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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

UNIDO OFFICE FOR INDEPENDENT EVALUATION

Independent Terminal Evaluation

UNIDO Project Number: XX/CMB/12/X02
SAP No. 120047

ACCESS TO CLEAN ENERGY FOR PRODUCTIVE USES IN CAMBODIA

FINAL REPORT

Brahmanand Mohanty
International Evaluation Expert

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna

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Project Managers: Mr. Jossy Thomas and Ms. Tonilyn Lim

International Evaluation Expert: Dr. Brahmanand Mohanty

The international evaluation expert engaged to undertake the terminal evaluation of the UNIDO GEF project “Access to Clean Energy for Productive Uses in Cambodia” would like to acknowledge and thank all partners and counterparts who spared their time during the field mission and contributed to the evaluation.

Special thanks are due to the staff at UNIDO Headquarters, UNIDO Office as well as the project implementation team in Cambodia for their precious time, support and the facilitation of the logistics during the first evaluation mission conducted in Cambodia from 10 to 16 January 2016 and the follow-up short mission conducted early June 2016.

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ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
AFD	French Development Agency (Agence Française de Développement)
BCS	Battery charging station
CKN	Kram Ngoy Center (Centre Kram Ngoy)
CSO	Civil society organization
EAC	Electricity Authority of Cambodia
EDC	Electricity of Cambodia (Electricité de Cambodge)
GHG	Greenhouse gas
ITC	Institute of Technology of Cambodia (Institut Technologie de Cambodge)
KOICA	Korea International Cooperation Agency
LFA	Logical Framework Matrix
MDG	Millennium Development Goal
MFI	Micro Finance Institution
MIH	Ministry of Industry and Handicrafts
MIME	Ministry of Industry Mines and Energy
MME	Ministry of Mines and Energy
NGO	Non-governmental organization
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PSC	Project Steering Committee
REAP	Renewable Energy Action Plan
REE	Rural Energy Enterprise
SBCS	Solar battery charging station
SME	Small and medium enterprises
SNV	Netherlands Development Organization
TERI	The Energy and Resources Institute (India)
UNIDO	United Nations Industrial Development Organization
WB	World Bank

