

GCF Solar power project in Cambodia

Feasibility Study Report

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Mizuho Information & Research Institute

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1 Framework of the model project

Based on outcomes of the research, options and directions for utilization of GCF fund in the solar power generation project in Cambodia have been discussed.

There are several types of solar power generation project in Cambodia, such as mega-solar, roof-top, mini-grid, etc. In the discussion for this project, mega-solar and roof-top types are selected, assuming that the project is conducted by formulating a special purpose company (SPC), using GCF funds in the forms of grant and/or loan via two entities of the AEs depending on funding type (JICA for GCF grant and ADB for GCF grant and loan). Moreover, combination with other schemes are also considered, including JCM subsidy and profit-contribution scheme.

Specifically, the following combinations have been considered.

- [1-1] Mega-solar power plant via JICA (GCF grant)
- [1-1'] Mega-solar power plant via JICA (GCF grant) plus JCM subsidy
- [1-1''] Mega-solar power plant via JICA (GCF grant) with profit-contribution scheme
- [1-2] Mega-solar via ADB (GCF grant + GCF loan)
- [1-3] Mega-solar via JICA (GCF grant) plus ADB (GCF loan)
- [2] Roof-top solar project via ADB (GCF grant, GCF loan)

[1-1] Mega-solar power plant via JICA (GCF grant)

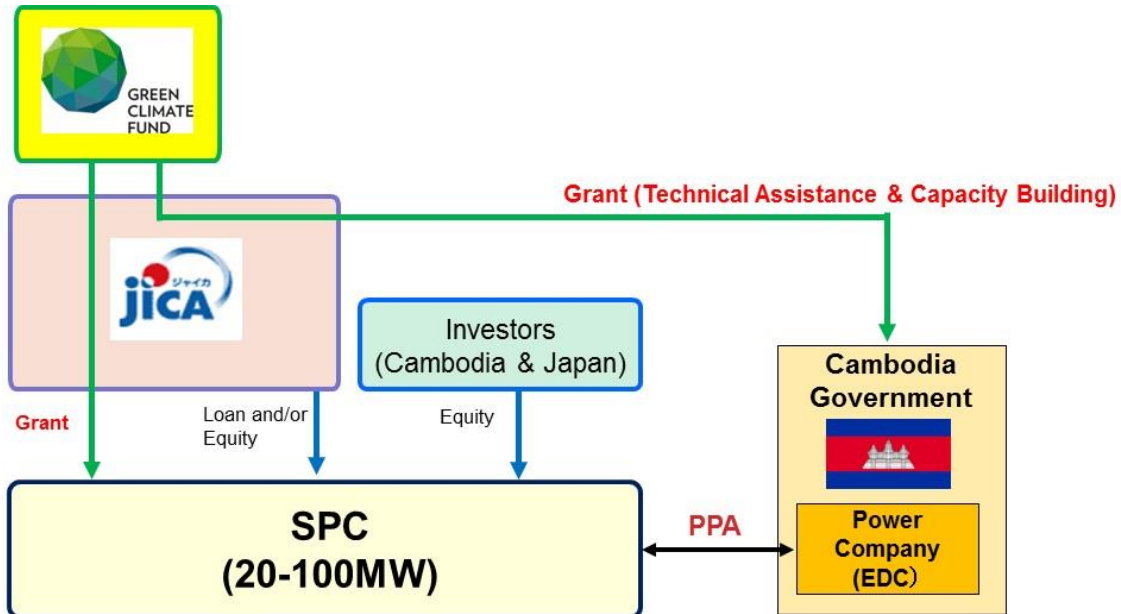


Figure 1 Project framework 1-1 (Mega-solar power plant via JICA (GCF grant))

- This type uses JICA's Private Sector Investment Finance along with GCF grant. (GCF grant is utilized for technical assistance and capacity building for Cambodian government.)
- A SPC for solar power business is established through investment from private sector. Electricity generated is sold to the EDC.
- Japanese companies will invest in the SPC, while JICA's Private Sector Investment Finance will be utilized.
- GCF fund (grant) will be utilized for the following purposes.
 - Provide technical assistance and capacity building on renewable energies and solar power generation will be provided to the electricity institutions in Cambodian government. (GCF grant).
 - ◇ In the interview with the GCF Secretariat, they mentioned that capacity building for Cambodian government in such manner is eligible to the GCF grant. GCF
 - ◇ JICA has set its policy on the use of GCF fund for scaling up and strengthening impact of JICA's cooperation activities. Therefore, using GCF fund to expand cooperation to Cambodia's energy institutions in such way is in line with JICA's policy. (This part may be covered by JICA's fund for technical cooperation to Cambodia. In such case, GCF fund will not be used.)
 - Utilize the GCF fund to compensate price gap in solar power project (difference in initial cost for investment that uses better quality of solar panels.) (GCF grant)

- ✧ “Utilization of advanced technology” is one of the priority areas of JICA’s policy on the use of GCF fund, assuming to use GCF grant into additional cost of climate actions (such as additional cost for using BAT to GHG emission reductions). The way to use GCF grant in this project type is in line with JICA’s policy.
- ✧ It should be noted that, even if covered by JICA’s Private Sector Investment Finance, the project using GCF fund, which is to be provided to the same SPC, is subject to GCF procurement rule which requires to hold international competitive bidding. Therefore, in such case, it would need to restrict technological specification in the funding proposal to the GCF (by limiting performance of solar panel that keeps power generation efficiency even in high-temperature conditions, etc.) in order to facilitate application of Japanese technologies in an appropriate manner.

