini-grid system using diesel generators is formed under the electrification policies that contribute to the improvement of living standards of residents and local industrial development. However, electric power generation systems that use fossil fuels lead to generation of greenhouse gas. Increases in fuel prices on a long-term span are also concerned. In response to these issues, this FS proposes the implementation of a hybrid mini-grid system in combination with a photovoltaic power generation system, which is a renewable energy system (not including storage battery).

Generally, when connecting with a system that mainly uses a diesel generator, we have to design the capacity of the photovoltaic power generation system at 20% or less of that of diesel generator at a maximum. This is to prevent burnout of the diesel generator caused by reverse flow of output current of the photovoltaic power generation to the diesel generator. Moreover, if the load becomes excessive low as a result of photovoltaic power generation when looked from the diesel generator, that could not only reduce power generation efficiency (fuel efficiency) but also generate soot and smoke due to imperfect combustion eventually, resulting in more frequent maintenance work. To solve these problems and increase the interconnection capacity of the photovoltaic power generation system, we can consider the use of a storage type storage battery. However, the introduction cost of storage batteries, including lithium ion batteries and lead acid batteries, is high, and they need to be replaced every 5 to 10 years due to their useful life, although depending on how to control discharge and charge. Therefore, it is difficult to find a positive economic effect from the long-term view.

Therefore, we apply a technology that can improve the introduction rate of photovoltaic power generation to diesel generator up to 60% at a maximum without introducing storage batteries. Specifically, we efficiently reduce the amount of fuel used for diesel generator by monitoring the balance between the generated power on the side of the generator and the demand power on the load side and controlling the output of photovoltaic power generation. This system is also characterized by elimination of modification and replacement of existing power generation facilities, as what is controlled is on the side of photovoltaic power generation. Figure 29shows the image of the system.

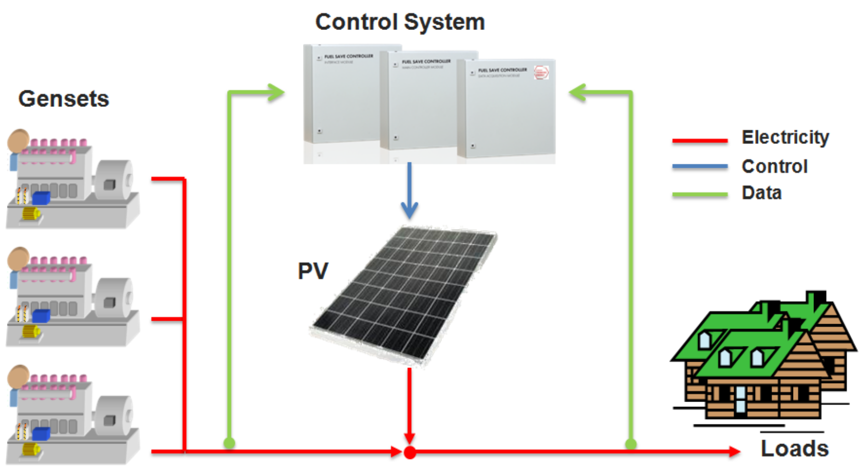


Figure 29 Image of DG-PV hybrid system

3.3.2 Examination and selection of project site

We provide the site selection criteria and select a potential site.

Site selection criteria

① It shall be located in the area where the extension of the national grid is difficult (isolated island, etc.).

② Diesel generator is being operated or is planned to be operated on the site.

③ Diesel generation is being operated (or planned to be operated) for 24 hours.

(Areas covered by the investigation)

We conducted the investigation for two sites where the mini-grid with diesel generator has been formed or is planned to be formed in the future.

・Mfangano Island (Lake Victoria) : located at latitude 0°28’01” north and longitude 34°03’53” east The Ministry of Energy is planning to introduce a photovoltaic power generation system of 150kW.

・Kokwe Island (Lake Baringo) : Located at latitude 0°36’10” north and longitude 36°04’18” east The site is recommended by Mr. Jeremiah K.Kiplagat, a professor of Jomo Kenyatta University.

3.3.3 Consideration of the system

Mfangano Island

1) Estimation of demand power

A diesel generator was installed in Mfangano Island in 2008. The current number of connection contract is 120 and the total amount of electric power consumption is approximately 22,000kWh per year. Figure 30 shows a pattern of daytime electric power consumption in November 2014.

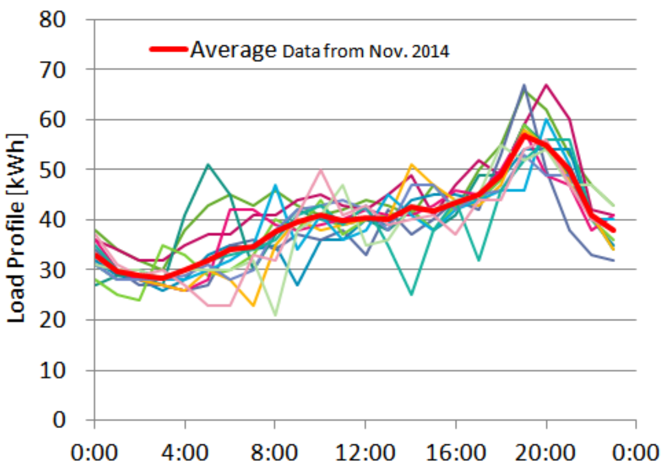


Figure 30 Power consumption pattern in November 2014

This is the profile in which the peak of electric power consumption occurs between 19:00 and 21:00 due to nighttime use of electric light, etc. Although the diesel generator of 500kVA is mainly operated at present, the operation state is below the minimum operation capacity of the diesel generator seeing from the profile. Mfangano Island always has a diesel generator of 150kVA ready. It is not used, however, because the power factor of load of the system is low and the diesel generator of 150kVA does not have adequate capacity. While the electric power supply and demand is quite unbalanced, the diesel generator of 500kVA is being operated as it is in a transition period of demand.

Connecting a large-scale photovoltaic power generation system without taking account of the operation state of power plant could become a cause of reduction in fuel efficiency of diesel generator. Moreover, it could involve the risk of burnout of generator main body, as reverse power flow is generated due to electric power of the photovoltaic power generation system if appropriate control functions are not installed.

The system assumed in this FS should have the control functions that cover all of the above issues. However, it is essential to design the system taking account of the amount of power demanded within the Island, which is expected to increase year by year. Therefore, we make a prediction of future electric power demand.

As preconditions for the prediction, we show the amount of power consumption during the period from the beginning of 2013 to October 2014 in Figure 31.

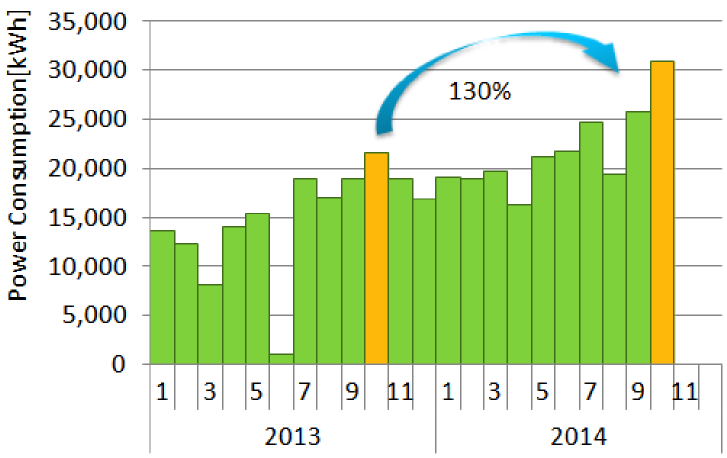


Figure 31 Data of power consumption in Mfangano Island

The amount of power consumption in October 2014 increased by 30% on a year-to-year basis. And the amount of power consumption throughout the year also increased by approximately 30%. Based on the data, we made an assumption that the amount of annual demand power would increase by 30% year-on-year. Our prediction of power demand by 2020 is shown in Figure 32. In addition, the daily power consumption profile in 2020 is shown in Figure 33.

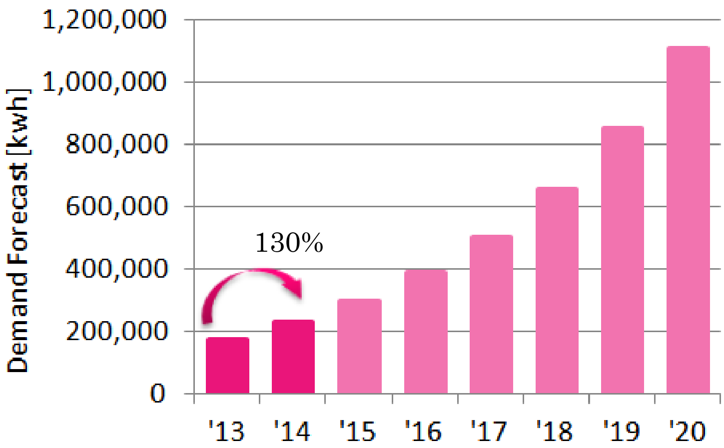


Figure 32 Prediction of annual power consumption in Mfangano Island

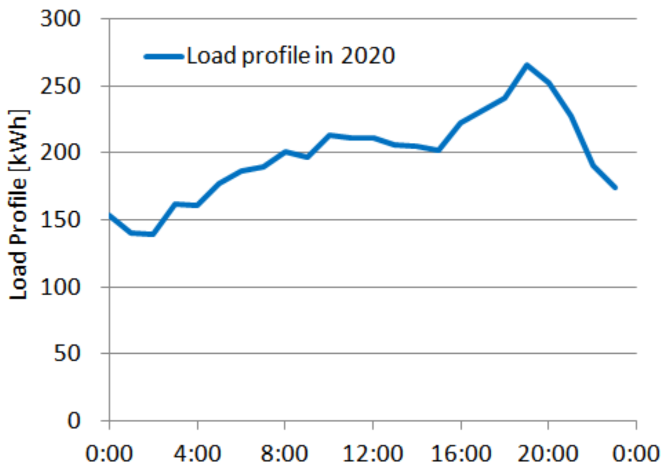


Figure 33 Predicted load profile in 2020

We include the estimated amount of power consumption by a hotel, which is expected to be connected to a grid as a result of extension of the grid, into the power demand prediction for 2020. The prediction is based on the analysis of the current state, and the demand could increase further depending on new industrial development, such as fishery within the Island.

2) Information about the site

Mfangano Island is located in the western part of Kenya. It is an island in Lake Victoria and its main industry is fishery. Although it is an isolated island, transportation of materials and equipment is relatively easy, because there is a ferry service from Mbita and passenger cars are transported also. In addition, there is an unused land near the power plant operated by KPLC, which allows for the installation of a large-scale photovoltaic power generation system. Figure 34 shows a candidate site.


Figure 34 Landscape of candidate site in Mfangano Island

3) System structure

We assumed that the scale of the photovoltaic power generation system in Mfangano Island is 199.7kW in total, using 768 units of 260W photovoltaic modules. The site layout is shown in Figure 35.

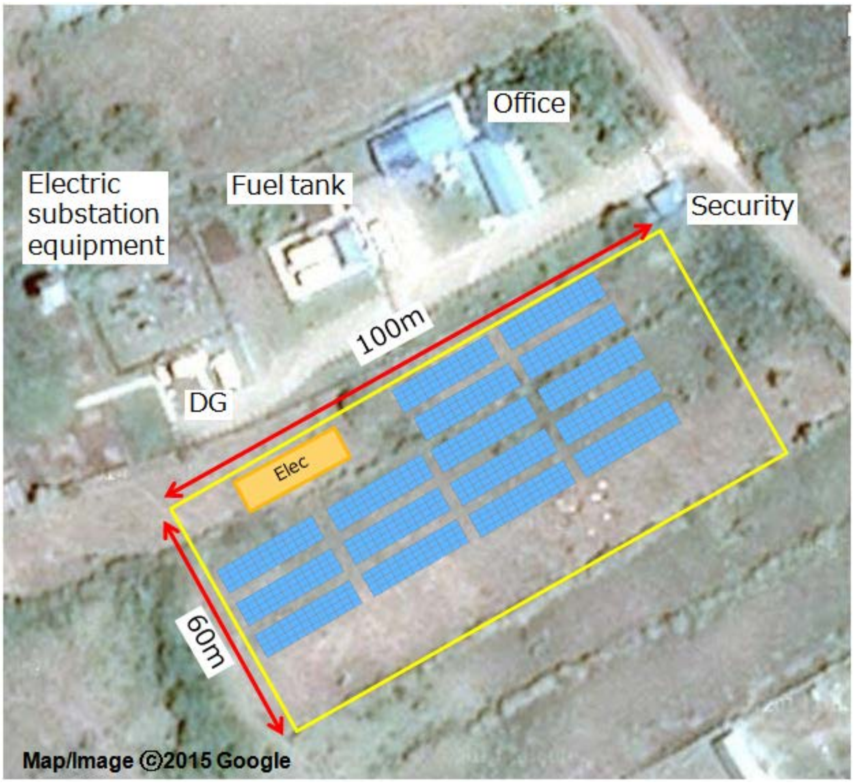


Figure 35 Site layout

The site of the existing power plant has a usable area of 100m by 60m. If the possible largest number of photovoltaic arrays is installed on the site, the capacity equivalent to 374kW may be installed. However, taking account of the load balance as mentioned above, we consider the plan at the scale of 199.7kW. Additional photovoltaic arrays may be installed in the future. The “Elec” as shown in the Figure assumes a container-type control equipment storage facility, inside which PCS, step-up transformer, output controller and measurement PC for collecting data are stored.

Next, the system block diagram is shown in Figure 36.

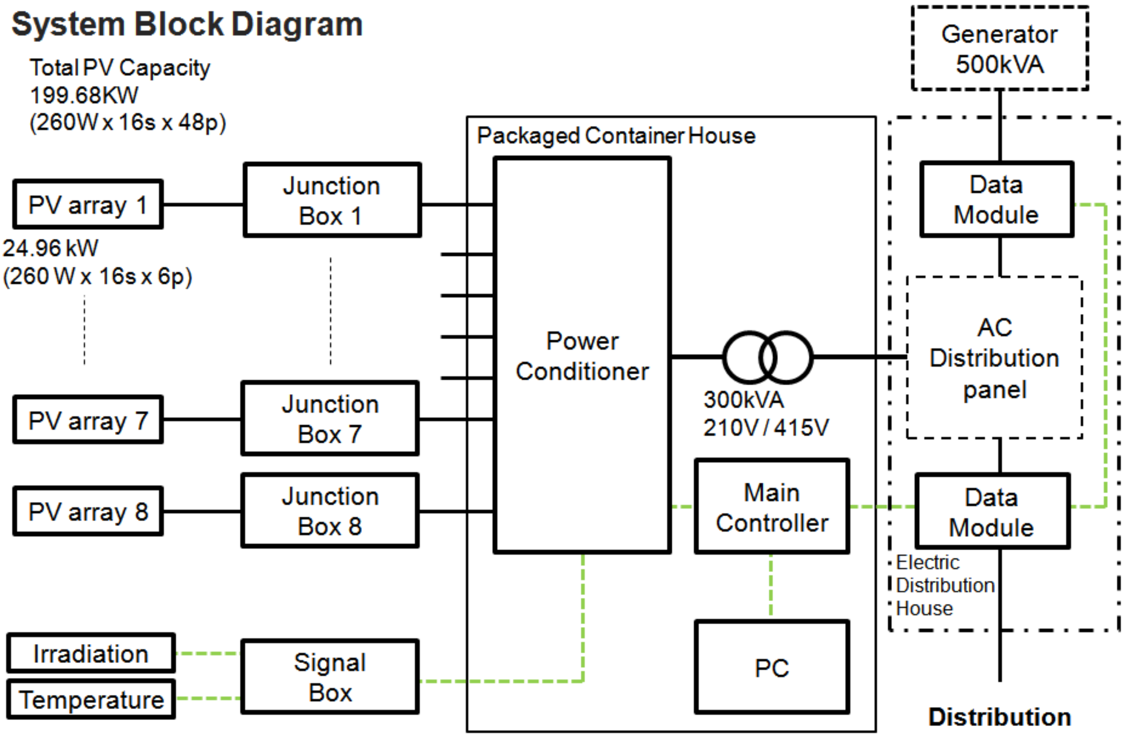


Figure 36 System block diagram

One PCS with rated output of 250kW is used. Data collected from the Data Module is aggregated in the Main Controller to control output of photovoltaic power generation. We assume to record operation data using an associated PC. PCS, step-up transformer, Main Controller and PC are stored in a packaged container house.

4) Simulation of power generation

Figure 37 shows the result of simulation for power generation in 2020 after this system had been installed. Conditions for estimation are as follows: the weather is clear and sunny that allows for efficient power generation, and if surplus electricity occurs to the load, output of a photovoltaic power generation system is adjusted to an appropriate level so as to maintain the minimum operation level of diesel power generation. Use of approximately more than 80% of photovoltaic power generation energy is feasible throughout the year.

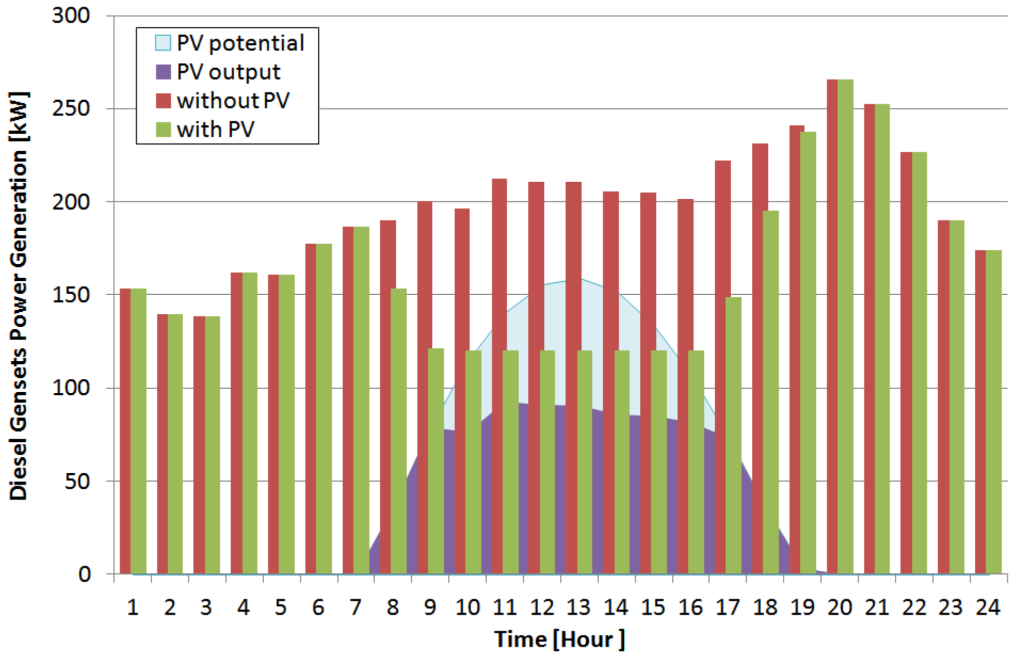


Figure 37 Simulation of power generation

5) Consideration of the price of the system

In considering the price of the system, we assume that we procure technologies that allow for a hybrid system with diesel power generation from Japan. We also plan to procure materials and equipment required for the photovoltaic power generation system from Japan from a viewpoint of system warranty.