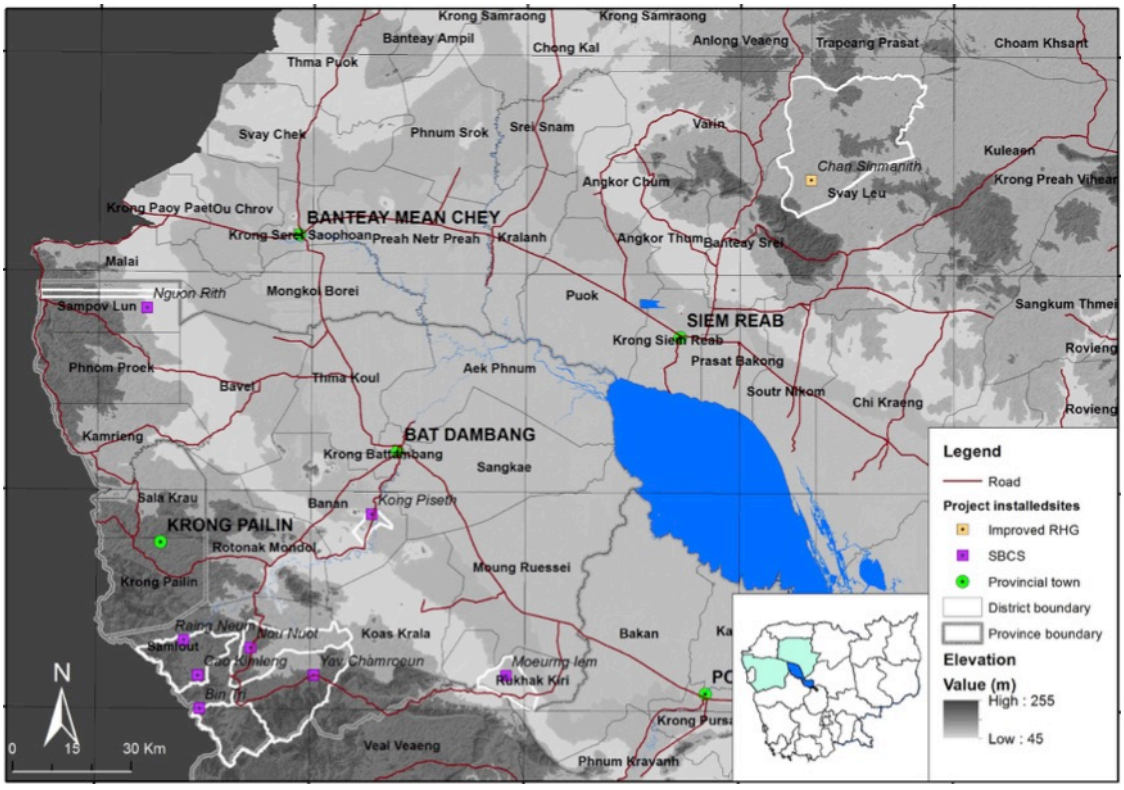
GLOSSARY OF EVALUATION-RELATED TERMS

Term	Definition
Baseline	The situation, prior to an intervention, against which progress can be assessed.
Effect	Intended or unintended change due directly or indirectly to an intervention.
Effectiveness	The extent to which the development intervention's objectives were achieved, or are expected to be achieved.
Efficiency	A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results.
Impact	Positive and negative, intended and non-intended, directly and indirectly, long term effects produced by a development intervention.
Indicator	Quantitative or qualitative factors that provide a means to measure the changes caused by an intervention.
Lessons learned	Generalizations based on evaluation experiences that abstract from the specific circumstances to broader situations.
Logframe (logical framework approach)	Management tool used to facilitate the planning, implementation and evaluation of an intervention. It involves identifying strategic elements (activities, outputs, outcome, impact) and their causal relationships, indicators, and assumptions that may affect success or failure. Based on RBM (results based management) principles.
Outcome	The likely or achieved (short-term and/or medium-term) effects of an intervention's outputs.
Outputs	The products, capital goods and services which result from an intervention; may also include changes resulting from the intervention which are relevant to the achievement of outcomes.
Relevance	The extent to which the objectives of an intervention are consistent with beneficiaries' requirements, country needs, global priorities and partners' and donor's policies.
Risks	Factors, normally outside the scope of an intervention, which may affect the achievement of an intervention's objectives.
Sustainability	The continuation of benefits from an intervention, after the development assistance has been completed.
Target groups	The specific individuals or organizations for whose benefit an intervention is undertaken.

PROJECT FACTSHEET

Project Title	**Access to clean energy for productive uses in Cambodia**
UNIDO project No. and/or SAP ID	**SAP ID: 120047**
Thematic Area Code	**EAE and EC33**
Country	**Cambodia**
Project sites	**Batambong and Pursat provinces**
Implementing agency	**UNIDO**
Implementing partner	**Ministry of Industry, Mines and Energy**
Project implementation start date	**1 January 2013**
Project duration	**24 months**
Total project cost (in Euros)	**500,000 Euros**
UNIDO inputs (in Euros)	**442,478**
Support costs (in Euros)	**57,522**
Counterpart inputs	**In-kind**
Terminal evaluation date	**January 2016**

MAP OF CAMBODIA AND THE PROJECT SITES



EXECUTIVE SUMMARY

The project entitled “Access to clean energy for productive uses in Cambodia” (Project Number: XX/CMB/12/X02 – SAP No. 120047) was initiated in January 2013 by UNIDO with financial support from the French Trust Fund with the objective to contribute to the vision of rural electrification of the Government of Cambodia by increasing access to clean energy for productive uses in selected off-grid areas of Cambodia, notably in the provinces of Batambong and Pursat. Activities were undertaken to achieve the following outputs: (1) Enhance capacity of selected institutions and gasifier manufacturers; (2) Install 5 Solar Battery Charging Stations (SBCSs) with various charging capacities in the off-grid communities of Battambang and Pursat provinces; and (3) Learn lesson and disseminate information.

As specified in the project document, an evaluation was carried out to assess the project performance in terms of its relevance, effectiveness and efficiency, and to determine outcomes and impacts (actual and potential) stemming from the project, including their sustainability. The two primary purposes were: (a) To provide evidence of results to meet accountability requirements, and (b) To promote learning, feedback, and knowledge sharing through results and lessons learned between UNIDO and its partners. The project has been able to exceed its initial target of installing 5 SBCSs in off-grid communities of Battambang and Pursat provinces. However, activities to achieve two of the important Outputs 1 and 3 have not been concluded, mainly due to the substantial delay in commissioning of the improved gasifier employing dry gas treatment technology. It is therefore too early to conclude the impacts of these outputs and their sustainability at this stage.

Nevertheless, based on the information available and the field missions carried out in January and early June 2016, this evaluation has attempted to assess the project using a set of criteria that include design, relevance, effectiveness, efficiency, sustainability, monitoring and evaluation, processes affecting the achievement of project results and gender mainstreaming. These are briefly presented along with some conclusions and recommendations.

Project Design: The project document has not been formulated based on the logical framework, hence there are inconsistencies between the project description and the logical framework. The project impact is inappropriately considered as the promotion of renewable energy for productive uses; the verifiable indicators mentioned in the logframe are not suitable to measure the effectiveness of the outcome. The main focus of the project is to enhance access to energy for productive uses but no

activities are proposed to either study what could be the possible productive uses or to conduct survey to learn the extent to which access to energy has led to its productive uses. Moreover, the project document has not dealt with the issue of how the project initiatives can be scaled up sustainably.

Relevance: The project is relevant to the national development and environmental priorities and strategies of the government and the population. The project's targets are the people at the base of the pyramid, local manufacturers/suppliers of biomass gasifiers and the government and other stakeholders who can learn from the project and scale up the efforts to enhance access to a vast population living without access to grid quality electricity. The project is also in line with UNIDO's mandate of promoting and accelerating inclusive and sustainable industrial development, and fostering innovation while safeguarding the environment.

Effectiveness: Compared to the target of setting up 5 SBCSs, the project has succeeded in installing 8 SBCSs. However the claims of the numbers of households served as well as the amount of diesel saved by the project are refutable. While the project's intention of favoring South-South cooperation to enhance the capacity of selected local institutions and gasifier manufacturers is noteworthy, the import of technology has not provided an active platform for hands-on training and local capacity building. As mentioned, it is too early to conclude on the technology that has been transferred as the gasifier is yet to be commissioned; similarly, the project has yet to disseminate information and provide policy direction to the institutional stakeholders for scaling up access to energy for productive uses in Cambodia.