[1-1'] Mega-solar power plant via JICA (GCF grant) plus JCM subsidy

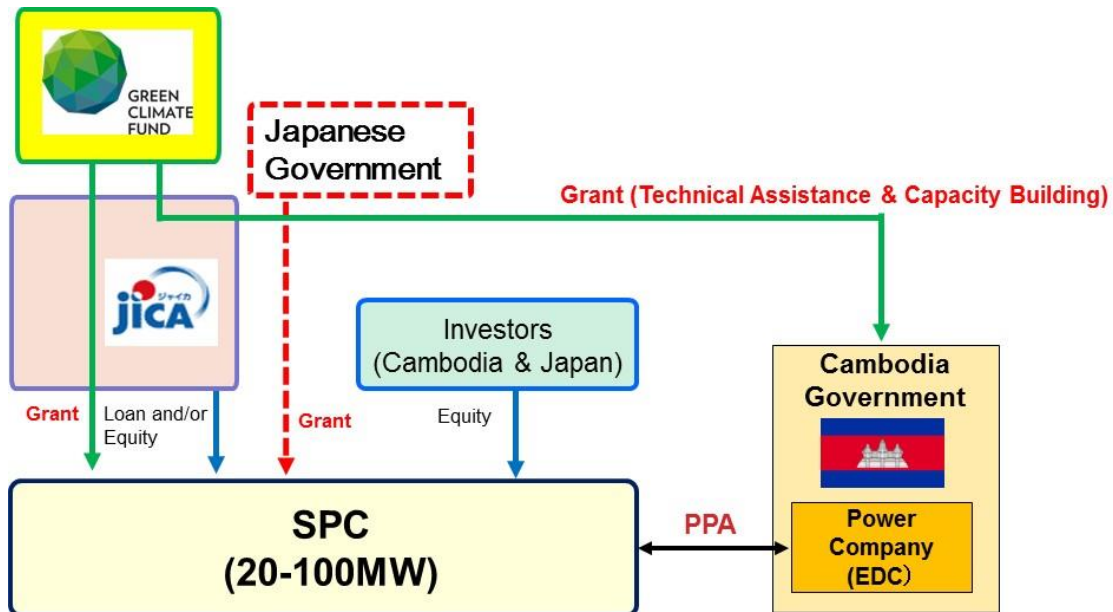


Figure 2 Project framework 1-1' (Mega-solar power plant via JICA (GCF grant) plus JCM subsidy)

- This type is derived form of [1-1], along with JCM subsidy that covers a half of capital investment.
- In the interview with the GCF Secretariat, it mentioned that an explanation would be required in the funding proposal to clarify why the project would need GCF fund besides other schemes such as JCM in a way “the project cannot be operated with JCM subsidy alone.” In addition, they emphasized a project using GCF fund must follow procurement policy of GCF and AEs.
- As with [1-1], it would need to restrict technological specification in the funding proposal to the GCF (by limiting performance of solar panel that keeps power generation efficiency even in high-temperature conditions, etc.) in order to facilitate application of Japanese technologies in an appropriate manner.

[1-1"] Mega-solar power plant via JICA (GCF grant) with profit-contribution scheme