Because Socabelec, which is described as a candidate EPC contractor in Chapter 2 (2) 3), has an experience in a renewable energy project, and a record of delivery of diesel power generation facilities to the power plant on the Island, we obtain a quotation for construction cost from the Company to make an estimation.

Items of the project cost are (1) cost of materials and equipment, (2) transportation cost, (3) commissioning cost and (4) construction cost. Total project cost is as shown in Table 13 Total project cost (VAT not included). In addition, VAT is added to the total amount.

Table 13 Total project cost (VAT not included)

No.	Description	Qty.	Price
①	Equipment		$ 829,800
1	Photovoltaic Module	768	
2	Mounting Structure	1	
3	Junction Box	8	

4	Power Conditioner	1	
5	Control System	1	
6	Monitoring System	1	
7	Metrological Equipments	1	
8	Cable & material	1	
②	Transportation cost		$ 72,300
③	SV cost		$ 116,400
④	Construction cost		$ 211,300
	Total cost		$ 1,229,800

6) Fuel reduction effect and investment recovery projection

Figure 38 Assumed fuel reduction shows a fuel reduction projection with this system. Assuming that the unit price of fuel is $1.656 per liter, the estimated earning and expense is as shown in Figure 39 The number of years required for investment recovery and earnings and expenses. The investment is expected to be recovered in 13 years.

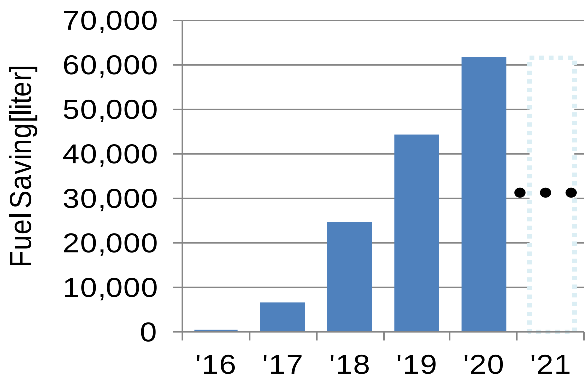


Figure 38 Assumed fuel reduction

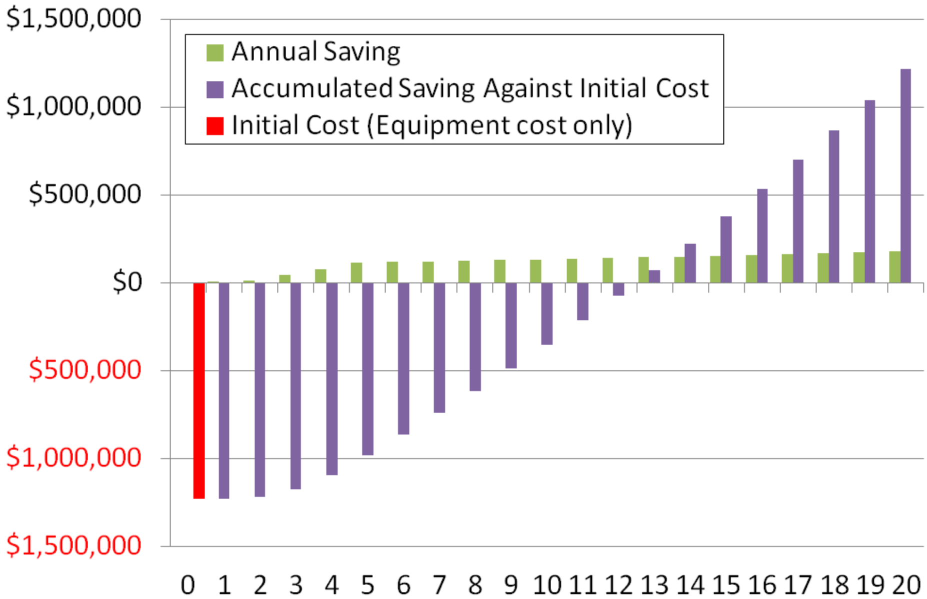


Figure 39 The number of years required for investment recovery and earnings and expenses

Kokwe Island

3.3.4 Consideration of the system

1) Estimation of demand power

Although it is currently a non-electrified village, Island Camp Baringo is located at the south end of the island, with which we expect to conclude a contract as a heavy consumer. According to the camp owner, Mr. Perrie Hennessy, while diesel in-house power generators of 60kVA in total power the camp, they are struggling over transportation of fuel. We have heard that he would take the initiative in concluding a contract, if a power plant is in place and it can supply electricity. In addition to that, use of electricity by public facilities, such as power supply to dispensaries and elementary schools, is expected. There is a record of concluding 100 connection contracts in 5 years in Mfangano Island. Based on this precedent, we estimated the amount of power consumption at general households in Kokwe Island, assuming that the same number of connection contracts would be concluded. Figure 14 shows the estimated power consumption by 2020. Figure 41 shows projected load profile in 2020, using a profile in Mfangano Island as a reference.

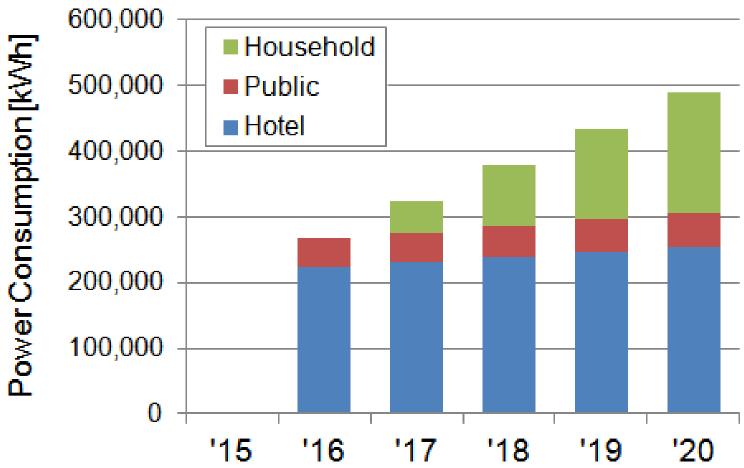


Figure 40 Assumed annual power consumption in Kokwe Island

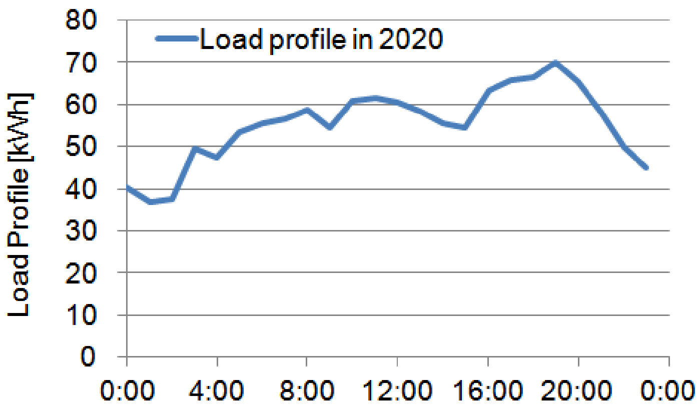


Figure 41 Assumed load profile in 2020

The above estimation is based on the time-lapse data after electrification in Mfangano Island. Power demand might increase as a result of a synergy effect created by industrial development with electrification, such as development of fishery and the tourist industry in the island.

2) Information about the site

Since Kokwe Island is a non-electrified area at present, we need to construct a sub-stable energy supply infrastructure, such as diesel power generation system, in the initial phase. The significant improvement of living standard as a result of electrification can be positioned as a very valuable policy, as can be seen from the example of development in Mfangano Island. On the other hand, the emission of greenhouse gas is a global problem and it is very important to consider measures to reduce it. From these viewpoints, we propose the use of a hybrid system consisted of a diesel generator and a photovoltaic power generation system. Therefore, a candidate site is required to have a sufficient area that allows for installation of the both facilities. We also considered the positional relation among Island Camp Baringo, which is expected to become a heavy consumer, elementary schools and dispensaries, as well as examined the terrain of the Island. As a result, we have selected a candidate site as shown in Figure 42.

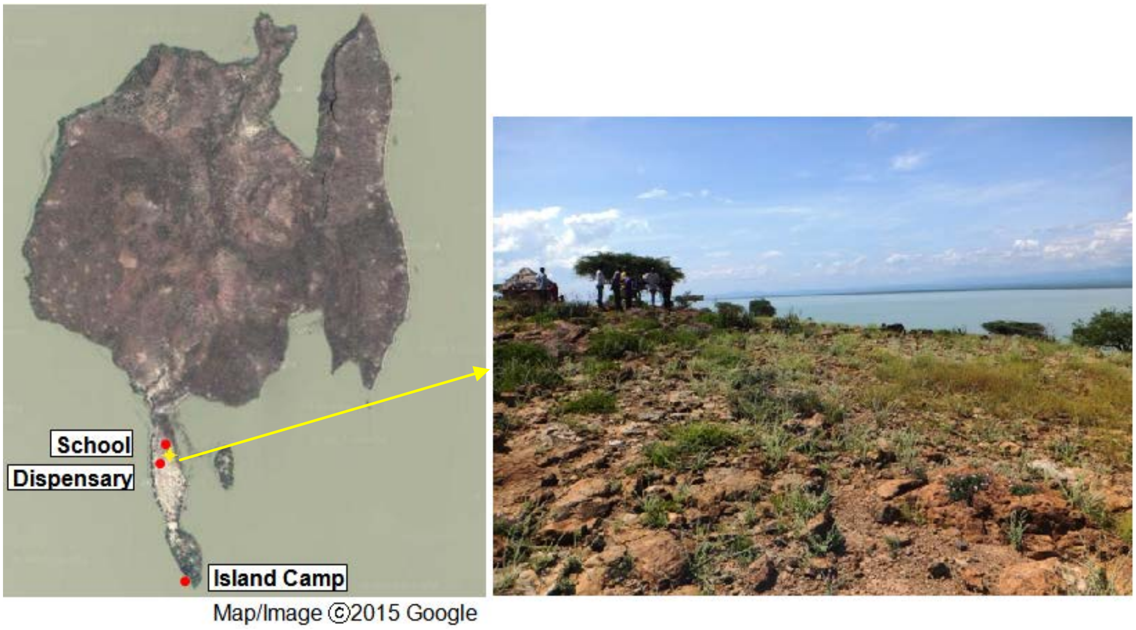


Figure 42 Candidate site in Kokwe Island

Since Kokwe Island has a hilly terrain, it is difficult to install general photovoltaic modules that use concrete foundation. Use of pile driving and screw piles is effective for the installation on an inclined ground like this. However, we cannot use these construction methods, because special machine tools are required and intrusion into rocky terrain of Kokwe Island is impossible. Therefore, we need a contractor that has techniques to install equipment and facilities under such special conditions in introducing a photovoltaic power generation system into Kokwe Island.

3) System structure

We recommend the introduction of diesel power generation system with the minimum capacity equivalent to 150kVA under the electrification policy in Kokwe Island. This demand capacity is estimated based on the fact that the facility capacity of Island Camp Baringo, which is expected to be a heavy contactor, is 60kVA, as well as on the preceding example of Mfangano Island. For this capacity, the most appropriate scale of the photovoltaic power generation system is approximately 50kW (for example, achieving 49.9kW with the use of 192 units of 260W photovoltaic modules). The site layout is shown inFigure 43.

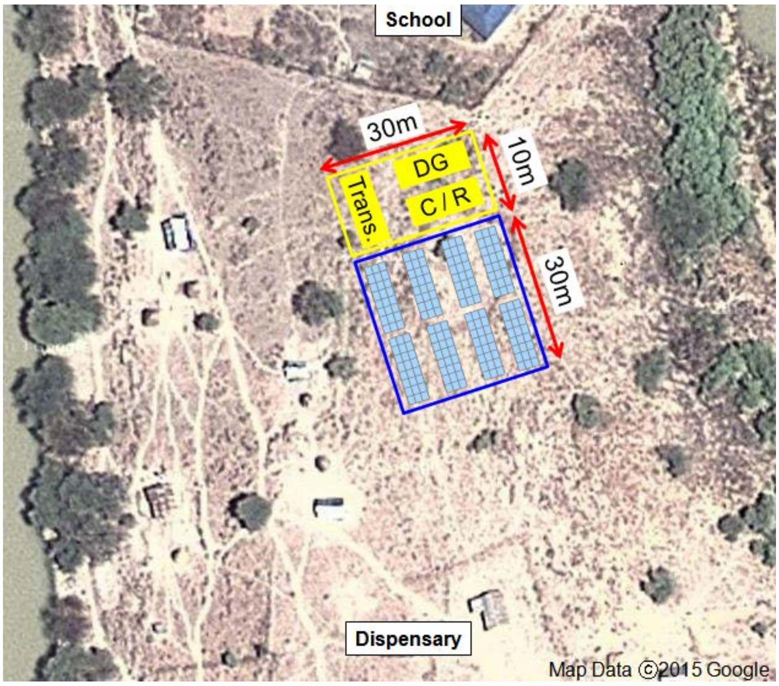


Figure 43 Site layout

We selected a site with the area of 30m by 40m that allows for installation of power generation facilities on the Island. Out of it, an area of 10m by 30m is to be used for diesel power generation facilities and an area of 30m by 30m is to be used for installation of photovoltaic arrays. An effective use of limited land is desired under the condition of hilly inclined land. The area indicated as “C/R” in the above Figure 43 is a control room, which is used to store an input-output panel that connects output of the diesel generator and photovoltaic power generation system.

Next, the system block diagram is shown in Figure 44.

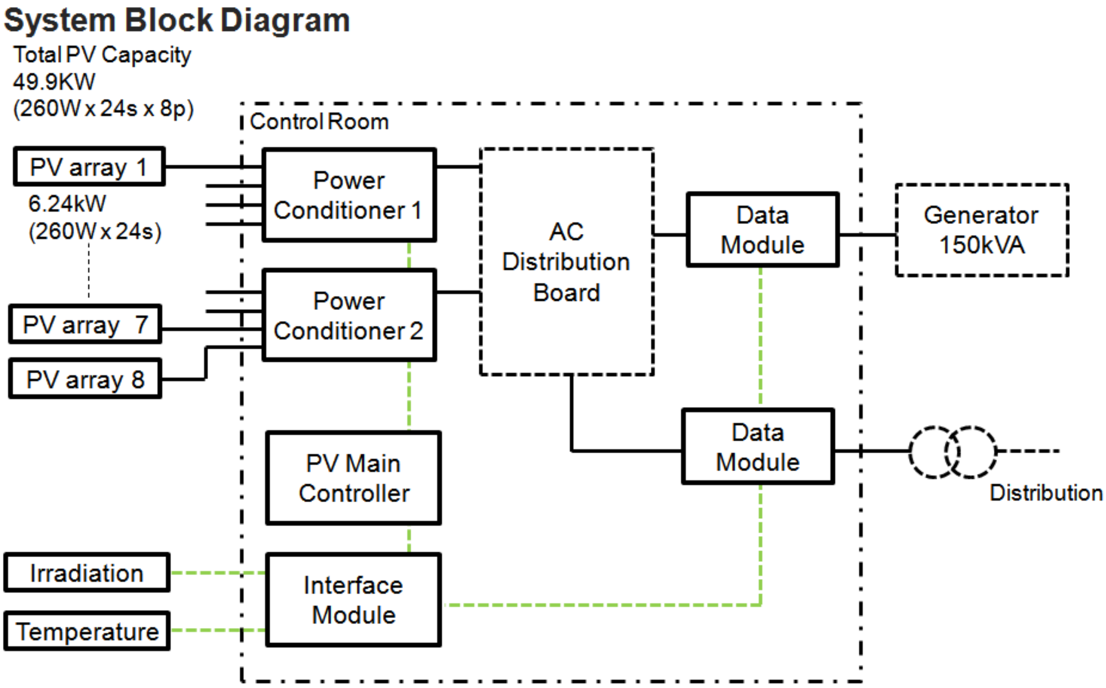


Figure 44 System block diagram

Two PCSs with the rated output of 25kW are linked, and data collected by Data Module is aggregated through Interface Module and controlled by PV Main Controller. Since this system utilizes the control function the diesel generator has, modification and renewal of generator is not required, allowing for changes of settings according to the specifications of a power generator to be introduced.

4) Simulation of power generation

Figure 45 shows a simulation of power generation in 2020 after the introduction of this system. If surplus electricity occurs to the load, output of photovoltaic power generation is reduced and controlled to maintain a minimum operation level of diesel power generation. While this balance allows for achieving utilization of more than 80% of energy produced by photovoltaic power generation throughout the year, it is possible to efficiently make an effective use through the proactive electric power utilization as a result of development of the area.

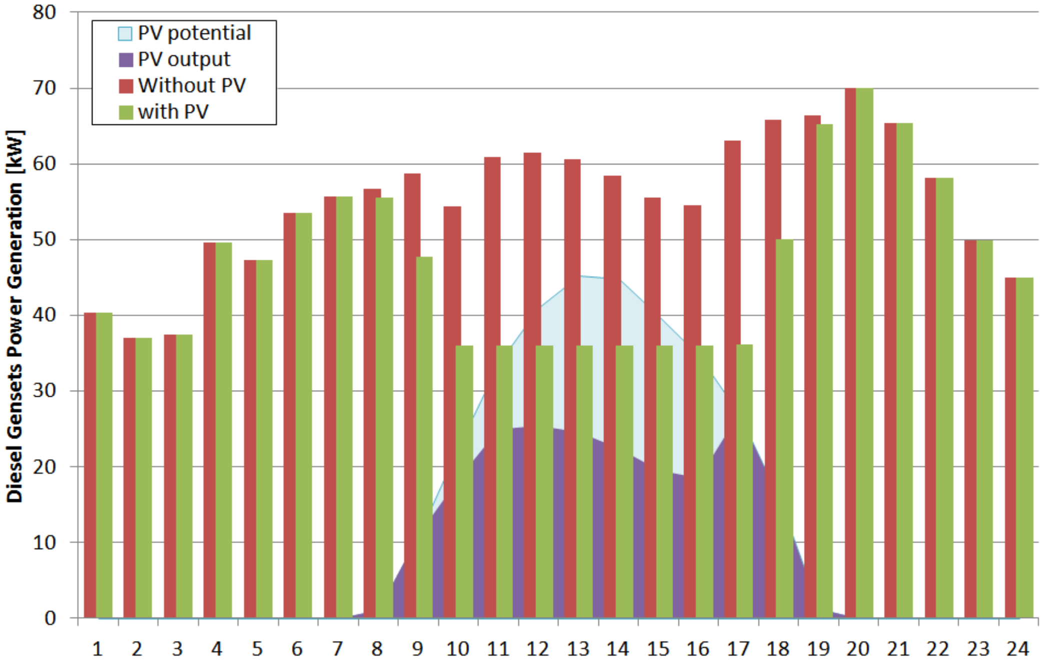


Figure 45 Simulation of power generation

5) Consideration of the price of the system

In considering the price of the system, we plan to procure technologies that achieve a hybrid system with diesel power generation. We also procure materials and equipment that are necessary for the photovoltaic power generation system from Japan, from a viewpoint of system warranty. As “Socabelec”, which is described as a candidate EPC contractor in Chapter 2 (2) 3), has an experience in a renewable energy project and a record of delivery of diesel power generation facilities to isolated islands, we obtained a quotation for the construction cost and estimated the cost.

Total project cost is as shown in Table 14 VAT is added to the total amount.