Efficiency: In the absence of any financial data shared by the project, it is not possible to assess the project efficiency in terms of what was budgeted for and what were the actual expenditures for the different budget lines. However, the delay in project execution by more than 1.5 years does not seem to have led to any budget constraints. The main cause of the delay has been the fabrication, installation and commissioning of the improved gasifier system.

Sustainability: Based on the evaluation, the sustainability of the project initiatives is compromised due to the absence of suitable business models. The model adopted for the SBCSs neither provides a sustainable solution to the potential beneficiaries in the villages nor does it propose suitable clean energy alternatives to mobilize the huge finances needed to benefit several hundred villages that will not have access to grid electricity for the next one or two decades. Similarly, no efforts have been made to showcase the techno-economic viability of the improved gasification system developed by the project as well as the business model to be adopted for its

widespread dissemination. The project has covered all costs associated with the supply of the improved gasifier but no life-cycle cost-benefit analysis has been conducted to analyze how cost-effective the technology would be and how would the incremental costs be mobilized for the scaling up of the technology in the future.

Monitoring and Evaluation: The monitoring, evaluation and reporting mechanism proposed in the project document has not been strictly followed. Bi-annual reports prepared during the project execution period do not demonstrate the adoption of any SMART (Specific, Measurable, Agreed upon, Realistic and Timely) goals in project planning. There is a lack of continuity in the reporting process and there is no critical analysis of the status of activities following the timeline in comparison with what was outlined in the project document.

Processes Affecting the Achievement of Project Results: Some of the key factors that have affected the project results are presented here. The weakness in project design has already been pointed out; there is also the need to ensure greater stakeholder involvement and participation at the design stage so that the key players are on board right from the start of the project and there is no need to waste time on stakeholder mapping during project execution. The country ownership in the project is found to be weak due to the low level of participation and commitment of the institutional partner, as observed during the different periods of project execution. The poor monitoring, evaluation and reporting can be partially attributed to the lack of training and experience of the project coordinators. Moreover, the project has not explored the possibility of collaborating and interacting with several other projects/programs that are also working in Cambodia for the same ultimate purpose of enhancing access to energy. Lastly, the project has not capitalized on the South-South technology transfer to facilitate hands-on training and capacity building of the local institutions and stakeholders.

Gender Mainstreaming: The project document briefly mentions about the consideration of gender aspect through both solar PV and gasifier interventions but the description is very general in nature and not much conscious efforts have been made in the project except for the fact that training was provided to 10 BCS operators out of which 2 were women. No specific activities have been undertaken by the project to explore how women could benefit from the access to energy for more productive activities. Also, there is no mention of any survey done to assess whether and to what extent the women were generating additional income through household productive activities.

Conclusions: The evaluation has concluded the need to address several technical and economic issues associated with the models proposed by UNIDO for the solar battery charging stations as well as for the gasifier-based mini-grid systems aimed at enhancing energy access for productive uses. The efforts to gather relevant techno-economic data to validate the proposed business models are considered to be poor. Moreover, the training and capacity building of both the SBCS operators and the gasifier manufacturers lack the hands-on aspect, as observed during the field visits of the SBCSs and the discussion held with one of the experienced gasifier manufacturers. As a result, the sustainability of project initiatives through widespread replication is questionable.

Recommendations: Based on the experience of the project, several recommendations are proposed, mainly addressing the concerned government agency and UNIDO, as listed below:

- The government should work in concerted manner with key stakeholders to have a clearer picture of the geographical locations that have little likelihood to have access to grid-quality electricity in the next one or two decades so that the efforts made to find suitable off-grid solutions are not in vein.
- The government should be driving the whole clean energy access process rather than playing more of an advisory role. Government could create greater synergies among the various developmental actors in order to tackle the challenges in a more holistic manner than encouraging dozens of isolated pilot initiatives that fail to operate much beyond project lives.
- Both UNIDO and the government should look beyond the pilot/demonstration projects and develop policies that can help Cambodia sustain such initiatives with least support from the international community.
- SBCS model of UNIDO is not viable as it does not address the problem in a holistic manner. Wherever possible, mini- or micro-grids should be favored to not only address the issues concerned with SBCS but also to encourage more productive uses that cannot always be fulfilled using small individual batteries.
- The vision of electrifying rural off-grid areas by using locally available renewable resources can only be achieved if the government considers ways to bridge the huge differences in the cost of grid and off-grid electricity.
- Government should seek necessary resources from the international community to cover the incremental costs of adopting technologies to reduce the dependence on fossil fuels and abate the global environmental emissions.

1. EVALUATION OBJECTIVES, METHODOLOGY AND PROCESS

1.1. INTRODUCTION

1. The project entitled "Access to clean energy for productive uses in Cambodia" (Project Number: XX/CMB/12/X02 – SAP No. 120047) was initiated in January 2013 by UNIDO with financial support from the French Trust Fund as a follow-up of an earlier project entitled "Rural energy for productive use and income generation in Cambodia" (Project Number: TFCMB04001), supported by the Government of Austria in 2005. Both projects were implemented by UNIDO in partnership with the Ministry of Industry, Mines and Energy which was split into two Ministries in 2014, namely the Ministry of Industry and Handicrafts (MIH) and the Ministry of Mines and Energy (MME).