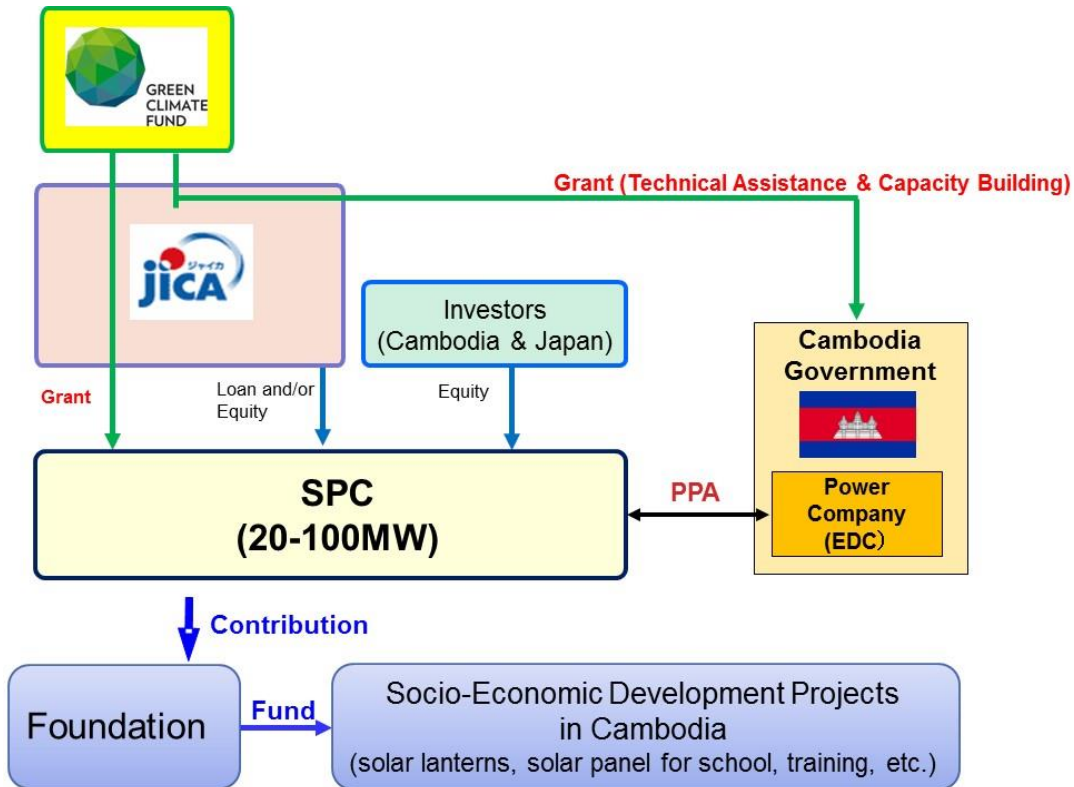


Figure 3 Project framework 1-1" (Mega-solar power plant via JICA (GCF grant) with profit-contribution scheme)

- This type is derived form of [1-1], adding a system to contribute a part of profit of solar power project.
- Profit contribution are used for introduction of solar power system in the government and public institutions (schools, hospitals, etc.) through financial assistance and personnel trainings. For selection of board members of the SPC that administers the fund, investors to SPC or borrowers are also included for a sound management of the fund.
- Profit contribution may also cover technologies that support adaptation to climate change such as solar lanterns. By doing so, this project may have a dual aspect of mitigation and adaptation.
- Such profit contribution scheme is included in "Water Sector Resilience Nexus for Sustainability in Barbados (WSRN S-Barbados)," approved in the 19th GCF Board in March 2018. (Note that profit sources of the WSRN S-Barbados is the cross-cutting project of "installation of stable power sources for well pumping (that uses PV and micro gas turbine) and sales of excess electricity from solar power, not a single-purpose mitigation project. Moreover, the AE of the WSRN S-Barbados is a Bajan entity (direct

access).

- In the meantime, in order to realize this scheme, it needs to create a new scheme in Cambodia in a different approach from the ADB's bidding process, which would require more works in operators and Cambodian government. This will depend on balances between how much fund would be provided by the GCF and how much cost would be needed for creating the scheme.

[1-2] Mega-solar via ADB (GCF grant + GCF loan)