Table 14 Total project cost (VAT not included)

No.	**Description**	**Qty.**	**Price**
①	Equipment		$ 162,000
1	Photovoltaic Module	192	
2	Mounting Structure	1	
3	Power Conditioner	2	
4	Control System	1	
5	Monitoring System	1	

6	Metrological Equipments	1	
7	Cable & material	1	
②	Transportation cost		$ 30,200
③	SV cost		$ 63,000
④	Construction cost		$ 88,800
	Total cost		$ 344,000

* Cost related to diesel power generation facilities is not included.

5) Fuel reduction effect and prediction for investment recovery

Projected fuel saving with this system is shown in Figure 46. Assuming the unit price of fuel is $1.656 per liter, earning and expense is as shown in Figure 47. The investment is expected to be recovered in 15 years.

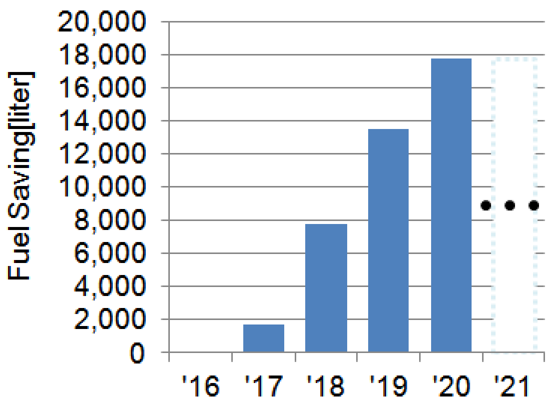


Figure 46 Projected fuel saving

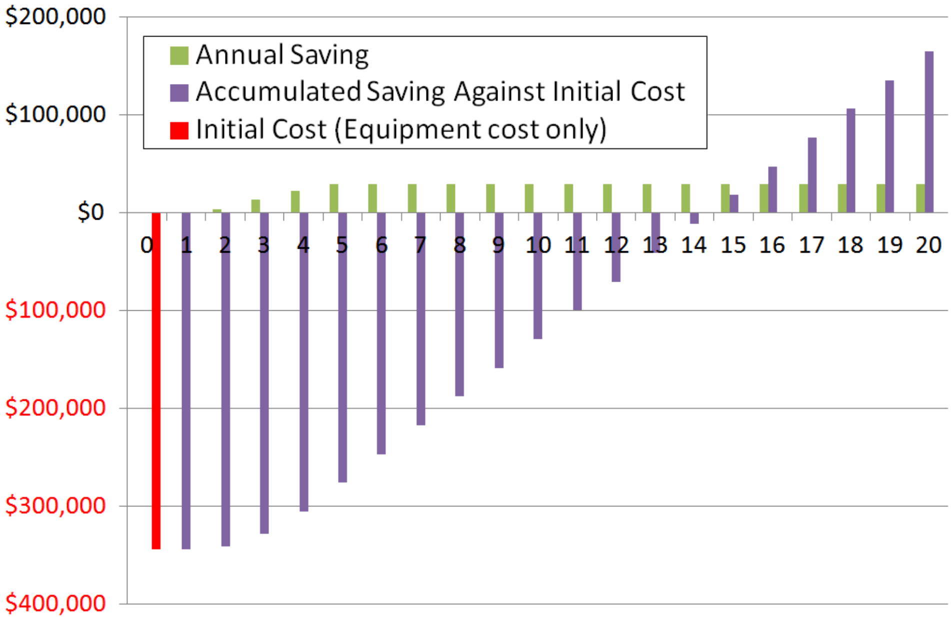


Figure 47 The number of years required for investment recovery and earnings and expenses

4 Analysis of Economic Effect for the Project Implementation

4.1 "Mega Solar Project" in Ethiopia

4.1.1 Analysis of Potential of Mega Solar Project

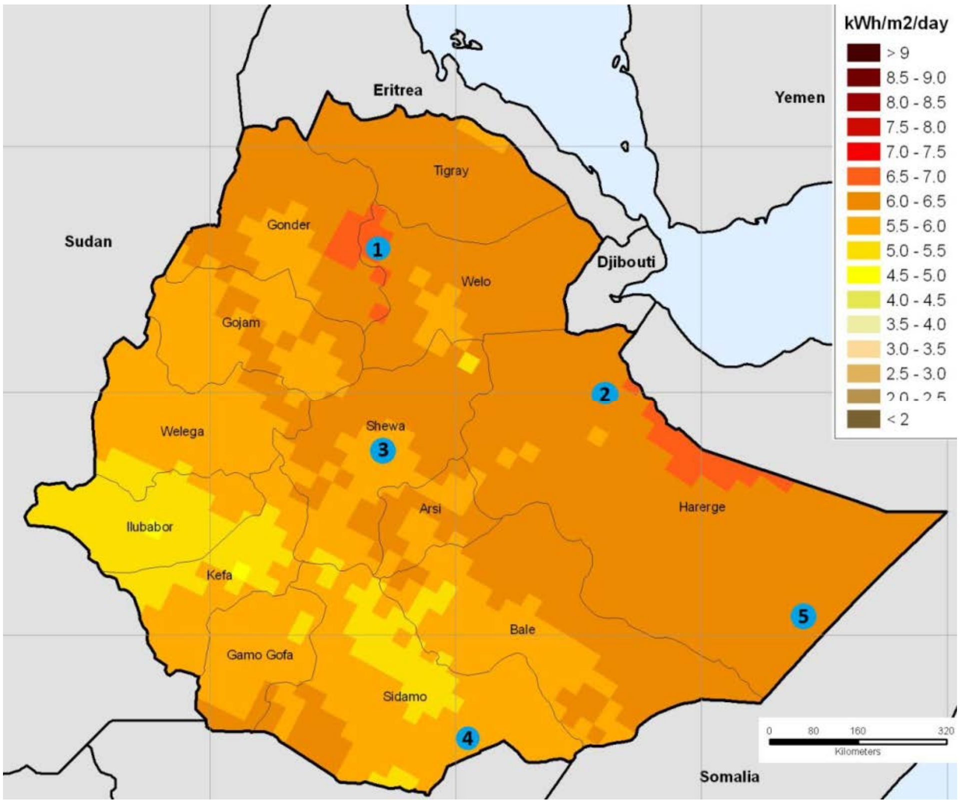


Figure 48 Electric Power Generation per Sqaure Meters and Candidate Sites for Mega Solar Project（1. Mekele , 2. Jijiga, 3. Addis Ababa, 4. Ethiopia/Kenya border, 5. Ethiopia/Somalia border ）

According to the Power Supply Master Plan Draft prepared by EEP (Ethiopian Electric Power, established when former EEPCo was split in December 2013 into EEP, a power generation utility, and EES, a power distribution utility) in November 2014, grid-connected solar power plants (100 to 300 MW mega solar power plants) that will be built in Ethiopia on the basis of the national power demand forecast will have an aggregate total of 1,264 MW at maximum installed capacity by 2025 and an aggregate total of 2,356 MW at maximum installed capacity by 2035.

In particular, construction of 300 MW mega solar power plants (100 MW × 3 sites) is scheduled to start in 2016. These solar power plants will be constructed by American corporations with an aid of the US7 billion dollars "Power Africa" project. The aid project was proposed by US President Obama and will be financed by the US Government and American corporations in the private sector to double electrification in the Sub-Saharan region.

The above-mentioned Master Plan has also proposed that, following the construction of the 300 MW mega solar power plants, additional five 100 MW mega solar power plants be constructed in five places shown in the above map (1. Mekele, 2. Jijiga, 3. Addis Ababa, 4. Ethiopia/Kenya border, 5. Ethiopia/Somalia border). It seems the potential of such total 500 MW mega solar power generation project could be regarded as the potential of our mega solar project. Since sites 1 and 3 in the map are located in suburbs of cities, acquiring the land of these sites will be a challenging issue.However, our hearing with MOWIE has obtained the comments that, since the entire land of Ethiopia is in control of the Federal Government, acquiring the land of these sites will be easy.

In addition, according to our hearing with personnel in charge of power plans at EEP, a not less than 50 MW mega solar project provided with financing can be proposed to EEP.

4.1.2 Economics of mega solar power generation

In Chapter 4, on the assumptions that 10 MW is set to be one unit and that increase in the output of solar power generation will be realized by multiple links of these units, we analyzed the economics of such one unit. Our trial calculation is on the basis of solar radiation amounts and climate data in the Mall Karsa region. The analytical results can be regarded as economic analysis of a mega solar power generation in Ethiopia.

—Capacity of Solar system	:10 MW
—Installed capacity	: 13,958 MWh/year
—Introduction cost	:US31,168,200 dollars (US3,116,820 dollars/MW)
—Number of years required for investment recovery	
	: Case of FiT 0.13 dollar/kWh: 20 years
	: Case of FiT 0.17 dollar/kWh: 15 years
	: Case of FiT 0.25 dollar/kWh: 10 years
	: Case of FiT 0.32 dollar/kWh: 7 years

Figure 1 Economics of Mega Solar Power Generation in Ethiopia
(Prepared from analysis in Chapter 4)

The current FiT price under discussion in Ethiopia is 0.08 dollar/kWh for cases that exceed 5 MW power generation. According to our hearings with MOWIE and the Ethiopia Electricity Authority, the FiT pricing is at the phase of receiving public comments, etc. from various stakeholders.We have won a certain understanding of our proposal in this study that 0.2 dollar is necessary at minimum in case that Ethiopia hopes investment through IPP implementation, etc. in the private sector. It is very likely that the Government of Ethiopia raises its FiT price gradually; if the FiT price is raised, implementation of this mega solar power generation project will be feasible with official aid including loans.

Table 15 FiT Prices on Solar Power Generation (continuous power)
(quoted from Chapter 2)

Capacity (MW)	FiT (US cents/kWh)
0.01 – 0.1	10
0.1 – 0.5	9.5
0.5 – 2.5	9
2.5 – 5	8.5
5-10	8

Source: Ethiopian Electric Agency, "Feed-in Tariff Proclamation No ---/2012"

In addition, this trial calculation is made on the presumption that all the procurement material and the site managers, etc. are from Japan. At the time of the project implementation, the operation cost will be cut, for example, in the following way: the parts of electrical systems subject to long-term warranty and the parts affecting power generation performance are procured from Japan and other parts are procured locally while the engineering on the whole is conducted in Japan.

With increase in the FiT price and system price control, this mega solar power generation project with official aid will become feasible.

4.1.3 Economicsize of mega solar power generation

On the basis mentioned above and on the presumption that cost per MW is set to US3,116,820 dollars/MW, the economic size of 500 MW mega solar power generation can be estimated to be US1,558,410,000 dollars.

In addition, the economic size of offerable 50 MW mega solar power generation per site can be estimated to be US155,841,000 dollars.

4.2 "Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia

4.2.1 Analysis of the potential

In our survey conducted in fiscal 2013, in cooperation with the laboratoty of Professor Tarun K.Raghuvanshi at Addis Ababa University, we surveyed the potential quantity of micro hydro power generation in the entire land of Ethiopia. As results, we were able to estimate a potential quantity of 83 MW in the entire land (estimated on the presumption that 3% of 2752.21 MW of total potential quantity is utilized) and a potential quantity of 27 MW from canals in which power generation systems can be introduced easily.

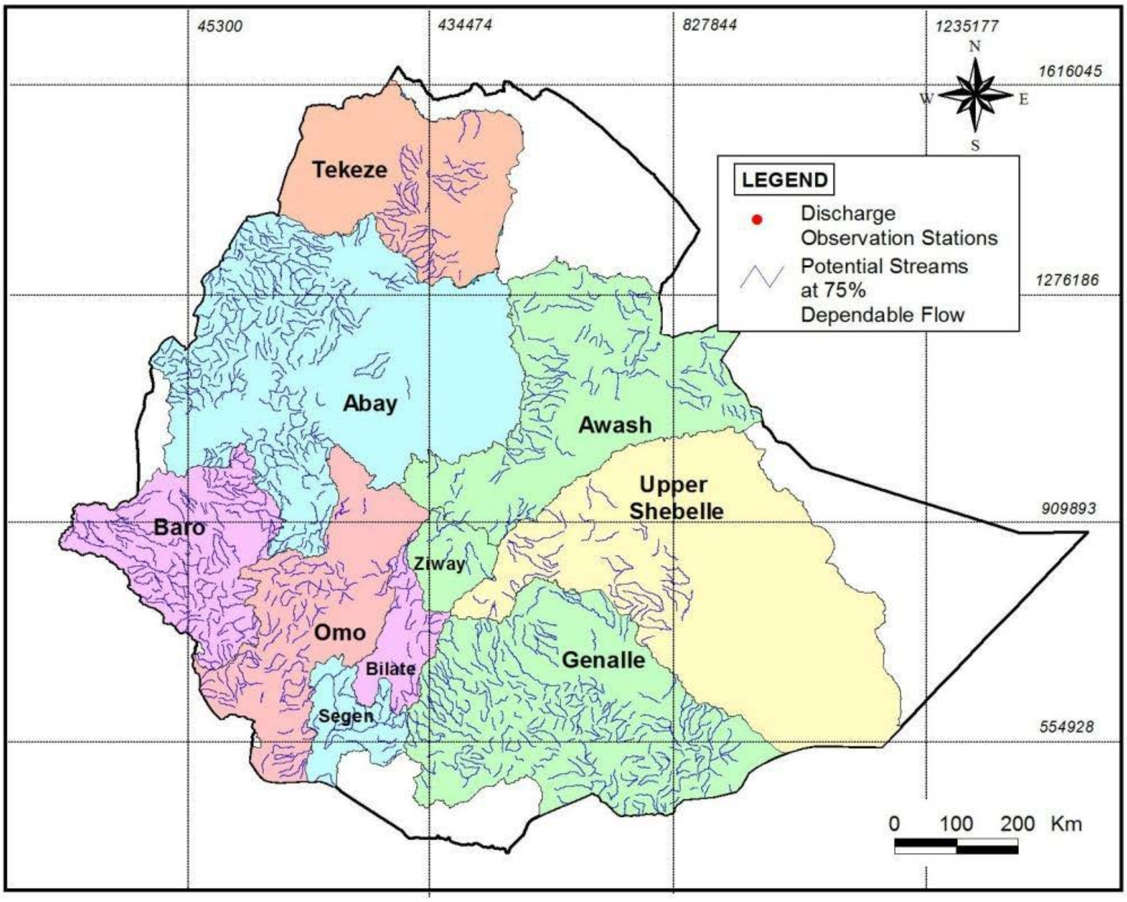


Figure 49 Natural Streams of Water That Enables Ultra Low Head Hydraulic Power Generation (in case that 75% frequency of water flow is secured)

We conducted hearing from Professor Tarun K.Raghuvanshi at Addis Ababa University for increase in potential through the hybrid of micro hydro power and solar power generation. The potential survey held last year regarded no power generation potential for the places that are not appropriate for power generation due to shortage of water after the seasonal factor is considered. According to results from the survey held last year, micro hydro power generation potential is estimated to increase by 20 to 30%. In other words, the total potential of 83 MW is estimated to increase to 99.6 MW to 107.9 MW (increase by 19.6 MW to 24.9 MW), while the potential of 27 MW of irrigation canals is estimated to increase to 32.4 MW to 35.1 MW (increase by 5.4 MW to 8.1 MW). Regarding the hybrid of micro-hybrid power generation and solar power generation that is discussed in Chapter 4, the output of the power generation system to be introduced is set to 10 KW for micro hydro power generation and 12.48 KW for solar power generation. When this system model is used, we can estimate that the potential of solar power generation is approximately 1.3 times the increasing portion of the potential of micro hydro power generation. In other words, there are potential of 5.48 MW to 32.37 MW in total and potential of 7.02 MW to 10.53 MW from irrigation canals.

Increasing portion of total potential of micro hydro power generation: (19.6 MW to24.9MW)×1.3
= Potential of solar power generation: 25.48 MW to 32.37 MW

Increasing portion of potential of micro hydro power generation from irrigation canals: (5.4 MW to 8.1 MW)×1.3
=Potential of solar power generation: 7.02 MW to 10.53 MW

Table 16 Power Generation Output Potential through Hybrid of Micro hydro Power Generation and Solar Power Generation

	Micro hydro power generation	**Solar power generation**
Micro hydro power generation alone	83 MW (canals: 27 MW)	—
Micro hydro power generation + Solar power generation	99.6 MW to 107.9 MW (canals: 32.4 MW to 35.1 MW)	25.48 MW to 32.37 MW (canals: 7.02 MW to 10.53 MW)
Increase through the hybrid	Increase by 19.6 MW to 24.9 MW	Same on the above side

	(canals: Increase by 5.4 MW to 8.1 MW)	

4.2.2 Economics and economic size

An outline of solar power generation of the hybrid system of micro hydro power generation and solar power generation, discussed in Chapter 4, are as follows:

－Capacity of Solar system	:Output12.40 kW
－Electric power generation	:16,914kWh/year (case of power demand at maximum)
－Cost	: US669,000 dollars (US53,952 dollars/kW) Portion of solar power generation facilities: US363,000 dollars (29,274dollars/kW)

Figure 50 Outline of Solar Power Generation of the Hybrid System of Micro hydro Power Generation and Solar Power Generation
(Prepared from analysis in Chapter 3)

The cost estimation was considered under the assumption that "blackout rate will be 0%". In addition, the price is fully customized case brought from Japan. In business phase, some materials include the possibility to adopt local procurement by suitable site situation.

Effective means to reduce the price is the localization and transfer of technology. In Ethiopia, companies, such as Alphasol, have experience in low-head hydro and solor power generation projects. Establishing a collaborative relationship or partnership with such companies enables the localization and transfer of technology. As to the approach to the federal government and local governments, cooperation with local companies enables a stable entry into the market and reduction in the price.

On the presumption that the power generation cost per kW is set to US29,274 dollars/kW on the above-mentioned basis, we obtained, through trial calculation, the economic size of solar power generation potential in total as 25.48 MW to 32.37MW and the economic size of that from irrigation canals as 7.02 MW to 10.53MW. In other words, we estimated, as potential, the total economic size of US745,901,000 dollars to US947,599,380 dollars and the economic size of US205,503,480 dollars to US308,255,220 dollars from irrigation canals.