2. Based on the project document, the main objective of the project was to increase access to clean energy for productive uses in off-grid areas and agro-based Small and Medium Enterprise (SMEs), especially in the rice milling industries. The project was expected to contribute to the vision of rural electrification of the Royal Government of Cambodia, which focused on electrifying all Cambodian villages in rural off-grid areas by using locally available renewable resources for electricity generation by 2020, and connecting 70% of the rural households to grid-quality service (24-hour mini-grids or national grid) by 2030.

3. The project document required the conduct of an independent evaluation by an international expert at the end of the project. Accordingly, an international evaluation expert was recruited by UNIDO to carry out the evaluation in January 2016.

1.2. OBJECTIVE AND SCOPE OF THE EVALUATION

4. The objective of the evaluation was to assess the project performance in terms of its relevance, effectiveness and efficiency, and to determine outcomes and impacts (actual and potential) stemming from the project, including their sustainability. The two primary purposes were:

    a. To provide evidence of results to meet accountability requirements, and

    b. To promote learning, feedback, and knowledge sharing through results and lessons learned between UNIDO and its partners.

5. The scope of the evaluation was to identify lessons of operational relevance for future engagement to increase access to clean energy for productive uses in off-grid areas and agro-based SMEs. Based on the project's intended outcomes, the

main questions to be asked during the evaluation were whether the project had helped in:

a. Building capacity of relevant institutions both in the public civil society organizations (CSOs) and private sector actors in improving access to energy for productive uses in the non-grid areas and SMEs in Cambodia;

b. Promoting South-South cooperation for transferring and strengthening technical capacities of technology institutions, non-governmental organizations (NGOs) who are promoting RE technologies, RE equipment manufacturers and agro-industries in SME sector who generate a high volume of agro residues and at the same time consume a large amount of diesel to fuel their production operations;

c. Promoting community-managed model of micro/mini grid systems for increasing the access to energy for productive uses;

d. Replacing environmentally malign fossil fuels use through both the technologies (Solar Battery Charging Stations or SBCS and improved gasifier), implying indoor pollution at household level and industry level is mitigated thereby improving the health issues of women and girl children who spend most of their time indoors;

e. Assisting women to earn additional income through some household productive activities with the help of better lighting, even during late evenings;

f. Supporting the Cambodian Government in formulating policies to increase access to clean energy for productive uses in the off-grid areas and agro-based SMEs;

g. Tackling some of the root causes such as quality and standards as well as lack of technical capability in improving designs that are preventing the widespread replication of such models.

1.3. OVERALL EVALUATION METHOD AND APPROACH

6. The evaluation involved a participatory approach whereby key stakeholders were kept informed and consulted throughout the evaluation process. Both quantitative and qualitative evaluation methods were used to determine project achievements against the expected outputs, outcomes and impacts.

7. The findings of the evaluation are based on the following:

    a. A **desk review** of:

i. Relevant background documentation.

ii. Project design documents, including outputs and activities.

b. Annual Work Plans and revisions to the project.

i. Project reports, progress reports from collaborating partners, meeting minutes, relevant correspondence etc.;

c. Interviews (individual or in group) with key stakeholders.

d. Project management – present and former UNIDO staff.

e. Supported CSOs/SMEs

8. The evaluation findings and judgements are based on sound evidence and analysis. Wherever possible, information was triangulated, and when verification was not possible, the single source has been mentioned. Analysis leading to evaluation judgements is clearly spelled out.

9. The evaluation involved assessing the project with respect to a minimum set of evaluation criteria grouped in six categories:

a. Strategic Relevance;

b. Attainment of objectives and planned result, which comprises the assessment of outputs achieved, effectiveness and likelihood of impact;

c. Sustainability and replication;

d. Efficiency;

e. Factors and processes affecting project performance, including preparation and readiness, implementation and management, stakeholder participation and public awareness, country ownership and driven-ness, financial planning and management, UNIDO supervision and backstopping, and project monitoring and evaluation; and

f. Complementarity with the UNIDO strategies and programmes.

10. In attempting to attribute any outcomes and impacts to the project, the evaluation has considered the difference between what has happened with and what would have happened without the project. Therefore the evaluation has considered the baseline conditions and trends in relation to the intended project outcomes and impacts. Where baseline conditions and trends were lacking, the evaluation has highlighted the issue along with the simplifying assumptions that were made to make informed judgements about project performance.

1.4. LIMITATIONS ENCOUNTERED AND VALIDITY OF FINDINGS

11. The time allocated to conduct the evaluation was rather limited. Moreover, major activities of the project had not been carried out during the initially designed evaluation framework. As a result, after conducting the planned short mission, the evaluator took it upon himself to wait for the completion of the main project activities in order to carry out a second phase of evaluation that would provide a better picture of what was actually achieved in terms of outputs and outcomes. Since the completion of the project activities were delayed by over 4 months, the second phase of field visit was conducted during the first week of June 2016.