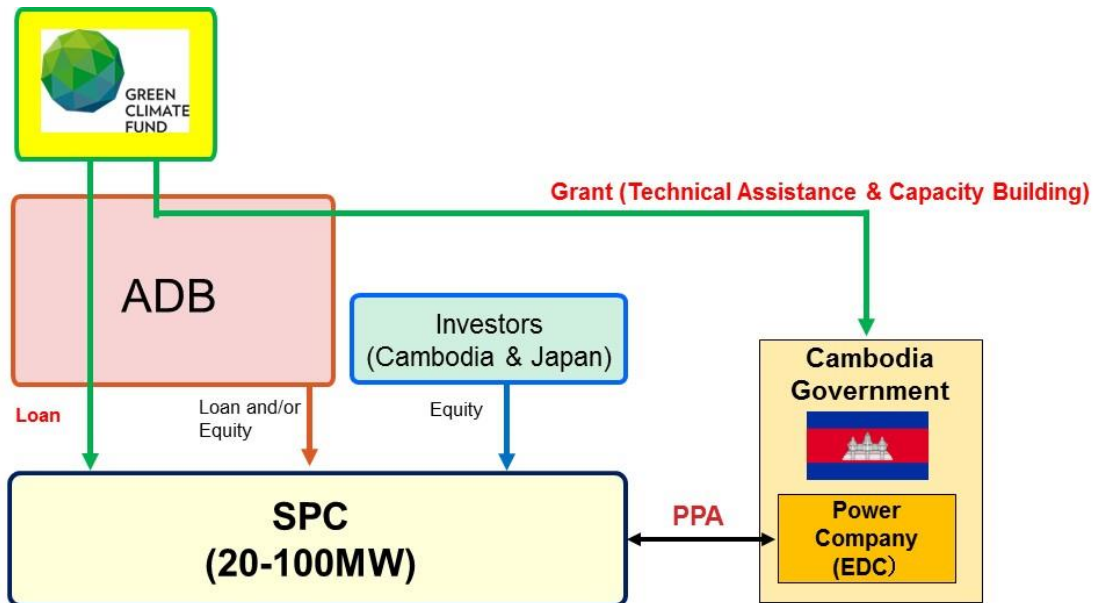


Figure 4 Project framework 1-2 (Mega-solar via ADB (GCF grant + GCF loan))

- This type uses GCF loan for a mega-solar plant via ADB. (GCF grant is also utilized for technical assistance and capacity building to Cambodian government in parallel with the loan.) For the SPC, ADB's investment and loan scheme covers.
- GCF fund (grant, loan) will be utilized for the following purposes.
 - Provide technical assistance and capacity building on renewable energies and solar power generation will be provided to the electricity institutions in Cambodian government. (GCF grant).
 - ✧ In the interview with the GCF Secretariat, they mentioned that capacity building for Cambodian government in such manner is eligible to the GCF grant.
 - ✧ ADB has set its policy on the use of GCF loan and grant in the project to which ADB provides its loan, in clean energy areas such as renewable energies, energy savings, urban construction, transport, etc. Therefore, using GCF fund to expand cooperation to Cambodia's energy institutions in such way is in line with ADB's policy. (This part may be covered by ADB's fund for technical cooperation to Cambodia. In such case, GCF fund will not be used.)
 - Low-interest loan to the solar-power SPC (GCF loan)
 - ✧ As mentioned above, ADB has set a policy on the use of GCF loan and grant in the projects to which ADB provides its loan, in clean energy areas such as renewable energies, energy savings, urban construction, transport, etc.

Therefore, using GCF fund is in line with ADB's policy.

[1-3] Mega-solar via JICA (GCF grant) plus ADB (GCF loan)

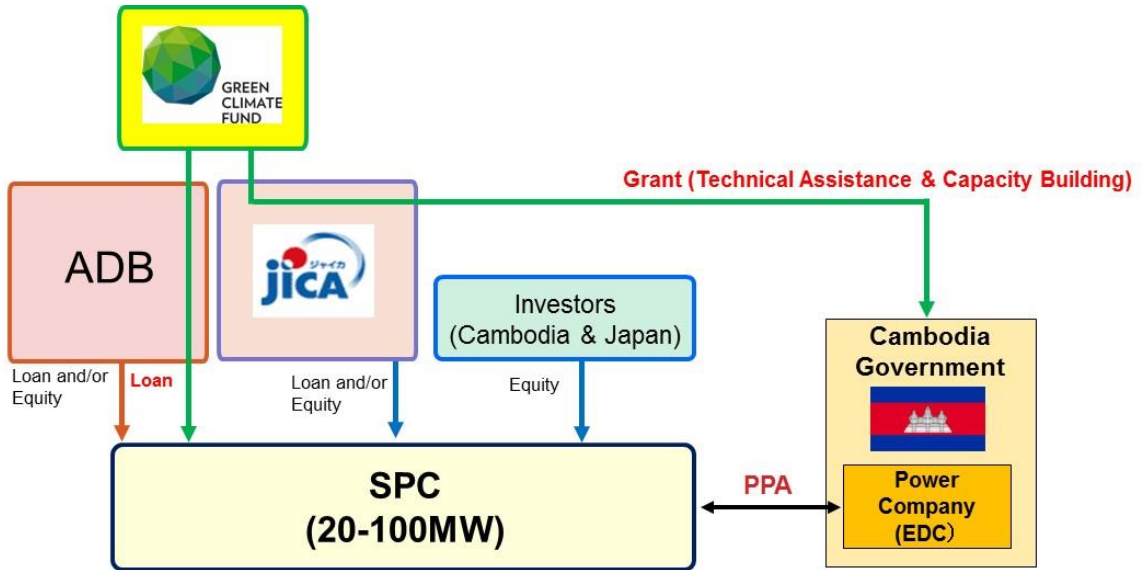


Figure 5 Project framework 1-3 (Mega-solar via JICA (GCF grant) plus ADB (GCF loan))

- This type uses JICA's Private Sector Investment Finance and GCF loan for a mega-solar plant. (GCF grant is also utilized for technical assistance and capacity building to Cambodian government in parallel with the loan.)
- JICA does not cover to provide GCF loan. For using GCF loan along with JICA's Private Sector Investment Finance, the project can be operated with a combination of more than one AE. (If there is a direct access AE (eligible for GCF loan) in Cambodia, GCF loan can be provided from such entity instead of ADB. However, selection of local banks for direct access is at a screening stage.)
- As described above, more than one AE may participate in a single project for the use of GCF fund as an option. However, it should be noted that such type of project would take more time to proceed as more coordination would be needed between related parties at each stage.