4.3 "Hybrid Mini-Grid Project" in Kenya

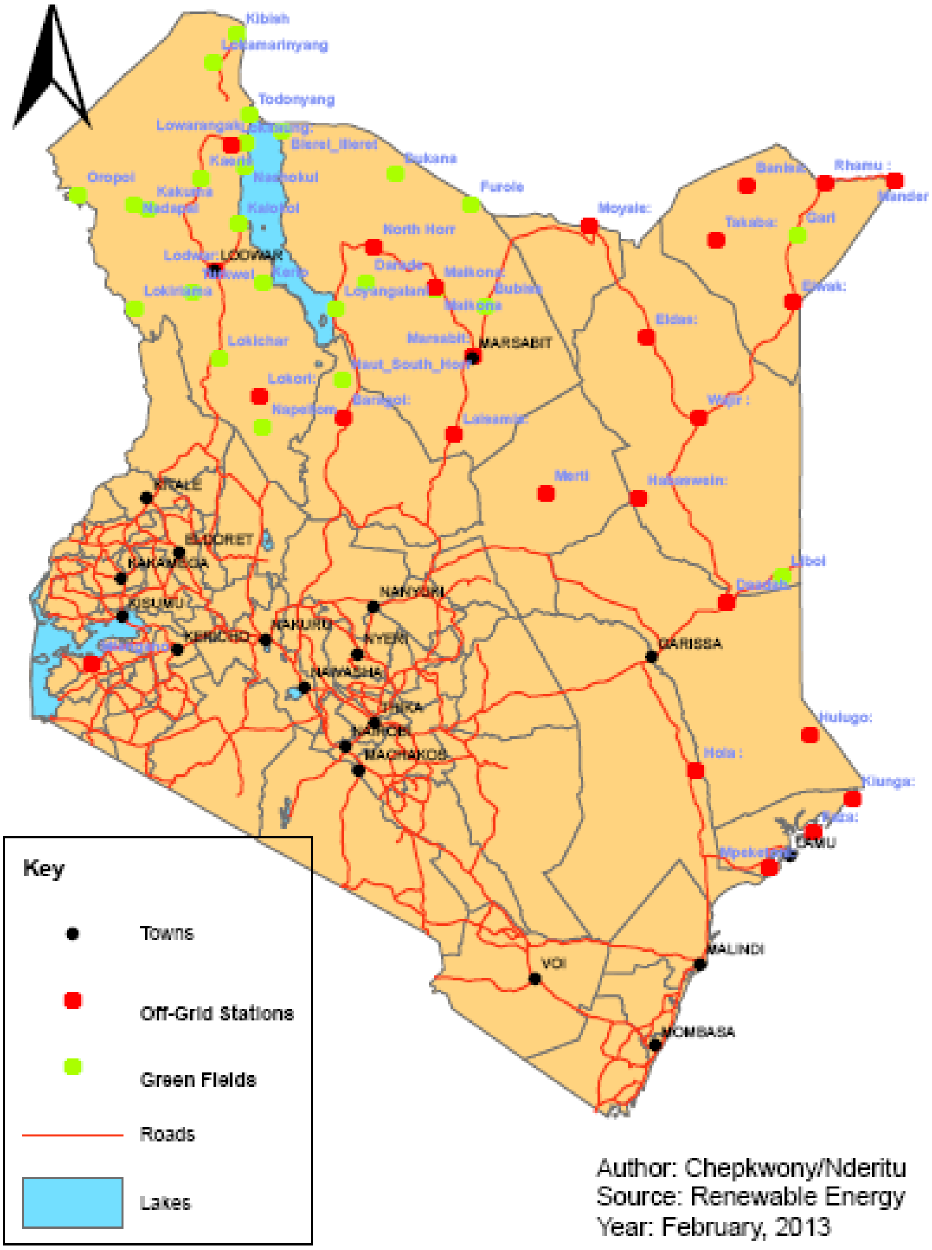


Figure 51 Distribution of Hybrid-Mini Grids
(Source: Kenya Power)

The above figure shows the sites planned for hybrid mini-grids in Kenya plotted in the map. Site where hybrid mini-grids are planned are plottted in red, while candidate sites where no hybrid mini-grids are planned are plotted in green.

In 2011, the Climate Investment Funds prepared the Scaling-up Renewable Energy Program (SREP) and submitted the SREP Investment Plan in Kenya (September 2011) to the Government of Kenya. The "Hybrid Mini-Grids" project in the investment plan aims to replace some 30% of the total power generation from the existing mini-grids with renewable energy.

In particular, existing 12 independent mini-grids (approximately 11 MW in total of the installed capacity) will have approximately 3 MW solar power generation and wind power generation facilities. In addition, the Government of Kenya has a policy of adding 27 such facilities (approximately 13 MW of capacity in total).

Prior to implementing this project since then, the Government of Kenya repeated negotiations with various donors. The AFD (French Agency for Development) decided to provide a low-interest loan of 30 million euros (approximately 4 billion yen) in 2013 for 23 sites in the map shown below. “Number 3, Lodwar” in the table below is scheduled to expand the solar power generation system with a grant aid from NORAD (Norwegian Agency for Development Cooperation).

Table 17 Hybrid Mini-Grids Plan (Source: Material[4] Provided by MOEP)

NUNBER	STAION NAME	EXISTING			PROPOSED for AFD	
		DIESEL CAPACITY (KW)	SOLAR PV (KW)	WIND (KW)	SOLAR PV (KW)	WIND (KW)
1	MANDERA	1,600	350	0	200	0
2	WAJIR	3,400	0	0	800	300
3	LODWAR	1,440	60	0	250	0
4	HOLA	800	60	0	100	0
5	MERTI	128	10	0	100	100
6	HABASWEIN	360	30	50	100	0
7	ELWAK	360	50	0	100	0
8	BARAGOI	128	0	0	100	100
9	MFANGANO	520	11	0	100	0
10	RHAMU	184	0	0	50+50	0
11	ELDAS	184	0	0	30+70	0
12	TAKABA	184	0	0	50+50	0
13	LOKICHOGGIO	640	0	0	80+70	0
14	LOKORI	184	0	0	150	0
15	FAZA	360	0	0	100	100
16	KIUNGA	230	0	0	150	0
17	HULUGHO	230	0	0	150	0
18	LAISAMIS	184	0	0	80	0
19	NORTH HORR	184	0	0	100	100
20	LOKITANG	184	0	0	150	0
21	DADAAB	640	0	0	200	0
22	MAIKONA	640	0	0	100	100
23	LOKIRIAMA	0	0	0	150	0
24	BANISA	0	0	0	100	100
TOTAL		12,764	571	50	3,730	900

4 AFD(African Solar Designs and Marge) "AFD Feasibility Study for an Off- Grid Programme in Kenya", June 2014

Concerning solar power generation systems and wind power generation systems in these 23 sites, the material and technology to be adopted will be decided through tenders held by REA (Rural Electrification Authority). For the time being, aggregate 3.7 MW solar power generation indicated in this plan is the potential of hybrid mini-grids.

4.3.1 Economic analysis of the hybrid mini-grids

The table shown below indicates results of the economic analysis of the hybrid mini-grids discussed in Chapter 4. The number of years required for investment recovery is estimated based on the reducing portion of diesel fuel after growth of power demand is taken into consideration. If electrification makes progress faster than anticipated, the number of years required for investment recovery will be shortened.

■ Pattern 1: Mfangano Island

—Capacity of Solar system :200kW

—Electric power generation :259,882kWh/year
(case of power demand at maximum)

—Introduction cost : US1,229,800 dollars (US6,149 dollars/kW)

—Number of years required for investment recovery : 13 years

■Pattern 2: Kokuwa Island on Lake Baringo

—Capacity of Solar system :50kW

—Electric power generation :65,310kWh/year
(case of power demand at maximum)

—Introduction cost: US344,000 dollars (US6,880 dollars/kW)

—Numbaer of years required for investment recovery: 15 years

Figure 52 Economic Analysis of Hybrid Mini-Grids in Kenya
(Prepared from analysis in Chapter 3)

On the basis of the F/S[5] on the hybrid mini-grids in 23 sites that was conducted by AFD, we make comparison of unit prices with the system proposed by Kyocera. The first and second rows in the table below indicate the unit prices of solar power generation (system without batteries and system with batteries) estimated by AFD, while the third row

[5] ibid.

indicates the unit price when the conditions similar to those of AFD are applied to the the trial calculation of cost discussed in Chapter 4. An output of solar power generation is set to be 200 kW, which is same output as study for Mfangano Island.

The unit price does not cover management costs, a portion of the construction costs and a portion of the civil engineering works , which vary depending on the site where the system is introduced, etc. To elaborate the discussion, comparison under the same parameters is necessary. However, the comparison in the table below is made under almost similar conditions.

Table 18 Comparison of Unit Prices of Hybrid Mini-Grids

	Cost for PV 200kW
1. Solar system **WITHOUT** batteries (F/S by AFD)	3.631 USD/W (3.200 Euro/W)
2. Solar System **WITH** Batteries (F/S by AFD)	4.410 USD/W (3.886 Euro/W)
3. Solar system **WITHOUT** Batteries (KYOCERA Proposal)	4.787 USD/W *not the price for commercialized stage

Kyocera proposes "3. solar system without batteries," which is an alternative of "2. solar system with batteries." Regarding 1, trial calculation is made on no presumption of hybrid with diesel. Furthermore, regarding 3, trial calculation is made on the presumption that all the procurement material and the site managers, etc. are from Japan. At the time of the project implementation,the operation cost can be reduced to the unit price indicated by AFD , for example, in the following way: the parts of electrical systems subject to long-term warranty and the parts affecting power generation performance are procured from Japan and other parts are procured locally while the engineering on the whole is conducted in Japan. It is considered that the technology that Kyocera proposes has good competitiveness even without taking price control to be introduced in future when local implementation is made. Furthermore, regarding "2, Solar systemwith batteries," the batteries, accounting for 20% of the total costs, are required to be replaced in intervals of five to ten years, depending on the control system. When the replacement cost is taken into consideration, it is commendable that Kyocera's proposal is suitable for hybrid mini-grids.

4.3.2 Economic size of hybrid mini-grids

On the presumption that the cost per kW is set to US6,149 dollars/kW on the above-mentioned basis, the potential that introduces a 3.7 MW solar power generation system among the hybrid mini-grids to be introduced with AFD's low-interest rate loan could be regarded as US22,751,300 dollars. When the budget of four billion yen on the whole is taken into consideration, it is appropriate that the portion of solar power generation has a potential of 2.7 billion yen in market size.

According to REA, in addition to the plan covering 24 sites including Lodwar, at least four sites are scheduled to be arranged for hybrid mini-grids[6]. Furthermore, at the local debriefing session on this survey, MOEP indicated the continuous arrangement of hybrid mini-grids with some 100 kW solar power generation system.

[6] Four sites, namely, Kotulo, Khorondile, Kamorliban, and Kakuma. Introduction of a hybrid system of some 100 kWsolar power generation system is expected.

5 Consideration of Emission Reduction Methodology Applicable to the Project Implementation and Trial Calculation of Emission Reduction Forecasts based on the Methodology

5.1 "Mega Solar Project" in Ethiopia

5.1.1 Summary of issues in preparing methodology

In LDCs like Ethiopia, electrification rate is extremely low. Those countries have a point of view that when a power plant is built in a project, it does not substitute for the existing power plant but is added to the existing power plant. This point of view is examined for the geothermal power generation in the “Feasibility Study for Geothermal Power Generation Project in the Great Rift Valley” of “Global Warming Mitigation Technology Promotion Project,” implemented in fiscals 2011 and 2012.

Hydraulic power generation accounts for approximately 90% of the gross generation in Ethiopia. Since the grid emission factor is very low, no grid-connected renewable energy project is feasible in CDM. However, Ethiopia is also heading for power generation other than hydraulic power generation, specifically, diesel power generation, which is already in use in independent grids. The above-mentioned studies in fiscals 2011 and 2012 consider that a new geothermal power generation project does not substitute for the existing grid-connected power plant but substitutes for a planned fossil fuel power plant construction and have prepared the methodology.

As two years have passed since fiscal 2012, this study aims to re-confirm the national power plan of Ethiopia and consider the setting of emission factors for grid connected power, as a major point at issue.

5.1.2 Hearings with stakeholders

We conducted hearings for future power plans with MOWIE (section in charge of energy planning and section in charge of rural electrification) and HOAREC (Addis Ababa University Horn of Africa Regional Environment Centre and network), an NGO/university institution specialized in CDM trends.

■Hearing item 1: Composition of electrical sources of the national grid (NG)

MOWIE Section in charge of energy planning	・Hydraulic power generation accounts for most of the composition of electrical sources. Since the emission factor is close to a zero, GHG emission is hardly reduced in a power generation project that is connected to the NG. Because of this, the MOWIE section understands that there is no incentive to implement CDM projects. ・The Federal Government maintains an ongoing policy of power source development by utilizing solar power and other renewable energies, which benefits not only Ethiopia but also the world on the whole. It is necessary to consider how to assess and handle the policy through the JCM.
MOWIE Section in charge of energy planning	・The Federal Government proceeds with its power source development policy centering on utilization of renewable energies. It is very unlikely that the government expands utilization of fossil fuel. ・Hydraulic power accounts for most of the composition of power sources. Since the emission factor for hydraulic power is close to a zero, any project of power generation connecting to the national grid hardly reduces GHG emission. Because of this, MOWIE officials understand that there is no incentive to implement CDM projects.
HOAREC	If construction and expanding of the national grid does not proceed with electrification, many areas will have to continue using kerosene lamps and diesel generators. Such conditions should be taken into account into the baseline as is meant in CDM.
Literature: Power Supply Master Plan[7]	・Volume 3, Generation Planning, 11-2 has a section concerning CDM. The section describes that EF is close to a zero and CER is hardly generated.

■Hearing item 2: Whether the emission factor for the national grid and related data necessary for the calculation are released.

MOWIE	・The Federal Government has released neither the emission

[7] Ethiopian Electric Power Corporation "Ethiopian Power System Expansion Master Plan Study Final Report", September 2014

Section in charge of energy planning	factor for the national grid nor the related data necessary to calculate the emission factor.
HOAREC	・ Neither the emission factor for the national grid nor the related data has been released.
Literature: Power Supply Master Plan	・ Neither the emission factor nor the data, etc. to calculate the emission factor is provided.

5.1.3 Point of view on emission factor for the national grid

Results of the above-mentioned hearings and literature searching revealed that at present there is no plan of constructing a fossil-fueled power plant in the future. We have to say that it has become very difficult to adopt the point of view that "renewable energy will substitute for fossil-fueled power plants scheduled to be constructed in the future," which was considered in the studies conducted in fiscals 2011 and 2012.

On the basis of the above-mentioned hearing results, repeated discussions with a third party institution (Japan Quality Assurance Organization) has reached a conclusion that it is very difficult to obtain the emission factor unless the Government of Ethiopia or the JC in its JCM scheme calculates and authorizes the emmission factor. In other words, grid-connected renewable energy projects will have no GHG reduction effect.

5.1.4 Methodology, and emission reduction

Pursuant to the JCM guidelines, we developed the methodology pertaining to this project under the presuppositions mentioned above. A set of the methodology documentation is attached to this report. The methodology includes a long-term warranty and eligibility criteria of a third party institution that will authorize that there is a small decrease in output, on the assumption that Kyocera's technology will be introduced. As mentioned earlier, since the reference emission stands at a zero, no GHG emission reduction effect can be confirmed. However, this methodology can be applied to grid-connected power generation projects to which Japanese solar power generation technology is applied, in other African countries, like Kenya, which have signed the JCM bilateral documents with Japan.

5.2 "Rural Electrification for Communities by Solar and Micro Hydro Power" in Ethiopia

5.2.1 Summary of issues in preparing methodology

In our fiscal 2013 project, we developed methodlogies pertaining to Micro Hydro power

generation. On the basis of the methodology, we decided to develop other methodology that cover solar power.
We incorporated a long-term warranty and eligibility criteria of a third party institution that authorizes that there is a small decrease in output so that Japanese solar power generation technology is applicable to the project.

5.2.2 Hearings with stakeholders

The methodology considered last year also cover an alternative means, namely, use of kerosene, in off-grid areas on the presumtion that monitoring of individual homes is necessary. Our methodology is roughly accepted by local stakeholders.

5.2.3 Methodology and emission reduction

On the basis of the above-mentioned facts, we developed the methodology pertaining to this project pursuant to the JCM guidelines. A set of the methodology docmentation is attached to this report. The methodology includes a long-term warranty and eligibility criteria of a third party institution that will authorize that there is a small decrease in output, on the assumption that Kyocera's technology is introduced.

Among the methodology, Calculation method 1 is used to calculate the presumed emission from solar power generation of the hybrid system.

Calculation method 1

$$RE_y = EC_{com,y} \times EF_{diesel}$$

Where:

RE_y	Reference emission in year y (tCO2)
$EC_{com,y}$	Electric energy consumed in year y by all of the community (MWh)
EF_{diesel}	Emission factor for diesel generator: 1.3 (tCO2/MWh)

$$PE_y = 0$$

Where:

PE_y	Project emission in year *y* (tCO_2/y)

$$ER_y = RE_y - PE_y$$

Where:

ER_y	Emission reduction in year y (tCO_2/y)
RE_y	Reference emission in year y (tCO2)
PE_y	Project emissions in year y (tCO_2/y)

The hybrid system at Fentale, considered in Chapter 4, has a capacity of 12.48 kW of solar power generation system. When load is maximized (on the assumption that the community consumes all of the possible electricity output), the electricity output reaches 16,914kWh/y.

$$RE_y = 16{,}914 kWh/y \times 1.3\ (tCO2/MWh)$$
$$= 22\ tCO2/y$$

Since PE_y is a zero, the emission reduction from solar power generation of the hybrid system at Fentale stands at 22 tCO2/y.

In addition, on the assumptions that Micro Hydro power generation has a generating capacity of 10 kW, a generation efficiency of 85%, a utilization factor of 87.5%, and that all of the generating power is consumed by the community, RE can be obtained in the following formula.

RE_y $=10kW \times 85\% \times 8{,}760\ hours/y\ (=24\ hours \times 365\ days) \times 87.5\% \times 1.3\ (tCO2/MWh)$
$=84.7\ tCO2/y$

Since PE_y is a zero, the emission reduction per 10kW Micro Hydro power generation is 84.7 tCO2/y.

In total, the emission reduction potential of the hybrid system at Fentale is 22 tCO2/y (Solar) + 84.7 tCO2/y (Micro hydro) =106.7 tCO2/y.

5.2.4 Ripple effect

Table 19 Potentials of power output from hybridized Micro Hydro power and solar power generation

	Micro Hydro power generation	**Solar power generation**
Micro Hydro power + Solar power generation	99.6 MW to 107.9 MW (canals: 32.4 MW to 35.1 MW)	25.48 MW to 32.37 MW (canals: 7.02 MW to 10.53 MW)
Increase by hybridization	Increase by 19.6 MW to 24.9 MW (canals: increase by 5.4 MW to 8.1 MW)	Same on the above side

The above table indicates the power output potentials of the hybridized Micro Hydro power and solar power described in Chapter 3.

The potential of solar power generation ranges 25.48 MW to 32.37 MW on the whole. On the basis of trial calculation at Fentale, when the annual electric power generation per kW is set to 1.76 kWh, the potential is estimated to range 44,845tCO2/y to 56,971tCO2/y.

RE_y $=1.76\ tCO2/y\ /\ kW \times 25.48MW \sim 32.37MW\ /1{,}000 \times 1.3\ (tCO2/MWh)$
$=44{,}845tCO2/y \sim 56{,}971tCO2/y$

Since PE_y is a zero, the emission reduction from solar power generation of the hybrid system ranges 44,845tCO2/y～56,971tCO2/y.

The introduction potential of power generation on the whole ranges 99.6 MW to 107.9 MW, which is the total of Micro Hydro power alone and hybridized Micro Hydro power and solar power.

$$RE_y = 99.6\ MW\ to\ 107.9\ MW \times 85\% \times 8{,}760\ hours/y \times 87.5\% \times 1.3\ (tCO2/MWh)$$
$$= 843{,}595\ tCO2/y\ to\ 913{,}894\ tCO2/y \quad ≒ 840{,}000\ tCO2/y\ to\ 920{,}000\ tCO2/y$$

Since PEy is a zero, the emission reduction potential of Micro Hydro power alone and hybridized Micro Hydro power in total ranges 840,000 tCO2/y to 920,000 tCO2/y.