12. At the time of writing the evaluation report, the improved biomass gasifier-based power plant had been installed and training was provided to the local manufacturers and operators. However, the technology supplier had been unable to successfully commission the gasifier-based power plant due to some technical issues. Also, the policy related workshop that was planned to accompany the handing over of the functional gasifier-based power plant had yet to be conducted because of the delay in the commissioning of the gasifier unit. It is therefore too early to conclude to what extent the improved power generation system has led to the intended outputs and outcomes.

2. COUNTRY AND PROJECT BACKGROUND

2.1. BRIEF COUNTRY CONTEXT

13. Cambodia has 181,035 km^2 area and population of over 15 million. The country is young; around half of the population is below 25 years.[1] Around 20 percent of the population lives in cities. The country shares borders with Vietnam to the east, Laos to the north, Thailand to the west, and the ocean coast to the Southwest.

14. The 1993 Constitution was amended in March 1999 to establish the Senate, a new legislative body. The Constitution divides the Cambodian territory into provinces and municipalities. Currently, there are 24 provinces and four municipalities (Phnom Penh, Sihanoukville, Kep, and Pailin).

15. Cambodia is one of the world's poorest countries, with most of the workforce still employed in subsistence farming. The poverty rate was 17.7 percent in 2012, with almost 3 million poor people and over 8.1 million who are near-poor. Cambodia achieved the Millennium Development Goal (MDG) of halving poverty in 2009. However, the vast majority of families who escaped poverty were only able to do so by a small margin, thus the significant share of the near-poor.[2]

16. The economy is dominated by garment-making, but tourism is expanding, and Cambodia hopes to tap into offshore oil and gas reserves and draw in overseas investment to replace aid. Cambodia continues to enjoy robust growth, albeit at a slightly slower pace. Real growth in 2015 is estimated to have reached 7 percent.

17. Human development, particularly in the areas of health and education, remains an important challenge and development priority for Cambodia. Eighty-two percent of Cambodians do not have access to piped water and 63 percent do not have access to improved sanitation (2014). Cambodia has made progress in improving maternal health, early childcare, and primary education programs in rural areas.[3]

[1] *http://www.indexmundi.com/cambodia/demographics_profile.html*
[2] *http://www.worldbank.org/en/country/cambodia/overview*
[3] *http://www.worldbank.org/en/country/cambodia/overview*

18. The country faces a number of development challenges including weak public service delivery, which impede inclusive development, ineffective management of land and natural resources, environmental sustainability, and good governance.

19. Cambodia has one of the worst deforestation rates in the world. Deforestation in Cambodia also results from subsistence activities, notably the collection of fuel wood and clearing for agriculture. Deforestation has been accelerating over the past decade, largely a product of industrial plantation expansion, logging, and conversion for agriculture.[4]

2.2. SECTOR-SPECIFIC ISSUES OF CONCERN TO THE PROJECT

20. Cambodia has undergone rapid economic development, with GDP per capita more than tripling between 1999 and 2013.[5] Along with the rising population and aspiration for a better quality of life, electricity demands have been forecast to grow at 17.9 percent annually from 2012 to 2020. Cambodia's energy sector faces challenges in terms of electricity's supply, distribution and self-reliance.

21. The key challenges facing Cambodia's energy sector are:

    a. Heavy dependence on imported fossil fuels and imported electricity. Most of Cambodia's electrical supply comes from heavy fuel oil and diesel oil generators, and imported electricity from Vietnam, Thailand and Laos PDR.

    b. The distribution of electricity infrastructure and access remains disproportionate between urban and rural populations.

    c. Many rural areas do not yet have electricity connections.

    d. Some options for domestic power generation such as hydropower and coal-fired stations have associated environmental risks.

22. Due to the high cost of imported fuels and fragmented power supply systems, energy prices in Cambodia are among the highest in the region, ranging from US$0.15/kWh in Phnom Penh to over US$1.00/kWh in some rural areas. Those

[4] *http://rainforests.mongabay.com/20cambodia.htm*
[5] *http://data.worldbank.org/indicator/NY.GDP.PCAP.CD*

without connection to the national grid rely mainly on expensive diesel generators and car batteries to meet their daily needs

23. In 2014, the Prime Minister of Cambodia made a commitment that all Cambodian villages would have electricity by 2020, while 70 percent of households would have power by 2030. Based on past trends, this appears to be ambitious.

24. Increased dependency on imported electricity remains a worrying trend. According to the annual energy reports by the Electricity Authority of Cambodia (EAC) from 2004 to 2013, the total volume of imported electricity accounted for more than 50 percent of the total energy available for supply since 2010.[6]

25. While locally generated electricity has been gaining prominence, the rising cost of imported diesel – a major overhead for this form of generation – poses a challenge.

26. The Electricity Law was passed in early 2001 with the aim of regulating the power sector, protecting consumers and ensuring a reliable and adequate supply of electricity at a reasonable cost. The law also sought to promote private investment and ownership of power facilities, and to encourage competition in the sector.

27. The Electricity Law established the EAC as a legal public entity with power to act as the regulator of power sector business activities. EAC is responsible for granting licenses, approving and enforcing performance standards, and determining tariffs, rates and charges for electricity. The EAC grants licenses for generation, transmission, distribution, retail, or a combined license.