[2] Roof-top solar project via ADB (GCF grant, GCF loan)

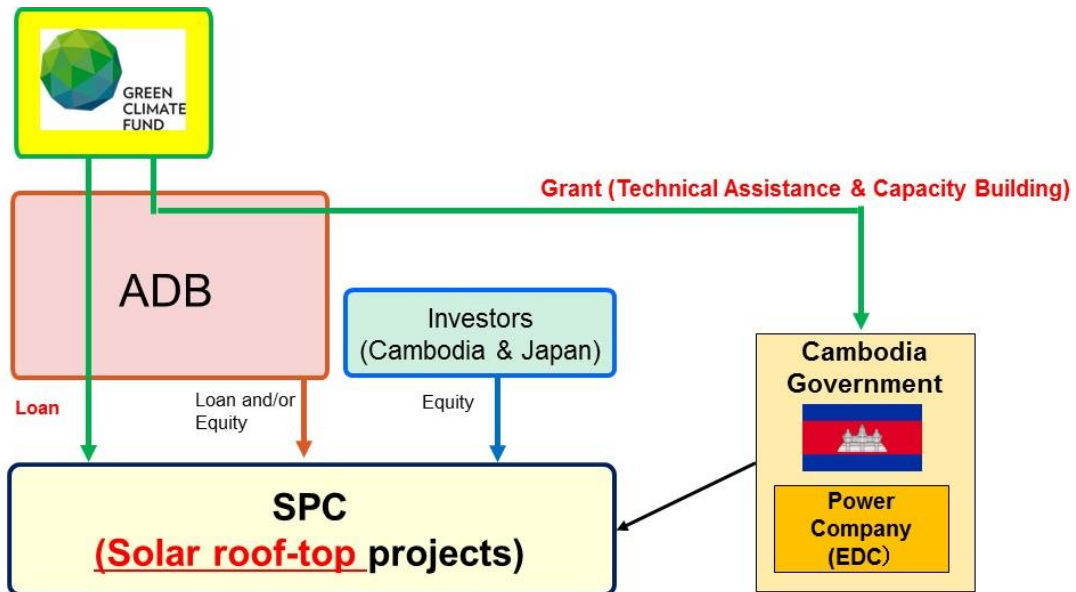


Figure 6 Project framework 2 (Roof-top solar project via ADB (GCF grant, GCF loan))

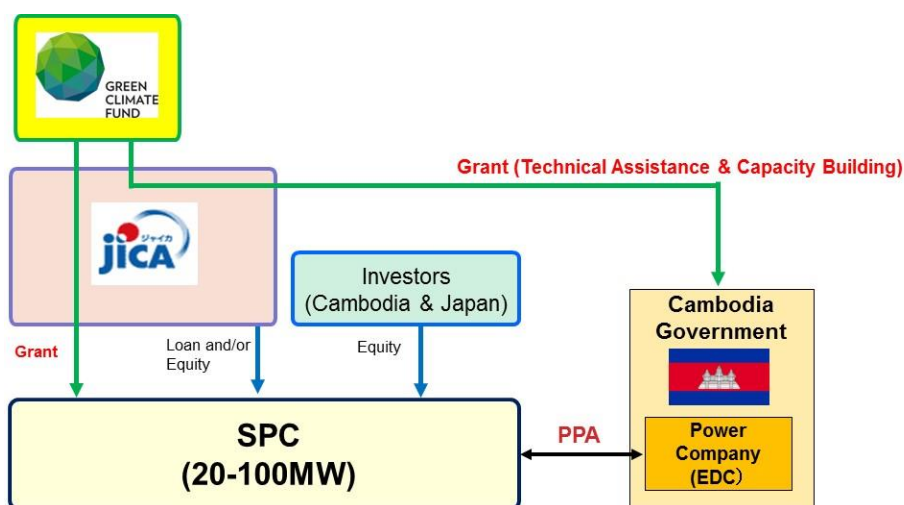
- This type uses GCF loan for a roof-top solar facilities via ADB.
- Solar panels for a self-consumption purpose are installed on roofs of plants located in Phnom Penh Special Economic Zone, etc.
- A precedent example of this type is those introduced by Coca Cola Co.
- According to hearings to the EAC, solar roof-top is currently not subject to regulation as long as it is for a self-consumption purpose.
- For the use of GCF fund, it needs to consider how to bundle small-scale roof-top projects.
- A precedent case of roof-top solar project is the proposal from India, which was approved by the GCF Board in its 19th meeting in March 2018, consisted with low-interest loan for installation of household roof-top solar panels.