5.3 "Hybrid Mini-Grid Project" in Kenya

5.3.1 Summary of issues in preparing methodology

Our fiscal 2012 project considered methodology pertaining to hybrid mini-grid projects. On this basis, we developed methodology pursuant to the JCM guidelines.
One of the points modified is that we incorporated a long-term warranty and eligibility criteria of a third party institution that will authorize that there is a small decrease in output into the methodology, in order to apply Japanese solar power generation technology to the project.
The subject at issue is how to set the emission factor in the reference scenario. Roughly, three methods are available. That is, 1. Applying the CM (combined margin) after calculating the OM (operation margin) and the BM (built margin) on the basis of operation records of independent existing grids; 2. Applying emission factor for the national grid; and 3. Regarding BOU as power generation by diesel engine.

5.3.2 Hearings with stakeholders

Our hearings with the Ministry of Energy and Kenya Power revealed that there was no emission factor for off-grid mini-grids other than operation data on off-grid mini-grids including existing hybrid mini-grids. However, the data is in short in calculating MO, BM and CM. To obtain the emission factor, additional data must be collected. Besides, monitoring data for at least one year is necessary.

5.3.3 Developing methodology

On the basis of the above-mentioned facts, we developed methodology pertaining to this

project pursuant to the JCM guidelines. A set of the methodology documentation is attached to this report. We incorporated a long-term warranty and eligibility criteria of a third party institution that will authorize that there is a small decrease in output into the methodology, on the assumption that Kyocera's technology is introduced in this project.
In addition, the reference emission covers following two methods: 1. Using the emission factors for the national grid or the existing mini-grid and 2. Using the emission factor for diesel. Actually, method 1 or method 2 will be applied to the project depending on the hybrid mini-grids plan of the Government of Kenya. Furthermore, whether applying method 1 or method 2 needs to be judged, depending not only on the policy trend but also on the consideration of progress in, for example, implementation of electrification policy. It is not rare in emerging countries that even an ambitious policy is made, the implementation does not proceed as planned. We also confirmed, in our hearings with Ministries and agencies relating to the environment, the need for considering the fact, namely, the gap between policy or plan and its implementation situations.

Described below is the methodology of calculating the reference emission for both methods.

F.2. Calculation of reference emissions

Considering the electrification plan and/or policy of the national/local government and actual status of the implementation of electrification plant, it can be determined whether the reference emission causes by consuming the electricity supplied through a national or regional grid or supplied by a diesel generator systems fossil-based electricity generation system.

If the electricity supplied through a national or regional grid would be consumed at the rural community to be electrified by the project activity, the reference emission is calculated as follows:

$$RE_y = EG_y \times EF_{EL,y}$$

Where:

RE_y	Reference emissions in year y [tCO2e/y]
EG_y	Amount of electricity supplied to consumers in rural areas isolated from national/regional grid by the HMS in year y [MWh/y]
$EF_{EL,y}$	Emission factor of the electricity supplied by a national or a regional grid to be likely to be connected to the rural area of the project activity in the case that the project activity would not occur [tCO2e/ MWh]

If the electricity supplied by a diesel generator system would be consumed at the rural community to be electrified by the project activity, the reference emission is calculated as follows:

$$RE_y = EG_y \times EF_{diesel,y}$$

Where:

RE_y	Reference emissions in year y [tCO2e/y]
EG_y	Amount of electricity supplied to consumers in rural areas isolated from national/regional grid by the HMS in year y [MWh/y]
$EF_{diesel,y}$	Emission factor for diesel generator systems in the case that the project activity would not occur [tCO2e/ MWh]

The status of the electrification plan and/or policy of the national/local government and actual status of the implementation of electrification plant are to be monitored annually. And the most likely reference emission shall be calculated.

5.3.4 Trial calculation of emission reduction

We use the methodology developed to make trial calculation of GHG emission reduction when the project is implemented. For the reference scenario, "2. Using emission factor for diesel," will be applied. When the projected is implemented, the quantities of diesel fuel used before and after the project is implemented are considered pursuant to the methodology. However, our trial calculation targets GHG emission originated from diesel fuel that is supposed to be reduced on the basis of the estimated electric power generation of renewable energy.

Kokwe Island

As we considered in Chapter 3, the hybrid system could generate 65,310kWh/y of electricity under the assumption that the demade is maximised.

RE_y =65,310kWh/y / 1,000×0.8 (tCO2/MWh)
=52.2tCO2/y

Since PE_y is a zero, the emission reduction from Solar system of Hybrid Mini Grid sytem at Kokwe island will be 52.2tCO2/y.

Mfangano Island

As we considered in Chapter 3, the capacity of Solar system will be 200kW for the Hybrid Mini Grid at Mfangano. And the system will be able to generate 259,882kWh/y under the assumption that the demade is maximised.

RE_y =259,882kWh/y / 1,000×0.8 (tCO2/MWh)
=207.9tCO2/y

Since PE_y is a zero, the emission reduction from Solar system of Hybrid Mini Grid sytem at Kokwe island will be 207.9tCO2/y.

5.3.5 Ripple effect

The potentioal of implementation for solar system will be 3,730 based on the F/S by AFD (23 sites + Lodwar).

On the basis of trial calculation at Mfangano, when the annual GHG reduction per electric power generation (kWh) is set to 1.03tCO2/y / kW（207.9 tCO2/y / 200kW）, the potential is estimated to 3,842 tCO_2/y.

$$RE_y = 1.03\ tCO2/y\ /\ kW \times 3{,}730kW$$
$$= 3{,}842\ tCO2/y$$

6 Seminar for government officials of the partner country

6.1 Study tour and seminar on Kyocera solar power generation system during the training in Japan

From December 15 to 20, 2014, a training program in Japan, "The UNIDO/HIDA[8] LCET Awareness Training Program for Ethiopia (ULAE[9])" was held for Ethiopian government officials. The program had 12 participants in total including Mr. Mehari WONDMAGEGN who is from the Ministry of Environmental Protection and Forestry and also a member of the joint committee between Ethiopia and Japan and other officials from the following organizations. On December 19, they visited Kyocera Sakura Office to look at the solar power generation system that has been operating on the roof of the Office since the installation in 1984 and took a seminar that presented the superior durability, long-term warranty and high quality of the Kyocera's system.

Table 20 Training participants

Affiliation	Title/No. of participants (subtotal)
Ministry of Water, Irrigation and Energy	Managing Director, engineers, etc., 7
Ministry of Environmental Protection and Forestry	Managers, 2
National Regional State of Oromia, Water Mineral and Energy Bureau	Head, etc., 3

[8] HIDA (The Overseas Human Resources and Industry Development Association) is an organization under the jurisdiction of the Ministry of Economy, Trade and Industry aiming at technical cooperation for private sectors. Its main purpose is to promote technical cooperation for industry and human resources development in developing countries through training and experts dispatch and other programs.

[9] ULAE (The UNIDO/HIDA LCET Awareness Training Program for Ethiopia) is part of the LCET framework and an activity continued from the 5th Tokyo International Conference on African Development, TICAD-V.

Figure 53 Study tour of solar power generation system at Kyocera Sakura Office

For Kenya, NTT Data Institute of Management Consulting has held a training program in Japan to introduce related technologies of Japan as part of the project, “Feasibility study on hybrid mini-grid in rural electrification of Kenya with renewable energy” carried out according to FY2012 Global Warming Mitigation Technology Promotion Project by the Ministry of Economy, Trade and Industry. Since then, the efforts to develop and maintain the relation with the Kenyan government have been made until today. Since the interest and knowledge of the local government have relatively accumulated, we held a training program targeting Ethiopia for the project this year.

6.2 Report of workshop

In February 2015, we held workshops in both countries to report study achievements and propose a project. The proceedings of each meeting are provided in the end of this chapter.

6.2.1 Ethiopia

In February 24, 2015, we held a workshop in Capital Hotel in Addis Ababa to report the achievements of this study. We had 28 participants in total as in the table below, including government officials, business people and five members of this study.

Table 21 Workshop participants (Ethiopia)

No.	Affiliation	Title/No. of participants (subtotal)
1	Ministry of Water, Irrigation and Energy (MoWIE)	Senior Vice Minister, Head, etc., 5
2	Ministry of Environment and Forestry (MEF)	JCM staff, 1
3	Ethiopian Energy Authority (EEA)	Head, 1

4	National Regional State of Oromia, Water Mineral and Energy Bureau	Staff, 1
5	Amhara Regional State, Mine and Energy Agency	Expert, 1
6	Tigray Mine and Energy Agency	Staff, 1
7	Southern Nations, Nationalities, and Peoples' Regional State, Water Resource Bureau, Mines and energy agency	Staff, 1
8	Ethiopian Electric Power (EEP)	Head, Strategy and Investment, 1
9	Alphasol	Managing Director, etc., 2
10	HOPE2020 (NGO)	Executive Director, 1
11	Jimma University	Professor, etc., 2
12	United Nations Industrial Development Organization (UNIDO)	Staff, 3
13	Japan International Cooperation Agency (JICA)	Staff, 2
14	Embassy of Japan	Second Secretary, 1

The workshop was started off by an opening speech of the representative of the Ministry of Water, Irrigation and Energy and it was followed by the overall review of the results of this study. Then, Kyocera made a technical proposal and presentation aiming at commercialization. Alphasol, a local private company, made a presentation on "Trend of renewable energy business in Ethiopia from the viewpoint of a private sector."

The following are the opinions we obtained from the local side in the discussion session.

<u>Ministry of Water, Irrigation and Energy</u>

➢ Mega solar system

- Solar power generation is a promising business in Ethiopia and an essential technology in terms of the current status where zero-emission plan is promoted.
- The superiority of Kyocera's technology and quality is robust and secure.

- We understood the importance of long-term warranty.
- The hurdle is still high costwise and we request cost reduction. We would like to know the future target unit price for power generation.
- FiT is important for business promotion but since Fit price has been lowering in developed countries, we think we need long-term discussion.
- We would need to secure a vast land but since land is owned by the government, it would not be a difficult concern.

➢ Hybrid power generation system with micro hydro power

- Since the renovation of the micro grid system is under study, we can say there is demand.
- It would be also effective as a pumped hydro power generation system.

➢ Others

- As a JCM project, capacity building is necessary for MRV management.
- The energy policy of the country is currently under modification and study. We invite private sectors for discussion and we would like to invite Alphasol as well.
- You did not refer to the effect of the recent drop of fossil fuel price on the renewable energy business. We would like to know your idea on it.

<u>Ethiopian Energy Authority</u>

- Solar power generation is an essential technology for Ethiopia.
- Current FiT price was low when the study draft was prepared. We will modify it in the future and we expect inputs from proposals of project developers and public comments.

Energy agencies of regional governments

- National Regional State of Oromia
  - We hope project development and implementation after Fantale.
  - We need to address cost issues and expand the scale.
  - We saw an actual Kyocera system and learned high technological capabilities during the training program in Japan last December.
- Southern Nations, Nationalities, and Peoples' Regional State
  - We have carried out five or more micro hydro power generation projects with support from GIZ, etc.
  - We hope to aim at the hybrid with solar power.
  - We hope to promote information sharing.
- Regional State of Tigray
  - Currently, six irrigation dams are under construction. We hope to introduce the hybrid system of micro hydro power and solar power for off-grid houses.
  - In reality, since we have an issue of seasonal fluctuation of irrigation water volume, the hybrid system is a good idea.
  - We hope to learn it by seeing the precedents of Fantale and Southern Nations, Nationalities, and Peoples' Regional State.

HOPE2020 (NGO)

- We expect the development of distributed power supply and renewable energy will be promoted by the green growth policy of the Ethiopian government.
- Independent solar power generation may be feasible.
- It is also necessary to raise the awareness of the community about the promotion of renewable energy introduction.

Figure 54 State Minister of Ministry of Water, Irrigation and Energy (center) and participants

Figure 55 Workshop (Ethiopia)

6.2.2 Kenya

In February 26, 2015, we held a workshop in Laico Regency Hotel in Nairobi to report the achievements of this study. We had 20 participants in total as in the table below, including government officials, business people and five members of this study.

Table 22 Workshop participants (Kenya)

No.	Affiliation	Title/No. of participants (subtotal)
1	Ministry of Energy and Petroleum (MoEP)	Engineers, staff, etc., 3
	Rural Electrification Authority (REA)	Staff, etc., 2
2	Ministry of Environment, Water and Mineral Resources	Expert, 1
3	National Environment Management Authority (NEMA)	Staff, 1
4	Kenya Power	Director, 1
5	Que Energy	Representative, 1
6	Institute for Development Studies, University of Nairobi	Researcher, 1
7	Jomo Kenyatta University of Agriculture and Technology	Researcher, 1
8	Kenya Association of Manufacturers	Coordinator, 1
10	United Nations Industrial Development Organization (UNIDO)	Staff, 2
12	Japan International Cooperation Agency (JICA)	Chief Adviser, 1

The workshop was started off by an opening speech of the representative of Renewable Energy Section, Ministry of Energy and Petroleum and it was followed by the overall review of the results of this study. Then, Kyocera made a technical proposal and presentation aiming at commercialization. The Ministry of Energy and Petroleum made a presentation on “Policy of Kenya for hybrid mini-grid development.”

The following are the opinions we obtained from the local side in the discussion session.

Rural Electrification Authority

- Possible means for project participation would include (1) participation in the bid as a partner of a Kenyan company, (2) implementation by securing fund and (3) partnership with a stakeholder.
- The proposed system is costly, which makes price competitiveness weak under present conditions.
- Besides AfD, the study reports of World Bank and other donors should be consulted.

Kenya Power

- The fact should be noted that currently diesel price has dropped by as much as 50%.
- Transportation cost would be too high if Kyocera's technology and equipment are brought in from Japan.
- Other hybrids, such as biomass and solar power, should be considered.

Ministry of Energy

- Can the residents in Kokwa bear electricity bills?
  (→ Answer: Kyocera is not an operator, and since it considers this is a project of Kenya Power, charge setting will be left to Kenya Power.)
- We are studying to prepare technical requirements for hybrid mini-grid development for future application.
- We will proceed with power selling contracts with private companies under FiT policy.
- We count on the role of the county government for the capacity building for hybrid mini-grid management.
- For project authorization, approval must be obtained from the Energy Regulatory Commission (ERC), county government and National Environment Management Authority (NEMA).
- Desirable project scale is 100 kW.

Que Energy

- For cost calculation, delivery cost differences between each service should be considered.
- We hope other hybrid technologies, such as biomass, are studied as well.

Kenya Association of Manufacturers

- Fifteen years are too long for investment recovery.
- If the provision of high-value-added system is intended, smart grid should be adopted.
- In light of the fact that funding of 40 million euro (AfD) has been determined, the project is promising and the moves of private sectors for hybrid mini-grid development will be active in the future. Chinese and Indian companies and a French company, Schneider have also moved into the market.
- The guideline of competitive solar power generation cost is USD0.16/kWh.
- USD0.2/kWh or more is required as FiT price.

Jomo Kenyatta University

- I know Kyocera's solar power panels because I have seen them in Kenya since many years ago. You should actively appeal that achievement to establish trust.
- Along with the proposal of new development items, the hybrid mini-grid that has been implemented by the Ministry of Energy and Petroleum should be reviewed.

Figure 56 Workshop (Kenya)

NTT DATA KYOCERA

Project Review Meeting

Feasibility Study on "Mega Solar" and "Rural Electrification for Communities" by Japanese Solar PV

Supported by the Ministry of Economy, Trade and Industry, Japan

Date& Time	**Tuesday, 24th February 2015** **10.00AM-12.15PM**
Objective of the Meeting	Project Review and Defining Way Forward
Location	Capital Hotel & Spa, Addis Ababa, Ethiopia
Key Attendance	**Stakeholders Representatives:** • The Ministry of Water, Irrigation and Energy (MoWIE) • The Ministry of Environment and Forests • Ethiopian Electric Power • Regional Government (Amhara, Oromia, SNNPR and Tigray) • Private Sector • Academia • International Organizations • Government of Japan, Japan International Cooperation Agency (JICA)
Agenda	**Welcome Address** by Mr. S. Higashi, NTT DATA IMC. 10:00-10:10 **Opening Remarks** Mr. Wondimu Tekle, State Minister, MoWIE 10:10-10:20 **Project Overview** by Ms. T. Hoshiko, NTT DATA IMC. 10:20-10:30 • Project overview **Technical Proposal** by Mr. M. Yokota, KYOCERA Corporation 10:30-10:50 • Overview of technology and application proposal for "Mega Solar" and "Rural Electrification for Communities" in Ethiopia **Strategic Engagement for Renewable Energy in Ethiopia** by Mr. S. Higashi 10:50-11:10 • The way forward • Conclusion
	TEA BREAK (20 min. max)

	Dynamism of Renewable Energy from the Perspective of the Private sector by Mr. Girmay G. Michael, Alphasol Internatinal Group 11:30-11:50 • Current dynamism of renewable energy • Motivations and challenges **Panel Discussion: "Way forward beyond F.S. Project (Phase II)"** facilitated by Mr. S. Higashi 11:50-12:10 **Wrap Up** 12:10-12:15
	LUNCH

Figure 57 Agenda of the workshop in Ethiopia

Project Review Meeting

Feasibility Study on the "Hybrid Mini-Grids" by Japanese Solar PV in Kenya

Supported by the Ministry of Economy, Trade and Industry (METI), Japan

Date& Time	**Thursday, 26th February 2015** **10.00AM-12.00PM**
Objective of the Meeting	Project review and defining way forward
Location	LAICO REGENCY HOTEL, Nairobi, Kenya
Key Attendance	**Stakeholders Representatives:** • The Ministry of Energy and Petroleum (MoEP) • The Ministry of Water, Environment and Mineral Resources • Rural Electrification Authority (REA) • Kenya Power • Private Sector • Academia • International Organizations • Embassy of Japan, Japan International Cooperation Agency (JICA)
Agenda	**Welcome Address** by Mr. S. Higashi, NTT DATA IMC 10:00-10:10 **Opening Remarks** 10:10-10:20 **Project Overview** by Ms. T. Hoshiko, NTT DATA IMC 10:20-10:30 • Overview of the project **Technical Proposal** by Mr. M. Yokota, KYOCERA Corporation 10:30-10:50 • Overview of technology and application proposal for "PV Hybrid System for Diesel Generator" in Kenya **The way forward and Conclusion** by Mr. S. Higashi 10:50-11:05 • Desired outcome from the project and the way forward • Implication to Joint Crediting Mechanism (JCM) between Kenya and Japan
	TEA BREAK (15 min. max)
	Development of Hybrid Mini Grid by Ministry of Petroleum and Energy 11:20-11:40 • Current policy and plan • Motivations and challenges **Discussion** 11:40-11:55 **Wrap Up** 11:55-12:00
	LUNCH

Figure 58 Agenda of the workshop in Kenya

7 Way forward and Conclusion

We have conducted SWOT and stakeholder analysis for each of the three projects, which are the themes of the survey of this year. We have clarified the road map of our future activities through the SWOT analysis and expectations and the roles of each sector through the stakeholder analysis. Based on these findings, we have made policy recommendations.

7.1 Mega Solar Project in Ethiopia

7.1.1 SWOT analysis

The following diagram shows findings from SWOT analysis on the Mega Solar Project in Ethiopia. Based on these findings, we have considered the future problems of the mega solar project and measures to be taken. The "Strengths" and the "Weaknesses" are relevant to internal elements of the Kyocera project in Ethiopia. The "Opportunities" and "Threads" are relevant to external elements, such as the project environment in Ethiopia. We have derived four recommendations by considering these elements.