28. Cambodian households get electricity through centralized grid, mini-grid or isolated systems. Grid systems represent a suitable option for urban and semi-urban areas. The remaining consumers are served by mini-grid systems of Rural Energy Enterprises (REEs) using diesel generators or isolated systems run by operators of battery charging stations using diesel generators. The electricity cost is high because of the overall system inefficiency as well as the high cost of diesel.

[6] *Electricity Authority of Cambodia, "Reports on Power Sector of Kingdom of Cambodia" (2004-2013)*

29. Though only 0.7% of total electricity is sold through isolated systems, mainly in rural areas, consumers being served through these systems make up almost 9% of total electricity users.[7]

30. The government is placing great emphasis on the development of local energy resources to raise the living standard of the rural population. Renewable energy sources, especially solar energy, have been identified as important sources of local energy, not only to raise the living conditions of rural villages, but also to develop local industries to stimulate economic growth.

31. Solid biomass plays an extremely important role in meeting Cambodia's energy needs: the share of biomass in the national primary energy mix is 71%, the highest in the Southeast Asia region.

32. The government established Renewable Electricity Action Plan (REAP) in 2003 with the support of the World Bank Group. REAP focuses on supplying and distributing renewable energies that may be well suited to the dispersed areas. Following are the priority areas for REAP:

    a. *Technical support on policies and regulations:* improve policies and regulations on rural power supply and renewable energy distribution

    b. *Nurturing human resources in public and private sector:* train personnel for renewable energy management and technicians, establish educational institutes

    c. *Enhancing public awareness and developing market:* spread and promote technologies to strengthen demands for renewable energy

    d. *Conducting renewable energy projects:* expand power supply through renewable energy projects such as hydropower, solar power, biomass, etc.

33. Since the starting of the project early 2013 to the present, there were two important developments that would affect the intended Project outcomes:

[7] *Electricity Authority of Cambodia, 2013. Report on power sector of the Kingdom of Cambodia.*

a. Cost of electricity to consumers has been reduced by 25% thereby making electricity more competitive with decentralized power generation production for mini-grids or industries;

b. EDC is not approving Power Purchase Agreements (PPA) over USD 0.08 per kWh, which is not economically attractive. Any feasible biomass power generation facilities in the near future are likely to be grid-independent. Also, such installations have to be carefully chosen in areas that are unlikely to have the extended power grid for at least a decade.

34. Despite these developments, decentralized rural population, mainly outside of Phnom Penh still requires reliable supplies of electricity. To this end, there should be interest amongst REEs to generate electricity using biomass gasifier-based system rather than diesel generator that will contribute to lower electricity tariffs, and among operators of battery charging stations to switch from diesel to solar energy.

2.3. PROJECT SUMMARY

35. The main objective of the project was to contribute to the vision of rural electrification of the Government of Cambodia by increasing access to clean energy for productive uses in selected off-grid areas of Cambodia, notably in the provinces of Batambong and Pursat. Activities were to be undertaken to achieve the following outputs:

a. Establish RE based micro-grids in the off-grid communities of Batambong and Pursat provinces;

b. Enhance capacity of selected institutions and gasifier manufacturers

c. Learn lesson and disseminate information

36. According to the Project Document, UNIDO was to implement the project through its country office in close collaboration with the Ministry of Mines and Energy (MME).[8] UNIDO had identified implementing partners such as the Institute of

[8] *At the time of project formulation, UNIDO collaborated with the Ministry of Industry, Mines and Energy (MIME), which was split into two different ministries as Ministry of Industry and Handicrafts (MIH) and Ministry of Mines and Energy (MME) in 2014.*

Technology of Cambodia (ITC), Kram Ngoy Centre (CKN), technical training institutes, agro-based SMEs, local gasifier manufacturers and remote communities.

37. The project was initially planned to start in January 2013 for a period of 2 years. UNIDO mobilized the financial support from the Government of France and counterpart inputs were expected to be in-kind assistance.

38. The project was a follow-up of an earlier project entitled "Rural Energy for Productive use and Income Generation in Cambodia" which was implemented between 2005 and 2011 with financial support from the Government of Austria and in cooperation with the Ministry of Industry, Mines and Energy (MIME). That project went through considerable changes in comparison with the initial objectives and outputs. Following are some of the outputs of the earlier project that have some relevance to the present project:

    a. Performance assessment of locally manufactured gasifiers: the shortfalls of the systems included users' lack of knowledge of the performance parameters and safety issues; no measurements of operating parameters and water usage; lack of scientific approach in producing gasifiers.

    b. Installation of 6 battery charging stations in villages, serving more than 1,000 households

    c. Design, fabrication and commissioning of a solar drying system to enhance the production of dried fish

    d. Grant for the procurement of gasifier system for producing and distributing electricity to rural communities in Charchuk Commune, Angkor Chum District, Siem Reap province.

39. While the project document also mentions about replicating and scaling up of the Solar Battery Charging Station (SBCS) model that was demonstrated previously in 6 villages in Cambodia, there is no mention of this activity or output in the project logical framework matrix.

40. The project is a stand-alone initiative and there is no mention of collaboration with other initiatives of Government, other donors, private sector, etc.

3. PROJECT ASSESSMENT

3.1. DESIGN

41. The project design does not appear to be adequate to address the challenges that are faced by the population at the base of the pyramid in remote areas without access to grid electricity.