2 Response to the GCF Requirement

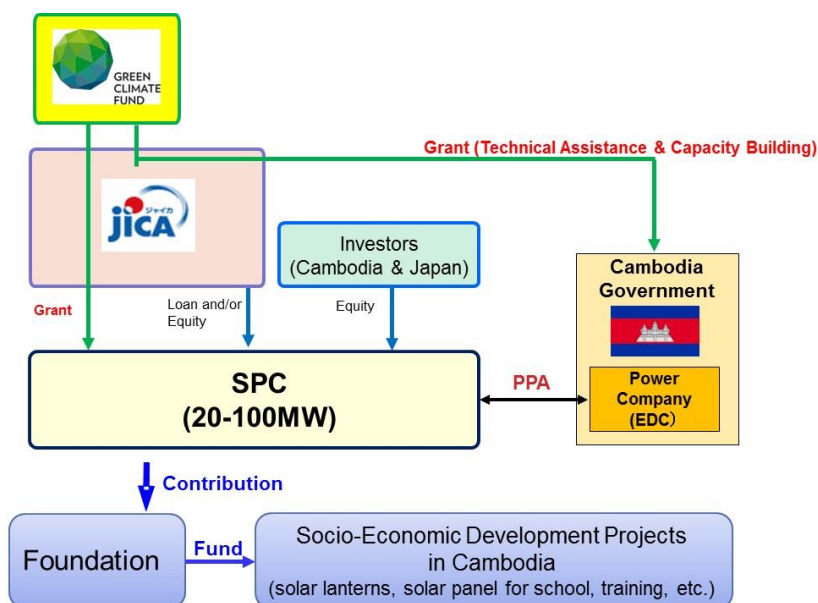
Among the project frameworks as described in the previous section, we made further consideration on schemes for the use of GCF fund, setting JICA as the AE from the viewpoint of accessibility for Japanese companies (in the forms of mega solar project via JICA (with GCF grant), with/without a profit-contribution scheme), taking into account GCF's investment guideline.

Project framework for consideration of how to respond to GCF requirement

[1-1] Mega-solar power generation via JICA (GCF grant)



[1-1'] Mega-solar power generation via JICA (GCF grant), with profit-contribution scheme



2.1 Impact potential (incl. potential for CO2 emission reductions)

In this project, construction of a mega-solar power plant and transmission of electricity generated from solar power to the grid will reduce CO2 emissions from grid power generation.

According to the literatures, average solar radiation in the suburb of Phnom Penh is estimated at approx. 6.2[kWh/m²/day]. Assuming a total design factor of PV system as 0.8 (upper value in the NEDO's guidance for introduction of mega-solar PV systems), a mega-solar power plant (20-100MW) can generate approx. 36[GWh/y] and 181[GWh/y] for 20MW and 100MW systems, respectively.

In Cambodia, CO2 emission factors of grid electricity are 0.2339[t-CO₂/MWh] for operating margin and 0.5338[t-CO₂/MWh] for build margin (Source: IGES List of Grid Emission Factors). Therefore, CO2 emission reductions in this project can be estimated at the range of approx. 8,500[t-CO₂/y] (operating margin) to 19,000[t-CO₂/y] (build margin) for 20MW of installed capacity, and from approx. 42,000[t-CO₂/y] (operating margin) to 97,000[t-CO₂/y] (build margin) for 100MW ones. As Cambodia seeks to reduce greenhouse gas emissions from energy sector by 1.8M[t-CO₂/y], as stated in its INDC, emission reductions from this mega-solar power generation project is equivalent to up to 5% of the target value.

Calumative emission reductions for 20 years of project period can be estimated at up to 1.9M[t-CO₂] (100MW installed capacity, build margin).

Meanwhile, this project will also benefit many Cambodians in terms of adaptation by providing goods and products that help adaptation efforts such as solar lanterns through the profit-contribution scheme.

2.2 Paradigm shift potential

2.2.1 Potential for scaling up and replication, and its overall contribution to global low-carbon development pathways being consistent with a temperature increase of less than 2 degrees Celsius (mitigation only)

The solar power generation in this project will adopt highly efficient, compact solar panels that keeps a certain level of performance even in high-temperature conditions in which power

output goes lower than planned. Such property, with lower risks in power generation efficiency, will make solar power reliable power source in Cambodia. Moreover, by demonstrating its advantages and stabilities in this project, the solar panels, the first of its kind in Cambodia, may attract neighboring ASEAN countries where temperature remains high enough to deteriorate power generation efficiency from conventional solar PV system.

Moreover, the profit-contribution scheme can also be conducted in other developing countries with a good prospect for expansion of solar power generation, utilizing experiences in program designing of this project.

2.2.2 Potential for knowledge and learning

In Cambodia, where electricity demand surges as its economy grows, there are increasing number of power development plans that uses coal in new facilities. In order to lead Cambodia to a lower-carbon economy, it needs to promote renewable energy sources such as solar PV, not later but now, instead of coal-fired power generation.