Mega Solar Project By Japanese Technology	**Opportunities** • Master Plan for developing Mega Solar (500MW) • Proposal of Mega Solar Projects with 50MW or more is acceptable .	**Threats** • Other technologies from other companies and countries. • Specific Sites for installation (enough space and well paved road for transportation) • FiT policy
Strengths • Assurance of performance for 20 years based on long term experience. • Certification from Institutions	**[1] S X O** • With the long term reliability with over 20 years records, we make proposals to take part in Mega Solar Project.	**[2] S X T** • Conducting detailed F/S to specify the appropriate sites for Mega Solar. • Pilot / ODA project to demonstrate the Japanese technology including long term reliability with support from Japanese Gov't
Weaknesses • Total costs • Supply chain to Ethiopia	**[3] W X O** • Strong commitment to Ethiopia • Efforts to reduce the EPC and maintenance cost.	**[4] W X T** • Awareness building for Ethiopian Public / Private sector to introduce Japanese technology • Awareness building for Japanese Public / Private sector to take part in the market in Ethiopia.

Figure 2 SWOT analysis on Mega Solar Project

[1] Strengths × Opportunities: Proposal of development of mega solar that provides

long-term reliability

> Key points
> - We would like to make proposals to contribute to the Master plan of Mega Solar.
> - The term of Mega Solar will be over 15 years.
> - To estimate the performance and economic evaluation of Mega Solar, the PV modules should be assured based on long term records and

According to Ethiopia's power master plan, the country is planning to construct a 100 MW mega solar system at five locations. This is where Kyocera has a business chance that utilizes its technology. Besides the project of a total of 500 MW, a mega solar project of 50 MW may be implemented. As described later, the current problem lies in the very low price of FiT at USD0.08/kWh. If the Fit price is raised to a level that allows the entry of private businesses, Ethiopia would be a attractive market as shown in the Chapter 4 since it has 1.5 times the quantity of solar radiation in Japan.

To enhance the chance for the Japanese technology to be accepted in the market, we need to appeal our long-term reliability, as shown in Chapter 1. An energy project, such as mega solar, has a long project period of 15 to 20 years. If a product cannot endure a long-term use, the mega solar cannot be economically justified. We will make the public and private sectors in Ethiopia understand this point and propose them to make the long-term reliability a requisite for deploying mega solar.

To appeal the long-term reliability, we have invited them to Sakura Plant of Kyocera as part of the Ethiopia-to-Japan Tour Program to give them a chance to see the solor power generation system which has been operated since 1984. In field surveys and local report meetings, we have emphasized the importance of using a solor power generation system having a long-term reliability and have successfully gained some understanding.

[2] Strengths × Threads: Demonstration of technology

Key points

- In parallel with the proposal to Mega Solar, we will make proposals for Japanese.
- Proposals are including Detailed F/S to specify the site for Mega Solar.
- Based on the detailed F/S, we will make a proposal to develop Mega Solar by funds from Public sector.
- The first project will be a "Pilot / Demonstration " to show the Japanese

As described above, we have successfully gained some understanding of the superiority of Kyocera's solor power generation system having long-term reliability. Unfortunately, the superiority of our technology has a low visibility. To increase the visibility, we need to install a solor power generation system at a local site and perform demonstration.
The United States, which supports the construction of a 300 MW mega solar system, European nations and China are now waiting for a chance to enter the renewable energy market in Ethiopia. In such circumstances, the demonstration will also give us a chance to enhance the presence of the Japanese technology.
The barriers of the Mega Solar Project in Ethiopia include the procurement of a site and a transportation infrastructure. In an interview survey with EEP, we have heard that new entrants have a difficulty in procuring a mega solar site, in particular, in big cities, such as Addis Ababa and Mekele. In addition, mega solar construction requires transportation of a great number of solar panels, which makes an improved road a prerequisite for the project. To overcome such barriers, we need to perform a detailed preliminary field survey for implementing the above pilot project.
Ideally, such a mega solar pilot project, as well as the detailed preliminary field survey, should be performed in a public-private collaboration, supported by the Japanese government. At the same time, the involvement of the Ethiopian government is also needed; the Ethiopian government should understand the Japanese technology and request us to implement such a pilot project and survey.

<u>[3] Weaknesses × Opportunities: Enhancing commitment to Ethiopia</u>

Key points

- As showed by the presentation from KYOCERA, they have a strategy of commitment to Ethiopia as follows;
  - Short term : Project formation by Japan's ODA
  - Long term : Private driven business (SPC etc) by FiT policy
- With Support from Japanese Government (e.g. ODA) , we would like to Develop Mega solar in Ethiopia.
- In the process of projects, the "Total costs" and "Supply chain to Ethiopia" will be improved.

The current biggest weakness is the price. The factors that boost the price of the mega solar project in Ethiopia include the procurement of everything in the system from Japan and the construction of the plant under the management of the Japanese. Thus, elements of the solor power generation project other than key technology and comprehensive engineering should be outsourced to local partners as much as possible. Such a transfer of technology can reduce the entire cost. The supply chain to Ethiopia will be optimized during the implementation of the project.
Planning and implementing a subsidized demonstration project will help promote technology transfer and improve the supply chain.

[4] Weaknesses × Threads: Enhancing awareness in both countries

Key points

- We have to enhance the awareness toward to Japanese technology for Ethiopian Public / Private sectors.
- At the other hand, Awareness building for Japanese Public / Private sector is necessary to enlarge the markets presence in Ethiopia.

The weaknesses of the Japanese technology in Ethiopia, including but not limited to the mega solar project, include a low local visibility and a lack of price competitiveness. In addition, many nations are waiting for an opportunity to enter the new market of Africa, the last frontier. The key to overcoming such circumstances is to enhance awareness in the public and private sectors of the two countries. The field surveys and the pilot project using JCM should be regarded as measures to enter a market, which are quite

different from the conventional approach to Africa.
Various activities have been performed in this projects, such as the surveys from Japan to Ethiopia, local report meetings, and the inspection tour program from Ethiopia to Japan. By enhancing such activities, we can raise awareness in the both countries.

We have discussed with local companies based on the SWOT analysis. In the discussion, they have proposed a new way to utilize a limited amount of resources. In the proposal, local companies do not make an alliance with a Japanese company for each project, but a consortium in which multiple companies from the both countries participate is formed to develop renewable energy. The basic idea of this proposal is that multiple companies provide resources to fully utilize the strengths and opportunities and overcome the weaknesses and threads. The proposal aims to combine companies having various strengths and thereby increase opportunities in Ethiopia, not just for mega solar. Such formation of a permanent consortium would be more effective than the solo entry of a company into the market in African nations, including Ethiopia.

7.1.2 Stakeholder analysis

The following table shows findings from stakeholder analysis on the Mega Solar Project in Ethiopia. The table summarizes the expectations of stakeholders toward the mega solar project and their roles in the project based on the four proposals derived from the SWOT analysis.
The stakeholders shown in the table participated in the report meeting held in February 24, 2015. We have gained an overall understanding of the stakeholder analysis.
We have received a noteworthy comment from power-related sectors (MOWIE and EEA): "We have received various comments on the price of FiT from a variety of perspective. One of such comments says that the price of FiT should be USD0.2 or higher for private businesses to consider entry into business. We want to take it into account."

Table 1 Stakeholder analysis of mega solar project

Stake holders for "Mega Solar"	Stakeholders expectation for Mega Solar	Function of Stakeholder for implementing Mega Solar
-Federal Government -Electricity sector (e.g. EEP)	- Accomplish the master plan for Mega Solar (100MW X 5 = 500MW) - Industrial development regarding renewable energy sector.	- Introducing reliable PV system - Proposals and request for support from foreign country. - Specify the appropriate sites for Mega Solar. - Preferable treatment for Mega Solar development such as FiT.
-Regional State	- Utilization of the electricity generated by Mega Solar e.g. Irrigation Scheme, Water Supply, Industrial Development	-Specify the appropriate sites for Mega Solar. e.g. Enough Space, the sites with infrastructure such as transportation and main grid.
-Foreign Countries (including Japan) -International Organization	-Sustainable development -Engagement in Ethiopian market	-Financial supports e.g. Grant for pilot project, Low interests loan -Technical supports e.g. Technical transfer, Capacity building
-Private Sector (Ethiopia)	-Business in Mega solar development e.g. civil works, installations, manufacture & maintenance of system Site selection, engineering etc -Technical transfer from Japan	- Low cost and effective EPC - Interests and appreciation of Japanese technology, especially for long term reliability
-Private Sector (Japan)	-Attractive Markets in Ethiopia and Africa -R&D for developing countries	- Localization of technology and price - Technical transfer to Ethiopia - Commitment and strategy for Ethiopia and Africa

7.2 Rural Electrification for Communities by Solar and Micro Hydro Power in Ethiopia

7.2.1 SWOT analysis

Similar to 3.1, we have performed SWOT analysis on the Rural Electrification for Communities by Solar and Micro Hydro Power.

Solar + ULH MHP By Japanese Technology	**Opportunities** •Rural electrification plan by both Federal Government and Regional State •Potential of ULH MHP (100MW) and Solar (20MW)	**Threats** •Other technologies from other companies and countries in the future. •Awareness for ULH MHP and Hybridization of Solar
Strengths •No competitors for Ultra Low Head Micro Hydro Power •Adaptation to the fluctuation of water flow	**[1] S X O** •Promotion of "Solar + ULH MHP" to Federal Government and Regional State.	**[2] S X T** •Pilot project in Fentale Irrigation Scheme in Oromia.
Weaknesses •Total costs •Supply chain to Ethiopia	**[3] W X O** •Technical transfer •Efforts to reduce the EPC and maintenance cost.	**[4] W X T** •Awareness building for both Ethiopia and Japan. •Further R&D to take advantages of "first - mover advantage"

Figure 3 SWOT analysis on the Rural Electrification for Communities by Solar and Micro Hydro Power

<u>[1] Strengths × Opportunities: Urging the federal government and state governments to use solor power generation and extremely low-head hydro power</u>

Key points

- The Federal Government, Rural Electrification Fund (REF) in MoWIE are in charge of rural electrification.
- They seems to have initiative and budget to develop Small Hydro Power for off grid area.
- Regional States has plan to develop Small hydro and irrigation scheme by their own budget.
- We can promote ULH MHP and Hybridization with Solar to both Federal Government and Regional State.

In short, the Ethiopian federal government and local governments have budget for small-scale or low-head hydro power generation using irrigation channels and water channels. We want to demonstrate the possibility of generating power by installing a low-head hydro power generation system even for irrigation channels having a small difference in water level to the relevant sectors.For irrigation channels having a varied amount of water, we also want to demonstrate the possibility of stable power generation by using a hybrid system combining solor power generation generation with low-head hydro power generation. We will propose them to include the above possibility in a development plan and promote the installation of a power generation system.

In the 2013 survey, we have clarified our road map for the proliferation of the measures to electrify communities. More specifically, we sell our system to the irrigation and agriculture sectors and local governments for the moment, while aiming to promote rural electrification the cost of which is born by communities themselves in the future. In the survey of this year, we have conducted an interview survey with persons in charge of energy and irrigation in Amhara Region, Oromia Region, Southern Nations, Nationalities, and Peoples' Region, and Tigray Region. The interview has revealed that such local governments have budget for developing irrigation channels and installing small-scale or low-head hydro power generation involved in the development. It has been also found out that the federal government and local governments will also subsidize or support such small-scale or low-head hydro power generation. We have introduced low-head hydro power generation, as well as power generation technology combining low-head hydro power generation with solor power generation, through the survey project of this year. We have received a positive comment from a local government official that they are willing to consider installation of such a system.

For example, Oromia Region has Fentale irrigation channels introduced in Chapter 4. They take a forward-looking attitude toward a power generation project using irrigation channels. Amhara Region has Koga irrigation channels. The Koga irrigation channels has a problem of a shortage of water in the channel during the rainy season due to water being hold back by a dam in the upper stream and released during the dry season. We have successfully indicated that the problem can be solved by using a hybrid system combining low-head hydro power generation with solor power generation.

Figure 4 (Left) “Fentale irrigation” in Oromia, (Right) “Koga irrigation” in Amhara

Tigray Region has six irrigation channels under construction. Each of the irrigation channels has the budget of 100 million yen allocated to generate a total power of 100 kW. These channels, having a small difference in water level, would have high power generation cost with a conventional power generation method. An extremely low-head hydro power generation allows the channels to achieve desired power generation. The use of a hybrid system combining low-head hydro power generation with solor power generation may be also considered for such channels.

Figure 5 “Gerbe Segane irrigation” in Tigray

In Southern Nations, Nationalities, and Peoples' Region, low-head hydro power generation is performed using natural rivers. A hybrid system combining low-head hydro power generation with solor power generation allows headrace channels of mills having a low flow rate to be used for power generation.

Figure 6 “MHP project” in SNNPR

We want to appeal electrification through the low-head hydro power generation and the hybrid system combining low-head hydro power generation with solor power generation to the federal government and local governments through the pilot project at Fentale irrigation channels, described later, to explore the market.

[2] Strengths × Threads: Demonstration of technology

Key points

- KYOCERA showed their Hybrid System in the presentation.
- ULH MHP seems to be installed at Fentale from the support of UNIDO and Min of Economy Trade and Industry (METI), Japan.
- And we would like to add Solar system to ULH MHP.
- This is the pilot project to Ethiopia in general.
- By demonstrating the system at Fentale, we can enhance the awareness toward ULH MHP and Hybridization system with Solar.
- In addition, we would like to develop some demonstration projects in Regional States.

In response to the survey conducted in 2013 on the possibility of installing low-head hydro power generation, a pilot project on low-head hydro power generation will be conducted at Fentale irrigation channels in Oromia Region as part of Low Carbon Low Emission Clean Energy Technology Transfer Programme (LCET), jointly conducted by the Ministry of Economy, Trade and Industry and United Nations Industrial Development Organization (UNIDO).

In the pilot project, hybrid power generation combining low-head hydro power generation with solor power generation is to be performed in the future. Thus, the proposal of Kyocera technology introduced in Chapter 4 will give us an opportunity to demonstrate our technology. We have successfully raised interest in and promote understanding of the hybrid system combining low-head hydro power generation with solor power generation through the survey of this year. We are sure that the demonstration through the installation of an actual system will further increase the appeal to the federal government and local governments.

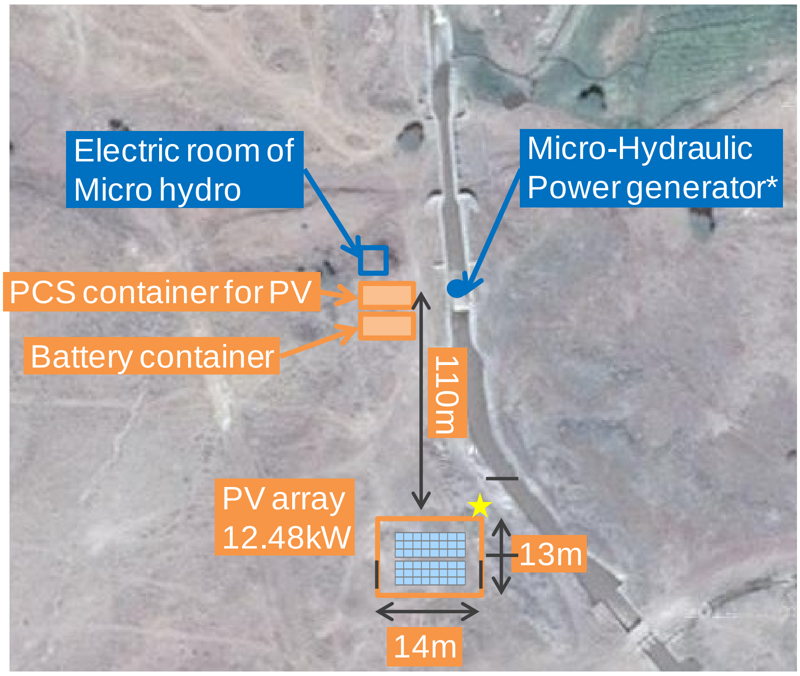


Figure 7 Pilot project of hybrid system at Fentale (image)

The demonstration should not be limited to Fentale irrigation channels. Demonstration in Amhara, Tigray, and Southern Nations, Nationalities, and Peoples' Regions will expand the range of application of our technology. Each region has its own problem: Amhara seasonal changes in the amount of water, Tigray a low flow rate due to pipe irrigation and a small difference in water level, and Southern Nations, Nationalities, and Peoples a low flow rate due to the headrace channels of mills. By proposing solution to these problems, we can successfully raise interest in and promote understanding of the technology.

[3] Weaknesses × Opportunities: Localization and transfer of technology

Key points
• To promote ULH MHP and Hybrid system with solar, we need "Localization and Technical Transfer" to Ethiopia. • By "Localization and Technical Transfer", the total price of the system, both initial and running costs will be decreased.

Similar to the mega solar, one of barriers to installation is the price. Effective means to reduce the price is the localization and transfer of technology. In Ethiopia, companies, such as Alphasol, have experience in low-head hydro and solor power generation projects. Establishing a collaborative relationship or partnership with such companies enables the localization and transfer of technology. As to the approach to the federal government and local governments, cooperation with local companies enables a stable entry into the market and reduction in the price.

More specifically, a system is established in which local companies assemble parts, manufacture accessories and perform maintenance at the start of a project, and the responsibility for more sophisticated processes is gradually transferred to the local companies.
The headquarters of African Union (AU) is in Ethiopia and many international conferences are held there. Appealing the technology may also raise demand for the technology in surrounding countries. An increased demand will reduce prices and promote the transfer of technology. Finally, Ethiopia will be a base for rural electrification of communities in Africa that focus on low-head hydro and solor power generation. If a certain level of a stable demand can be expected for our technology, the transfer of responsibility for more sophisticated manufacturing processes can further reduce the sales price.

[4] Weaknesses × Threads: Enhancing awareness in both countries

Key points

- We have to enhance the awareness toward to Japanese technology for Ethiopian Public / Private sectors.
- To maximize the advantages as "first - mover advantage", we have to pay efforts to further R&D. For example, application to Piped Irrigation scheme, penstock and so on.

Similar to the mega solar, the proliferation of the technology requires raised interest in and enhanced understanding of the technology in the public and private sectors in Ethiopia. This requires enhanced activities and proposals, including inspection tours to Japan, inspection tours of candidate sites by Japanese engineers, and proposals of technology.

At present, we have no competitor in this field, but competitive technology will appear soon as a worldwide interest in small-scale or low-head hydro power generation is growing. In order to maximize the advantage of the pioneer, we should continue R&D to expand fields to which the hybrid technology combining low-head hydro power generation with solor power generation is applied.