42. The brief description of the project sets the objective as increasing access to clean energy for productive uses in the off-grid areas and agro-based SMEs. The project is expected to increase the use of efficient and environmentally sound gasifiers based on rick husk fuel in the agro-industries cluster in the Battambang and Pursat provinces and to generate a number of productive activities. There is no mention at all of the solar battery charging stations (SBCS) either in the brief project description or in the project log frame.

43. In the section "UNIDO approach" there is mention of UNIDO using South-South Cooperation concept for transferring and strengthening technical capacities in gasification manufacturing, and promoting community managed model of micro/mini grid systems to increase access to energy for productive uses. Here too, there is no mention at all of the SBCS.

44. To be fair, there is a stand-alone section on SBCS in the project document. But the text is general and statements are not supported by facts. For example, while defining the baseline, it mentions that while "the private BCS charges from US$0.40 – 1.25 for 40 Ah battery, the SBCS will charge from US$0.125 – 0.175." Similarly, it says "Based on the past experience it can be calculated that on an average 1.5 panels can charge 1 battery per day". There is no mention of either the generation capacity of solar panels or the storage capacity of the battery. A much more structured and precise document would have been expected from a technical agency like UNIDO.

45. As mentioned earlier, this project is a follow-up of an earlier project in which UNIDO had funded 6 SBCS. However, this project document makes just a quick mention of the SBCS model demonstrated in 6 villages without highlighting the lessons learned from the previous project in order to improve the project design and render it more sustainable.

46. The project document makes reference to various partnerships but there is no mention of any participatory project identification process being adopted in selecting problem areas and national counterparts. No participatory and broad public consultation approach was considered. This is reflected by the fact that

different partners were solicited and mobilized during the project execution than those cited in the project document.

47. The developmental goal/impact of the project is defined as the promotion of renewable energy systems for productive uses. This cannot be the impact though it may be the means to achieve the ultimate impact, which could be reducing the dependence on fossil fuels (hence mitigating GHG emissions) and increasing the capacity to earn better livelihood, which will result in a better quality of life. Therefore, the verifiable indicators suggested (number of households and small industries with access to energy and productive uses) may not be that appropriate to measure the effectiveness of the outcome.

48. The verifiable indicators for the "lessons learned and information disseminated" are given as "number of information dissemination materials" and "number of policy related workshops". Such quantitative indicators do not appropriately reflect the effectiveness of the output.

49. In view of the inconsistencies between the project description and the project logical framework, the project document has not been formulated based on the logical framework. At the time of initiating project activities, there seems to have been a reformulation of the project design as well as the project results framework because the 2nd half-yearly report refers to activities carried out according to the project document but the outputs do not correspond to those outlined in the initial project document.

50. The project document refers to access to energy for productive uses but there are no activities to either study what could be the possible productive uses or to conduct survey to learn the extent to which access to energy has led to its productive uses.

51. Finally, one of the issues that the project document has not considered is the financial sustainability of the project initiatives. There are several initiatives of similar nature in Cambodia supported by various donors, and very often upon the request of concerned ministries. Projects such as these should strive to propose business models that have potential for wide-scale replication. Donor support would be more effective in overcoming the perceived barriers and bridging the financial gap, if any, between the real cost and the local affordability, especially if the project is addressing issues that are of global concern (e.g. GHG emissions).

3.2. RELEVANCE

52. The project is relevant to the national development and environmental priorities and strategies of the government and the population. Over the last decade

Cambodia has adopted several policy measures and created the institutional mechanisms to address the issue of access to energy. The network has been extended to deliver grid-quality electricity to many parts of the country. The government has set an ambitious goal of extending the grid and enhancing access to electricity in the future. However, it is clear by looking at the past trend that the grid extension to some of the areas with low-density population will be problematic and considering the high level of poverty, many people will still not be able to afford the cost of electricity generated with fossil fuels and supplied through mini-grids. The project is therefore designed to contributing to the vision of rural electrification of the government of Cambodia.

53. The main targets of this project are the people at the base of the pyramid who do not have access to clean and affordable energy for productive activities. The project's objective is also to assist the local manufacturers/suppliers of biomass gasifiers in improving the efficiency and environmental performances of the gasifiers. Also targeted are the government and other stakeholders who can learn from the experience gained from the project and scale up the efforts to enhance access to a vast population living without access to grid quality electricity.

54. The project is also in line with UNIDO's mandate of promoting and accelerating inclusive and sustainable industrial development, and fostering innovation while safeguarding the environment. UNIDO plays an important role in facilitating access to affordable and sustainable energy to support productive activities and the income and employment opportunities they create, thereby contributing to the mitigation of climate change.

3.3. EFFECTIVENESS

55. As pointed out earlier, the objectives and the outputs as well as outcome do not quite match with the activities proposed in the project document. Hence, the logical framework in the project document does not serve as the best means to assess the effectiveness of the project. Though there does not appear to be any official revised version of the project document, the modified logical framework presented in the progress report of July-December 2013 is used as the reference to assess the project outputs, as presented in Table 1.