Currently, solar PV technology in Cambodia is still at development stages. For mega-solar power generation, a pilot project is conducted with assistance of the ADB and based on its results further consideration will be given. For roof-top solar system, program design is underway to determine direction of regulation, etc.. Meanwhile, in the EAC (regulatory authority) and the EDC (power company), there is shortage in knowledge and manpower, despite both are crucial elements to promote solar power generation. (Here is an underlying problem: few knowledge and experience in power generation projects have been accumulated in EAC and EDC as power generation in Cambodia is conducted by IPPs and as the result such system keeps the government organizations away from the business front. Besides, an ongoing program supported by the ADB does not include technical assistance such as capacity building to Cambodian government.)

In this regard, it is important to help Cambodia strengthen its government institutions through technical assistance and capacity building, to be conducted in this project. In doing so, as a part of training, it is preferable to provide information related to this project, sorted in a handout material. The information may include efficiency of solar panels, risks of deteriorating efficiency under high temperature conditions, technologies to respond to such property, actual examples of specific solar panels introduced in other developing countries,

etc..

Moreover, along with distribution of solar-powered devices such as solar lanterns in the profit-contribution scheme, trainings of how to use them can be provided in order to input appropriate knowledges on electricity and solar PV to the general public as final consumers. Such activities will create an environment where solar-powered devices will be widely used in an appropriate manner even after implementation period of this project is over.

2.2.3 Contribution to the creation of an enabling environment

This project will help Cambodia strengthen governmental institutions through technical assistances and capacity building as planned, with an aim to improve regulatory frameworks which accelerates investment from private sector and eventually leads to rapid expansion of utilization of renewable energies such as solar power generation in Cambodia.

Moreover, this project uses specific solar panels that keep stable performance under high-temperature conditions and is conducted by a reliable business operator with abundant experiences in renewable energy projects in other countries. As one of the first examples of solar power generation in Cambodia, the project will be implemented in such trustworthy way, which will raise reputation of Cambodia's solar PV market and promote further investment from private sector in the future.

2.2.4 Contribution to the regulatory framework and policies

On the policy front, differences in performance of solar power generation systems is one of the most outstanding features in this project: specifically, the one to be used in this project keeps better performance even in high-temperature conditions compared to conventional ones, which will be emphasized through technical assistance and capacity building. In addition, this project will also encourage the government to improve business climate by introducing such as criteria for efficiency performance of the systems under high-temperature conditions.

2.3 Sustainable development potential

Once the mega-solar power plant is developed in this project and launches transmission to the grid, environmental burden associated with generating grid electricity in coal-fired

facilities will be lowered. Specifically, coal-fired power plants generate gases containing air pollutants such as SO_x, NO_x and other particles. Solar power plant is free from emissions of such gases.

In general, renewable energies can contribute to sustainable development in the world. However, along with its dissemination, there are concerns that land use changes associated with renewable energies may cause severe problems in the future. Even for solar power generation, if solar panels are placed in a cropland it may conflict with food production, or if placed in a field with abundant nature it may give adverse effects to local ecosystems. In contrast, this project will adopt high-efficient, compact solar panels that keep power generation efficiency even in high-temperature conditions, with space-saving feature. Therefore, this solar PV system will minimize the trade-off issues of land-use change associated with renewable energy utilization and contribute to sustainable development in a more effective way.

Furthermore, in addition to the mega-solar power generation project, the profit-contribution scheme is incorporated to distribute solar-powered devices such as solar lanterns while providing trainings on how to use them, which is in line with the United Nation's Sustainable Development Goals (SDGs): Goal 7 of "Ensure access to affordable, reliable, sustainable and modern energy for all."

2.4 Needs of the recipient (necessity for GCF's finance)

2.4.1 Economic and social development level of the country and the affected population

Despite some progresses in poverty eradication and economic growth in recent years, Cambodia still remains in the poorest country in ASEAN region. (Cambodia's per capita GNI is 1,070 dollars; classified as the least developed countries in the OECD DAC list and as ii/lower middle income country in the World Bank's grouping). In such least developed countries, climate-related policies tend to be set aside at lower priority compared to other policy agenda. Moreover, amid rising demand in electricity and urgent needs for supply expansion, fossil fuels would be an easier option to expand power generation capacities, which is more likely to happen. Therefore, in order to avoid such unsustainable cycle, it needs to help Cambodia get on track to low carbon economy by utilizing GCF's fund focusing on climate actions.

A severe fact of this county is scarcity of human resources as a result of the civil war in the past, which has emerged as more serious problem in many fields and sectors in this country. Capacity building to government organizations planed in this project is designed to supplement such shortage in human resources, assuming that the outcome will widely be back and contributed to the society.