7.2.2 Stakeholder analysis

Table 2 Stakeholder analysis on the hybrid system combining low-head hydro power generation with solor power generation

Stake holders	Stakeholders expectation for Micro Hydro	Function of Stakeholder for implementing Micro Hydro
-Federal Government	- Rural electrification (access to the electricity) - Development of RE - Sustainable development to gain income at communities	-Incorporation of "Solar and ULH MHP" into rural electrification policy. -Financial and Technical support for off grid area
-Regional State	- Rural electrification - Sustainable development to gain income at communities - Utilization of the electricity to other sectors. - Multi purposes of canals	-Incorporation of "Solar and ULH MHP" into rural electrification policy. -Cooperation, knowledge sharing with irrigation sector.
-Foreign Countries (including Japan) -International Organization	-Sustainable development -GHG reduction -Engagement in Ethiopia -Develop "model" for rural electrification for communities	-Financial supports e.g. Grant for pilot project, Low interests loan -Technical supports e.g. Technical transfer, Capacity building
Communities	-Development to gain income -Improve "basic human needs"	-Earn income to pay back initial costs, prepare maintenance and equipment replacement
Private Sector (Ethiopia)	-Business in rural developments e.g. civil works, installations, manufacture & maintenance of system -Technical transfer	-Providing the experience and knowledge of rural electrification with RE -Low cost and effective EPC
-Private Sector (Japan)	-Attractive Markets in Ethiopia and Africa -R&D for developing countries	- Localization of technology and price - Technical transfer to Ethiopia - Commitment and strategy for Ethiopia and Africa
University/NGO	-Rural electrification (access to the electricity) -Development of RE -Sustainable development to gain income at communities	-Promotion Centre of Rural electrification -Center of Carbon management -Providing the experience and Technical / Financial support

The above table shows findings from the stakeholder analysis of the hybrid system combining low-head hydro power generation with solor power generation in Ethiopia.

The outcome from the survey includes enhanced awareness of local governments. In particular, we received comments from a person in charge in Tigray Region that "We will change our current irrigation channel plan into the one that utilizes the technology," and "We want to utilize the electrification technology not only for rural electrification of communities but also for development policies of local governments, such as irrigation and water supply."

In local reporting meetings, we have also introduced the expectations and roles in the stakeholder analysis, most of which have been accepted. The report meetings have provided an opportunity for stakeholders of this project to gather and have activated a sector that develops rural communities using renewable energy. We want to take advantage of this opportunity to continue the effort to expand the market.

7.3 Hybrid Mini-grid Project in Kenya

7.3.1 SWOT analysis

We have performed SWOT analysis on the hybrid mini-grid project in Kenya to determine a policy for making recommendations.

Hybrid Mini Grid By Japanese Technology	Opportunities •Policy of GOK (3.7MW with 40mills funds from AFD) •Other green fields for "Hybrid Mini Grid"	Threats •Other technologies from other companies and countries. •Initiatives from other countries
Strengths •Diesel + PV hybrid system without batteries •Assurance of performance based on practical records and certification from Institutions	[1] S X O •Proposal of "Diesel + PV hybrid system without batteries" to GOK.	[2] S X T •Pilot project to demonstrate the Diesel + PV hybrid system without batteries" in Baringo with support from Japan and UNIDO
Weaknesses •Total costs •Supply chain to Kenya	[3] W X O •Efforts to reduce the EPC and maintenance cost.	[4] W X T •Awareness building for Public / Private sector in Kenya and Japan •Strong commitment to Kenya

Figure 8 SWOT analysis on hybrid mini-grid project

<u>[1] Strengths × Opportunities: Proposal of a hybrid system combining diesel with solor power generation without using battery</u>

Key points

- We would like to make proposals to contribute to the development of 24 off-grid station into Hybrid Mini Grid.
- The strong points are as follows;
  - Diesel + PV hybrid system without batteries
  - Assurance of performance for 20 years based on practical records and certification from Institutions
- Firstly, we will consider to take part in the tenders from REA with Kenyan EPC companies.
- KYOCERA will be in charge of "Engineering" and "Supply of PV modules as a manufacturer".
- Secondly, we will start the "Private driven business (SPC etc)" motivated by FiT policy.

As shown in Chapter 5, the Kenyan government, which receives support from AFD, is planning to construct a hybrid mini-grid at 23 locations. The construction cost is 4 billion yen. In the project, a 3.7 MW solor power generation plant is to be constructed. Products used for the solor power generation will be chosen through a bid. This indicates the existence of a market we can enter with our technology. For the moment, we are planning to participate in the bid for the hybrid mini-grid project in collaboration with local companies, such as Socabelec and Powe Point. Kyocera will be responsible for comprehensive engineering and the provision of a solor power generation system. The local EPC partners will be in charge of other tasks.

In the bid, we want to appeal the following advantages: (1) A hybrid system combining diesel with solor power generation without using battery, and (2) 20-year guarantee of performance based on our proven record of long-term operation and the accreditation of a third-party certification body.

All the hybrid mini-grid systems constructed at 23 locations are not necessarily subject to a bid at once; a bid is held phase by phase. Although we propose a system that eliminates the necessity for battery in this project, an initial bid will assume that the system is equipped with battery. Kyocera also has a proven record of successful installation of a system equipped with battery in small islands and thus has technological advantage. The price of our system does not have a large difference from an expected price, as shown in Chapter 4. Cooperation with local companies allows us to locally procure or install a part of necessary equipment and thus avoid unfavorable price competition.

We will continue to propose the hybrid system combining diesel with solor power generation without using battery, while participating in and winning such bids for a system equipped with battery, to encourage the government to make such technology a requirement of the bids for constructing the hybrid mini grid system.
The hybrid mini-grid system will be constructed at sites other than the 23 locations. The Kenyan government expects that the hybrid mini-grid system will be developed and operate by an Independent Power Producer (IPP). Given a project environment, such as an increase in FiT, that allows private businesses to enter the market, we want to participate in power generation business through investment or participation in SPC with local companies.

[2] Strengths × Threads: Demonstration of technology

Key points

We have explained the following technological advantage of Kyocera through this project and gained some understanding on the issue: (1) A hybrid system combining diesel with solor power generation without using battery, and (2) 20-year guarantee of performance based on our proven record of long-term operation and the accreditation of a third-party certification body. However, we have received a comment that says "I want to install a system first and then see how it works." While European companies focus on seeking business opportunities in rural electrification, we want to implement a pilot project to demonstrate Japanese technology.
More specifically, MOEP recommended Kokwa Island on Lake Baringo as a candidate site for the pilot project. We have received a comment that says "If Japan provides financial aid for the construction of a power generation system, the Kenyan government and Kenya Power will take care of power lines." In response to the results of this project, we are to propose the implementation of a pilot project, following the low-head hydro power generation in Ethiopia and Kenya, as part of the LCET program jointly

conducted by the Ministry of Economy, Trade and Industry and UNIDO.

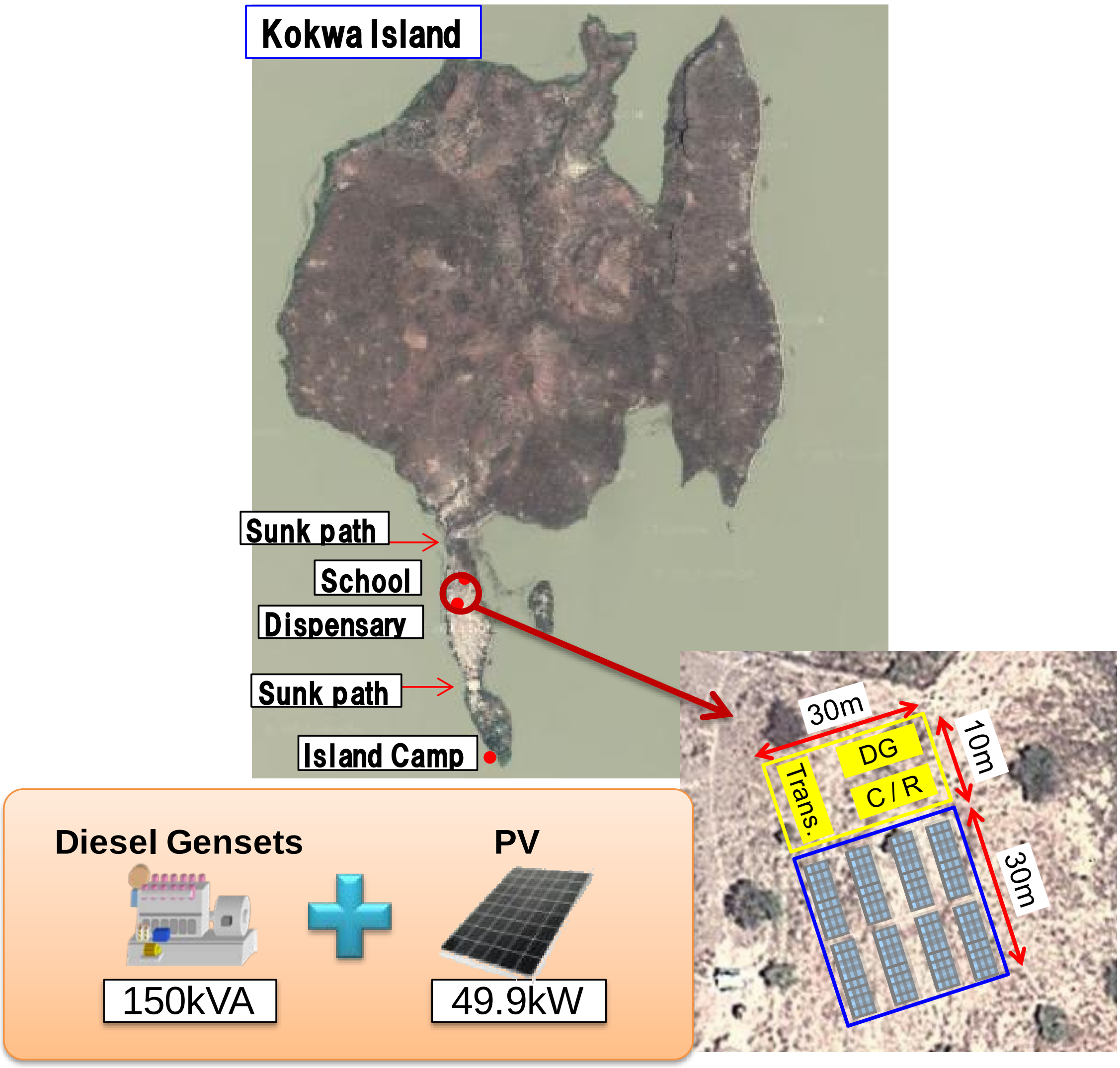


Figure 9 Implementation of hybrid mini-grid pilot project at Kokwa Island on Lake Baringo (Image)

In terms of the hybrid mini-grid policy or technology, which is achieved by adding renewable energy to independent mini-grid, Kenya may be regarded as an advanced country. Many countries have a concept of rural electrification using renewable energy, but fail to achieve the concept. Unlike such countries, Kenya has a concept of using renewable energy for the independent mini grid and is successfully installing such a system while receiving support from advanced countries. In the future, the construction of the hybrid mini-grid, supported by AFD, will proceed and related technologies will make a further progress.

The hybrid mini-grid in Kenya is often introduced in international seminars on the mini grid and “Africa Mini Grid Summit” was held in Nairobi, the capital of Kenya, in November 2014.

Figure 10 “Africa Mini Grid Summit” in Nairobi in November 2014

The increased presence of Japanese technology in Kenya, which is an advanced nation in terms of the hybrid mini-grid, will provide us with opportunities to enter the market not only in Africa but also in other regions.

<u>[3] Weaknesses × Opportunities: EPC and effort to reduct maintenance cost</u>

Key points • KYOCERA seems to have a strategy of commitment to Kenya as follows; ➢ Short term : Project formation with support from UNIDO and Japanese Government ➢ Long term : Private driven business (SPC etc) by FiT policy • Firstly, with supports from UNIDO and Japanese Government, we would like to Develop Hybrid Mini Grid projects in Kenya.

Similar to the project in Ethiopia, the current biggest weakness is the price. As shown in Chapter 4, the price of the hybrid mini-grid does not have a large difference from the target price of the Kenyan government. The elements that help reduce cost on a short-term basis include the local procurement of some of parts or equipment and the localization of management of processes. They can reduce the cost shown in Chapter 4.

A successful implementation of the pilot project shown in [2] allows compartmentalization from local EPC partners and the examination of supplier chains. This enables localization of technology and then further reduction in the installation price.

[4] Weaknesses × Threads: Enhancing awareness in both countries

Key points

- We have to enhance the awareness toward to Japanese technology for Kenyan Public / Private sectors.
- On the other hand, Awareness building for Japanese Public / Private sector is necessary to enlarge the markets presence in Kenya.

Similar to the project in Ethiopia, the weakness of the Japanese technology in the hybrid mini grid is a low local visibility and a lack of price competitiveness. To compensate for the weakness, we have emphasized the necessity for participating in local bids and implementing a pilot project that demonstrates the reliability of our technology.

In addition, visits to Japan by Kenyan stakeholders and reinforced commitment of Japanese companies to Kenya are also needed. A Demonstration of not only renewable energy including solor power generation systems but also the Japanese advanced technology of low-carbon to Kenya will increase the visibility of Japanese technology.

7.3.2 Stakeholder analysis

Table 3 Stakeholder analysis on hybrid mini-grid project

Stake holders for "Hybrid Mini Grid"	Stakeholders expectation for Hybrid Mini Grid	Function of Stakeholder for implementing Hybrid Mini Grid
-Federal Government -Electricity sector (Kenya Power)	- Accomplish the master plan for Rural Electrification. - Ambitious target "Electricity for all by 2030"	- Introducing "reliable", "efficient" and "reasonably priced" Hybrid Mini-Grid without batteries. - Proposals and request for support from foreign countries. - Preferable treatments to activate foreign investments such as attractive FiT (20 – 25 cents/kWh)
-County Government	- Utilization of the electricity generated by Hybrid Mini Grid e.g. Irrigation Scheme, Water Supply, Industrial Development	- Financial contribution to the development of Hybrid Mini Grid.
-Foreign Countries (including Japan) -International Organization	-Sustainable development -Engagement in Kenya -R&D for isolated grids development at large	-Financial supports e.g. Grant for pilot project, Low interests loan -Technical supports e.g. Technical transfer, Capacity building
-Private Sector (Kenya)	-Business in Hybrid Mini Grid development e.g. civil works, installations, manufacture & maintenance of system Site selection, engineering etc -Technical transfer from Japan	- Low cost and effective EPC - Interests and appreciation of Japanese technology, especially Hybrid Mini Grid without batteries.
-Private Sector (Japan)	-Attractive Markets in Kenya and Africa -R&D for developing countries	- Localization of technology and price - Technical transfer to Kenya - Commitment and strategy for Kenya and Africa

The following table shows findings from stakeholder analysis on hybrid mini-grid project in Kenya. The table summarizes the expectations of stakeholders toward hybrid mini-grid project and their roles in the project based on the four proposals derived from the SWOT analysis.

In the interview survey at individual visits and at local report meetings, we showed them the SWOT and stakeholder analysis. We received comments: "How do you reduce the price?" and "We need the demonstration of technology."

As for the price, we can reduce it to the target price of the Kenyan government through collaboration with local EPC companies, as mentioned before.

As for the demonstration of technology, we want to implement a pilot project to meet local expectations. The public and private sectors in Kenya, which see each nation earnestly attempting to expand the market in Kenya, take a cold look at the (rather passionless) commitment of the Japanese companies and the government. The honest feeling of Kenya is that "If Japan wants to expand the market, Japan should show the technological superiority in a pilot project, just as other countries and companies do."

7.4 Conclusion

7.4.1 Mega Solar Project in Ethiopia

Conclusion

1. Requirements for Mega Solar procurements / tender
   - "Assurance of performance for 20 years based on long term experience"
   - "Certifications from reliable institutions"

2. Project development by Japanese official support
   - To develop project by supports from Japanese Government, the requests from Ethiopian Government are essential.
   - We hope that Ethiopian Government prioritize "Mega Solar Projects".

3. Attractive FiT to activate the private sectors
   - As international trends, FiT minimum 20 – 25 cents attracts foreign investors.
   - We hope the FiT in Ethiopia will be gradually raised.

7.4.2 Rural Electrification for Communities by Solar and Micro Hydro Power in Ethiopia

Conclusion

1. Incorporation of "Solar and Micro Hydro Power" into rural electrification policy.
   - For Federal Government, incorporation of "Solar and ULH MHP" into rural electrification policy. And Financial and Technical support for off grid area
   - For Regional State, incorporation of "Solar and ULH MHP" into rural electrification policy. As well as cooperation, knowledge sharing with irrigation sector.

2. Technical transfer and localization
   - Technical transfer and localization of technology are essential to reduce the implementation / running cost.
   -

3. Awareness building
   - Awareness from both Public / Private should be enhanced.

7.4.3 Hybrid Mini-grid Project in Kenya

1. Requirements for Hybrid Mini Grid procurements / tender
   - Hybrid Mini Grid without batteries
   - With regard to Solar PV system, "Assurance of performance for 20 years based on long term experience" should be required.
     "Certifications from reliable institutions" should be required as well.

2. Technical Transfer / Awareness building
   - To develop Hybrid Mini Grid with technologies from foreign companies, including Japan, the collaboration with Kenyan EPC partners are essential.
   - We hope that Public / Private sectors of Kenya pay attention to Japanese technology for "Hybrid Mini Grid with out batteries".

3. Attractive FiT to activate the private sectors
   - As international trends, FiT minimum 20 – 25 cents attracts foreign investors.
   - We hope the FiT in Kenya will be gradually raised.

【Appendix】Drafts of Methodology for JCM projects

JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form	

Form for submitting the proposed methodology

Host Country	Ethiopia
Name of the methodology proponents submitting this form	NTT DATA INSTITUTE OF MANAGEMENT CONSLUTING, Inc.
Sectoral scope(s) to which the Proposed Methodology applies	1. Energy industries
Title of the proposed methodology, and version number	Mega photovoltaic power generation that supplies electricity to a grid, Ver 1.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	20/02/2015

History of the proposed methodology

Version	Date	Contents revised
1.0	20/02/2015	First Edition

A. Title of the methodology

Mega photovoltaic power generation that supplies electricity to a grid Version 1.0

B. Terms and definitions

Terms	Definitions
Mega photovoltaic power generation system (MPV)	MPV with a total capacity more than 1MW, which is connected to a national or a regional grid.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	New establishment of MPV to avoid using fossil fuel based power generation.
Calculation of reference emissions	Reference emission is calculated by the amount of electricity supplied by the MPV and emission factor of a national or a regional grid to which the MPV would connect.
Calculation of project emissions	No emission in the project scenario considered.
Monitoring parameters	The following parameters are to be monitored: ✓ The amount of electricity supplied by the MPV;

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The proposed project activity aims at supplying electricity to a national or a regional grid. The electricity is supplied only by the MPV.
Criterion 2	The proposed project activity is a Greenfield project (i.e. a project newly established in previously undeveloped site) of the MPV.
Criterion 3	The power generation efficiency loss of the solar cell during the technical lifetime of

	20 years shall be within 20 %. Furthermore, it can be guaranteed by the manufacturer of solar cell based on the performance of actual operation during more than 20 years.
Criterion 4	The solar cell installed shall comply with applicable international standards or comparable national, regional or local standards/guidelines.
Criterion 5	The total amount of electricity supplied by the MPV can be measured continuously.

E. Emission Sources and GHG types

The emission sources include all the following GHG emission sources and GHG types.

Reference emissions	
Emission sources	GHG types
Fuel consumption by the fossil-based electricity generation	CO_2
N/A	N/A
N/A	N/A
Project emissions	
Emission sources	GHG types
N/A	N/A
N/A	N/A
N/A	N/A

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions include only CO_2 emissions from electricity generation in fossil fuel fired power plants connected to a national or regional grid. The methodology assumes that all project electricity generation would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants in the case that the project activity would not occur. In Ethiopia, high percentages of rural community have not been electrified with a national grid or regional grid, most of rural areas are not electrified or electrified with stand-alone fossil-based electricity generation system such as diesel generator[10].