Furthermore, in addition to the mega-solar power generation project, the profit-contribution scheme is incorporated to distribute solar-powered devices such as solar lanterns while providing trainings on how to use them, which will contribute to strengthen resilience to climate change in communities in off-grid areas.

2.4.2 Absence of alternative sources of financing

The solar panels to be used in this project, as the first of its kind in Cambodia, tends to be more expensive than conventional ones, reflecting differences in power generation efficiency even in high-temperature conditions as well as its space-saving feature. However, in the scheme planned under ADB's assistance, electricity generated from solar energy must be purchased through auctions by the IPP, which means that it does not evaluate positive effects of this project, such as high-performance solar panels that reduce risks from land-use change at an earlier stage. Moreover, in Cambodia, there is no financial assistance programs nor subsidies that may promote high-performance solar panels.

2.4.3 Need for strengthening institutions and implementation capacity

The ADB conducts an assistance program that promotes introduction of solar power generation in Cambodia, but it does not cover technical assistance such as capacity building to the government. In the JICA's program also does not cover trainings to human resources on renewable energies so far. Therefore, despite a certain needs exists in the government, there is no other public financing scheme that supports capacity building to the government.

2.5 Country ownership

2.5.1 Coherence with existing policies

The Government of Cambodia states in the INDC that grid-connected renewable energy

power generation is one of the major options and that it intends to cut CO2 emissions from energy sector by 1.8Mt-CO2 by 2030 (16% reduction compared to BAU). In a hearing survey to Cambodia's Ministry of Environment (MoE), they assured that renewable energy is one of the priority areas in terms of mitigation.

Regarding policies on how to use GCF funds, Cambodia's MoE mentioned that they do not intend to propose more than one mega-solar project to the GCF and therefore a coordination would be necessary between candidate operators if there are several companies. In this regard, however, we have confirmed that there is no other operators that consider a proposal of mega-solar power project to the GCF, including UNDP's project that is not mega-solar one.

2.5.2 Capacity of accredited entities or executing entities to deliver

This project assumes JICA as the AE, and there is no problem in its implementation capacity. For implementation entity, this project assume a special-purpose company (SPC). We consider that Panasonic Eco Solutions Malaysia, which has experiences in formulation of and assistance to SPCs for solar power project in other Asian countries, is eligible to formulate a SPC in Cambodia, too, with full capacities as an implementation entity of this project.

2.5.3 Engagement with civil society organizations and other relevant stakeholders

For implementation of this solar power generation project, we plan to hold opportunities such as stakeholder meetings in an appropriate manner. In the profit-contribution scheme, explanatory sessions would be needed for instruction on how to use solar-powered devices such as solar lanterns, with participation by civil societies, as necessary.

2.6 Efficiency and effectiveness

2.6.1 Cost-effectiveness and efficiency regarding financial and non-financial aspects

In the proposal for GCF funds, besides financial validity, appropriateness of concessionality is evaluated as one of the investment criteria. In this regard, for example,

funding proposal may cover price gap only between high-efficient panel and conventional one, instead of entire cost of high-efficient solar panels, which can be explained as a request for assistance to an additional cost for a climate action.

2.6.2 Amount of cofinancing

This project intends to formulate a special-purpose company (SPC) through investment from private sector. Funding by the GCF is expected to call for investment from private sector as well as overseas investment and loan scheme from JICA (assumed as the AE).

2.6.3 Industry best practices

For more effective use of the GCF finance, it is important to adopt BAT and best practices. In this project, taking into consideration local climate conditions, using solar panels that keeps high performance under high-temperature conditions would be advantageous.

3 Consideration on a system that promotes introduction of Japan's technologies

In the application form of funding proposal to the GCF, there is a section to describe technologies adopted in the proposal, and the way to fill out this section can be a key to determine whether to promote Japan's technologies in solar power generation projects that intend to use GCF fund. For this project, along with description on technologies adopted, it may give a provision or technological specification in order to use nothing but this technology, namely the solar PV panels that keeps a certain level of efficiency in power generation under a high-temperature conditions in Cambodia.

Moreover, beyond the solar power project that use GCF fund, a system to promote autonomous introduction of Japan's technologies in Cambodia may include providing capacity building to the government and establishing technological criteria. Specifically, in the capacity building to be provided to Cambodia's electricity authority EAC and national electricity operator EDC, it may be worthwhile to consider approaches such as calling attention to differences in power generation efficiency in a high-temperature conditions, while encouraging them to establish criteria for power generation efficiency in a high-temperature conditions.

In conclusion, this project plans that the technology of solar panels that keeps efficiency performance in high-temperature conditions is adopted in a GCF-funded solar project and receives a high evaluation. Accordingly, providing capacity building to Cambodian government and/or establishing technological criteria are also be conducted. It is important to seek establishing a system that promotes Japan's advanced technologies in various solar projects in the future subsequent to GCF-funded ones.