[10] Following sources describe current situation of electrification and renewable energy

F.2. Calculation of reference emissions

The reference emission is calculated as follows:

$$RE_y = EG_y \times EF_{EL,y}$$

Where:

RE_y	Reference emissions in year y [tCO2e/y]
EG_y	Amount of electricity supplied by the MPV in year y [MWh/y]
$EF_{grid,y}$	Emission factor of the electricity supplied by a national or a regional grid [tCO2e/ MWh]

G. Calculation of project emissions

Thus project emissions are not estimated.

$$PE_y = 0$$

Where:

PE_y	Project emissions in year *y* (tCO_2/y)

H. Calculation of emissions reductions

Emission reductions are calculated as the difference between the reference emissions and project emissions, as follows.

$$ER_y = RE_y - PE_y$$

Where:

ER_y	Emission reductions in year *y* (tCO_2/y)
RE_y	Reference emissions in year y (tCO2)
PE_y	Project emissions in year *y* (tCO_2/y)

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usage in Ethiopia:
World Bank, "Access of electricity"
http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
IEA, "World Energy Outlook 2013 – Electricity Access Database"
Rural Electrification Authority website http://www.rea.co.ke/
Lighting Africa 2012, "Policy Report Note Kenya"

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* and to be monitored is listed as below.

Parameter	Description of data	Source
$EF_{grid,y}$	Emission factor of the electricity supplied by a national or a regional grid (tCO_2/MWh)	Calculated value using publicly available official statics data by the national or local government as per the valid version of CDM methodological tool, "Tool to calculate the emission factor for an electricity system"

JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Ethiopia / Kenya
Name of the methodology proponents submitting this form	NTT DATA INSTITUTE OF MANAGEMENT CONSLUTING, Inc.
Sectoral scope(s) to which the Proposed Methodology applies	1. Energy industries
Title of the proposed methodology, and version number	Rural electrification through Ultra Low Head Micro Hydro Power Generation and/or Photovoltaic Power Generation, ver 1.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information 1) Catalog of adopted technology
Date of completion	20/02/2015

History of the proposed methodology

Version	Date	Contents revised
1.0	20/02/2015	Initial Edition

A. Title of the methodology

Rural electrification through Ultra Low Head Micro Hydro Power Generation and Photovoltaic Power Generation, Version 1.0

B. Terms and definitions

Terms	Definitions
Ultra Low Head Micro Hydro Power System (ULMH)	Ultra Low Head Micro Hydro Power refers to hydraulic power generation with generator's capacity of 25 kW or less and 5 m-or-shorter head.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	With no fossil resource-derived fuels involved in this generation process, the amount of greenhouse gases equivalent to those from substituted fossil fuels can be slashed.
Calculation of reference emissions	Reference emission is calculated by the amount of consumed electricity and emission factor of fossil fuel.
Calculation of project emissions	No emission in the project scenario considered.
Monitoring parameters	✓ The actual amount of electricity consumed by a whole community. ✓ The actual amount of electricity consumed by each facility (e.g. households, SMEs, public buildings). ✓ The number of facilities supplied with electricity by ULMH and/or Photovoltaic Power Generation (PV). ✓ Status of the electrification plan and/or policy of the national/local government, and of the actual implementation of electrification plan.

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	Electrification of a community achieved through the installation of newly installed ULMH and /or PV that displaces fossil fuel use, such as in fuel-based lighting systems and stand-alone power generators.
Criterion 2	The proposed project activity is a Greenfield project (i.e. a project newly established in previously undeveloped site) to install renewable energy generation systems such as ULMH and/or PV in the rural areas which can be considered not to be covered by the electrification through a national or regional grid taking into account status of the electrification plan and/or policy of the national/local government, and of the actual implementation of electrification plan.
Criterion 3	Each of the installed ULMH has 25kW-or -less power-generating capacity and the vertical distance between the surface of the water at upstream and the surface of the water at the downstream (head) is 5 m or shorter. ULMH can be installed in open channel (e.g. agricultural water channel, irrigation water channel, by-pass channel, etc).
Criterion 4	The power generation efficiency loss of the solar cell during the technical lifetime of 20 years shall be within 20 %. Furthermore, it can be guaranteed by the manufacturer of solar cell based on the performance of actual operation during more than 20 years.
Criterion 5	The solar cell installed shall comply with applicable international standards or comparable national, regional or local standards/guidelines.
Criterion 6	Calculation Method 1 is applied when the actual amount of electricity consumed by a whole community, which is supplied electricity by ULMH and/or PV, can only be measured. Calculation Method 2 is applied, when the actual amount of electricity consumed by each facility which is supplied electricity by ULHM and/or PV can be measured.

E. Emission Sources and GHG types

The emission sources include all the following GHG emission sources and GHG types.

Reference emissions	
Emission sources	GHG types
Fuel consumption by kerosene lamps	CO2
Fuel consumption by electricity generation	CO2
N/A	N/A

Project emissions	
Emission sources	GHG types
N/A	N/A
N/A	N/A
N/A	N/A

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

This methodology defines a reference scenario in accordance with the report of World Bank[11] and the meeting report at CDM SSC WG[12], which are used for justification of CDM methodology AMS I.L[13]. In a reference scenario, fossil fueled systems are used for electrification to meet minimum service level in a rural community. In Ethiopia and Kenya, because much percentages of rural community have not been electrified with national grid, most of rural areas are not electrified or electrified with fossil fuel generation system like diesel generator. Due to lack of financial support from government and of understanding of renewable energy among rural communities, few communities use renewable energy for electrification[14].

Calculation method 1 uses whole electricity consumption amount of a community. This electricity consumption amount should be measured separately from both electricity generation amount and electricity consumption amount of ballast load. Meanwhile, Calculation method 2 uses electricity consumption amount at each facility in a

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11 POYRY, August 2011, "Justification document for proposed new baseline methodology for electrification of rural communities"

12 CDM SSC WG Thirty fifth meeting, Annex5 Page1, "Rational for default factors used in the proposed methodology SSC-I.L.: Electrification of rural communities using renewable energy"

13 CDM methodology "AMS-I.L.: Electrification of rural communities using renewable energy --- Version 1.0"

14 Following sources describe current situation of electrification and renewable energy usage in these two countries:
<Ethiopia and Kenya>
World Bank, "Access of electricity"
http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
IEA, "World Energy Outlook 2013 – Electricity Access Database"
<Ethiopia>
Ministry of Water and Energy, June 22 2013,"Ethiopia's Renewable Energy Power Potential and Development Opportunities"
<Kenya>
Rural Electrification Authority website http://www.rea.co.ke/
Lighting Africa 2012, "Policy Report Note Kenya"

community. When reference emissions are calculated by calculation method 2, calculation process is divided into two parts, the first 55 kWh of electricity consumption and electricity consumption greater than 55 kWh.

F.2. Calculation of reference emissions

Calculation method 1

$$RE_y = EC_{com,y} \times EF_{diesel}$$

Where:

RE_y	Reference emissions in year y ($tCO2$)
$EC_{com,y}$	Total amount of electricity consumed by a whole community in year y (MWh)
EF_{diesel}	Emission factor for diesel generators, 1.0 ($tCO2/MWh$)

Calculation method 2

$$RE_y = RE_{55,y} + RE_{55plus,y}$$

Where:

RE_y	Reference emissions in year y ($tCO2$)
$RE_{55,y}$	Aggregate reference emissions for facilities that consumed equal to or less than 55 kWh of renewable electricity from ULMH and/or PV in year y ($tCO2$)
$RE_{55plus,y}$	Aggregate reference emissions for facilities that consumed greater than 55 kWh of renewable electricity from ULMH and/or PV in year y ($tCO2$)

For facilities that consumed equal to or less than 55 kWh, reference emissions are calculated as:

$$RE_{55,y} = \sum_{x}^{N} EC_{x,y} \times EF_{55}$$

Where:

$EC_{x,y}$	Electricity consumed at the facility *x*, where the electricity delivered to that facility is equal to or less than 55 kWh in year *y* (MWh)
EF_{55}	Emission factor for electricity consumption equal to or less than 55kWh, 6.8 (tCO_2/MWh)
X	Facility supplied with electricity from ULMH and/or PV consuming equal

to or less than 55 kWh in year y

N	Number of facilities in the project activity consuming equal to or less than 55 kWh/year

For facilities that consumed more than 55 kWh reference emissions are calculated as:

$$RE_{55plus,y} = \sum_{z}^{M}\left(\left(EC_{z,y} - 0.055\right) \times EF_{55plus} + C\right)$$

Where:

$EC_{z,y}$	Electricity consumed at the facility *z*, where the electricity delivered to that facility is greater than 55 kWh in year *y* (MWh)
EF_{55plus}	Emission factor for electricity consumption greater than 55kWh, 1.0 (tCO2/MWh)
Z	Facility supplied with electricity from ULMH and/or PV consuming more than 55 kWh in year y
C	CO2 emission amount from electricity consumption of the first 0.055 MWh at each facility (regarded as consumption for lamps), 0.374 (tCO2), a constant calculated as (0.055 MWh x 6.8 tCO2/MWh)
M	Number of facilities consuming electricity greater than 55 kWh/year

The status of the electrification plan and/or policy of the national/local government and actual status of the implementation of electrification plant are to be monitored annually. Once the rural community which is supplied electricity by the project activity is connected to the grid, reference emission would be zero.

G. Calculation of project emissions

Projects to which this methodology is applied are run-of-river type, which does not need reservoirs that may generate methane gas or involve activities emitting GHG within the project boundary. Thus project emissions are not estimated.

$$PE_y = 0$$

Where:

PE_y	Project emissions in year *y* (tCO_2/y)

H. Calculation of emissions reductions

Emission reductions are calculated as the difference between the reference emissions and project emissions, as follows.

$$ER_y = RE_y - PE_y$$

Where:

ER_y	Emission reductions in year y (tCO_2/y)
RE_y	Reference emissions in year y (tCO2)
PE_y	Project emissions in year y (tCO_2/y)

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
EF_{diesel}	Emission factor for diesel generators (tCO_2/MWh)	Default value: 1.0 Refer to the available value in Table 2 of the CDM Methodology, AMS-I.F "Renewable electricity generation for captive use and mini-grid" This parameter should be determined in accordance with the latest version of the above source during a project period.
EF_{55}	Emission factor for electricity consumption equal to or less than 55kWh (tCO_2/MWh)	Default value: 6.8 Refer to the available value of the CDM Methodology, AMS-I.L. "Electrification of rural communities using renewable energy". This parameter should be determined in accordance with the latest version of above source during a project period.

EF_{55plus}	Emission factor for electricity consumption greater than 55kWh (tCO_2/MWh)	Default value: 1.0 Refer to the available value in Table 2 of the CDM Methodology, AMS-I.F "Renewable electricity generation for captive use and mini-grid" This parameter should be determined in accordance with the latest version of the above source during a project period.
C	CO2 emission amount from electricity consumption of the first 0.055 MWh at each facility (tCO2)	Default value: 0.374 Refer to the available value of the CDM Methodology, AMS-I.L. "Electrification of rural communities using renewable energy". This parameter should be determined in accordance with the latest version of above source during a project period.

JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form	
Form for submitting the proposed methodology	
Host Country	Kenya
Name of the methodology proponents submitting this form	NTT DATA INSTITUTE OF MANAGEMENT CONSLUTING, Inc.
Sectoral scope(s) to which the Proposed Methodology applies	1. Energy industries
Title of the proposed methodology, and version number	Rural electrification by establishment of hybrid mini-grid system, Ver 1.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	09/02/2015

History of the proposed methodology

Version	Date	Contents revised
1.0	09/02/2015	First Edition

A. Title of the methodology

Electrification of rural communities by establishing hybrid mini-grid system Version 1.0

B. Terms and definitions

Terms	Definitions
Hybrid mini-grid system (HMS)	Small-scale power system with a total capacity from 100kW to 15MW (i.e. the sum of installed capacities of all electricity generating units connected to the mini-grid is more than 100 kW and not exceeding 15 MW), which is not connected to a national or a regional grid and supplies consumers in rural areas isolated from any national or regional grid with electricity by hybrid of fossil-based electricity generation and renewable-based electricity generation.
Consumer(s)	They are end-user(s)/facility(ies) that may include households; public buildings; and/or small, medium and micro enterprises (SMMEs).

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Establishment of HMS using both of fossil fuel and renewable energy.
Calculation of reference emissions	Reference emission is calculated by the amount of electricity supplied by HMS and emission factor of a national or a regional grid which would be connected to the rural community in the case that the project activity would not occur, or emission factor for diesel generator systems which would be used for the electrification of the rural community in the case that the project activity would not occur.
Calculation of project	Project emission is calculated by the amount of fossil fuel

emissions	consumption by HMS and emission factor of consumed fossil fuel.
Monitoring parameters	The following parameters are to be monitored: ✓ The amount of electricity supplied by the HMS; ✓ The amount of fossil fuel consumed by the HMS; ✓ Status of the electrification plan and/or policy of the national/local government, and of the actual implementation of electrification plan

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

Criterion 1	The proposed project activity aims at the electrification of a community achieved through the establishment of HMS that displaces fossil fuel use, e.g. fuel-based lighting systems and stand-alone fossil-based power generators. The renewable-based electricity is generated only by solar photovoltaic system without any battery.
Criterion 2	The proposed project activity is a Greenfield project (i.e. a project newly established in previously undeveloped site) of HMS.
Criterion 3	Both of fossil-based/renewable-based electricity generation systems employed by the project activity are intended for permanent installation and not for portable systems, such as portable diesel generators or LED lanterns.
Criterion 4	The power generation efficiency loss of the solar cell during the technical lifetime of 20 years shall be within 20%. Furthermore, it can be guaranteed by the manufacturer of solar cell based on the performance of actual operation during more than 20 years.
Criterion 5	The solar cell installed shall comply with applicable international standards or comparable national, regional or local standards/guidelines.
Criterion 6	Both of the total amount of electricity supplied to consumers by HMS and the amount of fossil fuel consumed by the HMS can be measured continuously.

E. Emission Sources and GHG types

The emission sources include all the following GHG emission sources and GHG types.

Reference emissions	
Emission sources	GHG types
Fuel consumption by the fossil-based electricity generation	CO_2
N/A	N/A
N/A	N/A
Project emissions	
Emission sources	GHG types
Fuel consumption by the fossil-based electricity generation	CO_2
N/A	N/A
N/A	N/A

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

It is assumed in the calculation of reference emissions that fossil-based electricity generation system are used for electrification to meet low service level in a rural community located at the areas isolated from national/regional grid, in the case that the project activity would not occur. In Kenya, because much percentages of rural community have not been electrified with national grid or regional grid, most of rural areas are not electrified or electrified with stand-alone fossil-based electricity generation system such as diesel generator. Due to lack of financial support from government and of understanding of renewable energy among rural communities, few communities use renewable energy for electrification[15].

In the case that the project activity would not occur, there would be two future scenarios for electrification, the first is the installation of stand-alone fossil-based electricity generation system such as diesel generator, the second is the connection to a national or regional grid. In fact the BaU scenario highly depends on the local situation, and can be established considering the electrification plan and/or policy of the

[15] Following sources describe current situation of electrification and renewable energy usage in these two countries:
World Bank, "Access of electricity"
http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS
IEA, "World Energy Outlook 2013 – Electricity Access Database"
Rural Electrification Authority website http://www.rea.co.ke/
Lighting Africa 2012, "Policy Report Note Kenya"

national/local government and actual status of the implementation of electrification plan.

This methodology contains two approaches to calculate the reference emission by the amount of electricity supplied by HMS and emission factor of a national or a regional grid or emission factor for diesel generator systems to be applied for the electrification of the rural community. However, for conservative approach, it is appropriate to apply the emission factor of a national or regional grid, which seems to be lower than the emission factor for diesel generator systems, especially in the case that BaU scenario is not clearly or there is the possibility of electrification by connecting to a national or regional grid.

F.2. Calculation of reference emissions

Considering the electrification plan and/or policy of the national/local government and actual status of the implementation of electrification plan, it can be determined whether the reference emission causes by consuming the electricity supplied through a national or regional grid or supplied by a diesel generator systems fossil-based electricity generation system.

If the electricity supplied through a national or regional grid would be consumed at the rural community to be electrified by the project activity, the reference emission is calculated as follows:

$$RE_y = EG_y \times EF_{EL,y}$$

Where:

RE_y	Reference emissions in year y [tCO2e/y]
EG_y	Amount of electricity supplied to consumers in rural areas isolated from national/regional grid by the HMS in year y [MWh/y]
$EF_{EL,y}$	Emission factor of the electricity supplied by a national or a regional grid to be likely to be connected to the rural area of the project activity in the case that the project activity would not occur [tCO2e/MWh]

If the electricity supplied by a diesel generator system would be consumed at the rural community to be electrified by the project activity, the reference emission is calculated as follows:

$$RE_y = EG_y \times EF_{diesel,y}$$

Where:

RE_y	Reference emissions in year y [tCO2e/y]
EG_y	Amount of electricity supplied to consumers in rural areas isolated from national/regional grid by the HMS in year y [MWh/y]
$EF_{diesel,y}$	Emission factor for diesel generator systems in the case that the project activity would not occur [tCO2e/ MWh]

The status of the electrification plan and/or policy of the national/local government and actual status of the implementation of electrification plan are to be monitored annually. And the most likely reference emission shall be calculated.

G. Calculation of project emissions

Projects to which this methodology is applied are HMS of hybrid of fossil-based electricity generation and renewable-based electricity generation.

Thus project emissions are estimated as follows:

$$PE_y = \sum_{i}^{n} (FC_{i,y} \times NCV_{i,y} \times EF_{i,y})$$

Where:

PE_y	Project emissions in year y [tCO2e/y]
$FC_{i,y}$	Amount of consumption of fossil fuel ***i*** within the HMS in year y [kl, t, 1000Nm^3/y]
$NCV_{i,y}$	Net calorific value of the fossil fuel ***i*** consumed by the HSM in year y [GJ/kl, t, 1000Nm^3]
$EF_{i,y}$	Emission factor of the fossil fuel ***i*** consumed by the HSM in year y [tCO2e/ GJ]

H. Calculation of emissions reductions

Emission reductions are calculated as the difference between the reference emissions and project emissions, as follows.

$$ER_y = RE_y - PE_y$$

Where:

ER_y	Emission reductions in year *y* (tCO_2/y)
RE_y	Reference emissions in year y (tCO2)

PE_y Project emissions in year y (tCO_2/y)

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* and to be monitored is listed as below.

Parameter	Description of data	Source
$EF_{EL,y}$	Emission factor of the electricity supplied by a national or a regional grid (tCO_2/MWh)	Calculated value using publicly available official statics data by the national or local government as per the valid version of CDM methodological tool, "Tool to calculate the emission factor for an electricity system" of CDM
$EF_{diesel,y}$	Emission factor for a diesel generator system in the case that the project activity would not occur [tCO2e/ MWh]	Default value: 0.8 Referring to the most lower value in Table 2 under the category AMS-I.F "Renewable electricity generation for captive use and mini-grid"
$NCV_{i,y}$	Net calorific value of the fossil fuel ***i*** consumed by the HSM (GJ/kl, t, 1000Nm^3)	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
$EF_{i,y}$	Emission factor of the fossil fuel ***i*** consumed by the HSM (tCO2e/ GJ)	IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG

		Inventories