Table 1. Project achievements against outputs listed in the logical framework

Outputs	Indicators	Achievement	Comments
1. Capacity of selected institutions and gasifier manufacturers enhanced	- Number of engineers/technical persons trained - Number of improved quality gasifiers replacing diesel generators	- 15 trainees (including 5 equipment manufacturers) were trained by the Energy and Resources Institute (TERI) - 1 imported gasifier of improved design with 125 kW power generator replacing diesel generators	The training was more in the classroom and the local manufacturers were not able to get any hands-on training on manufacturing of improved gasifiers. The improved gasifier was just installed but has not been successfully commissioned. It has not been used so far to provide electricity to rural households.
2. 5 SBCSs with various charging capacity installed in the off-grid communities of Battambang and Pursat provinces	- kW of installed capacity - Number of households having access to clean and affordable energy	- 8 SBCS installed with total solar capacity of 23 kWp - 4,907 households being served - Average reduction in battery charging fees: 16% - Diesel consumption avoided: 37,184 liters/year	Considering the capacity of the solar panels installed, the number of households benefitting from the SBCS seems rather high. The reduction in the battery-charging fee is far less than what was initially projected. The diesel consumption avoided also seems to be high.
3. Lessons learned and information disseminated	- Number of information dissemination materials produced - Number of policy related workshops	- 2-3 information dissemination document prepared and one in preparation - One policy related workshop planned	Due to the delay in commissioning of the gasifier-based power plant, the policy related workshop has been postponed.

56. Based on the information available from the project team, 8 SBCS with an aggregated solar generation capacity of 23 kWp were installed in various sites without access to grid or mini-grid. There was an average reduction of 16% in the battery charging fees. It is reported that the system serves 4,907 households and the avoided diesel consumption is 37,184 liters/year but there is no concrete data to substantiate the figure.

57. If these numbers are true, then a rough calculation based on the aggregated installed solar plant capacity shows that only about 16 Wh of battery electricity is available per household (see Table 2). A typical household employing a 12 V battery of 40 Ah capacity would consume around 384 Wh every 5 days (or 77 Wh/day). Similarly, based on the aggregated installed solar plant, one can expect 35,359 kWh of electricity generation per year. If the diesel saved that is reported is correct, it would mean an extremely poor diesel power generating system (1.05 liter of diesel is needed to generate a kWh of electricity using the existing diesel power generator)!

Table 2. Calculations using data available from the project report

Installed solar plant	23	kWp
Average daily output	96,600	Wh/day
Solar generation	35,259	kWh/year
Diesel saved	37,184	liters/year
Diesel to produce elec.	1.05	liter/kWh
Battery storage	77,280	Wh/day
Number of households	4,907	households
Average energy use	16	Wh/day
Typical battery use	5	days/charge
Battery voltage	12	V
Battery capacity	40	Ah
Battery storage	384	Wh
Daily battery usage	77	Wh/household.day

58. During the evaluation mission, the SBCSs were found to be under-utilized in some of the sites visited. This is mainly due to the fact that the number of batteries was often much less than the installed capacity of the SBCS. In spite of the training provided to the SBCS operators, no systematic way of bookkeeping and reporting was noted, hence it was not possible to get a clear picture of the number of batteries being charged compared to the overall charging capacity of the SBCS. Moreover, some operators were visibly not well aware of how the system should be operated to get the best result. Others complained about the beneficiaries moving from their SBCS to the normal BCS operators because they felt that the batteries were not properly charged and did not last long enough. This is mainly due to the fact that in the absence of battery discharge controller, most households had the tendency to draw too much energy from the batteries. In fact, the batteries that are deeply discharged lose their storage capacity, resulting in a drastic reduction of their lives.

Figure 1. An example of under-utilized battery charging station

59. There is a need to create much greater awareness as to the differences in operation between SBCS and the diesel-based BCS. In the latter, the batteries get hot because of high current flow and over-charging of batteries, resulting in shortened life. On the other hand, the rate of charging with solar panel is much slower, as a result of which the charging is more efficient and the batteries do not get hot. But the beneficiaries are often under the impression that the SBCS is not charging well based on the fact that the batteries do not become hot.

Figure 2. Poster promoting solar products commercialized by the vendor, but no poster explaining the basic operating features of the SBCS with Dos and Don'ts

60. As for the design of the SBCS, UNIDO seems to have followed the configuration proposed by officials from MME (each battery being charged with a dedicated solar panel and charge controller), and did not seem to have learned from the experience of the previous project. The SBCS operator has no control over the storage capacity of the battery being brought by the client. With the system in place, there can be a mismatch between the charging capacity of the solar panel and the storage capacity of the battery. As a result, the battery may get charged earlier in the day or be partially charged at the end of the day. There have been similar experiences of projects that were undertaken by other agencies in collaboration with MME. One may refer to a 100 kW solar-diesel hybrid project that was undertaken in Kampot and Siem Reap provinces from 2009 to 2011 with support from the Korea International Cooperation Agency (KOICA). One of the reasons for failure of the chargers was cited as the charging of non-standard specification battery.

Figure 3. All types of batteries of different capacities being charged (faulty charge controllers not replaced due to lack of technical personnel)

61. Only one improved gasifier imported from India has been installed during the project period. Hence, in the absence of the installation of any indigenously produced improved gasifier, the project's claim to have enhanced the capacity of local gasifier manufacturers may be questioned.

62. However, an evaluation conducted after the classroom training provided by The Environment and Resources Institute (TERI) concludes that the trainees have understood the specific designing features of the improved gasifiers. One of the

local trainees with long experience in manufacturing and operating gasifiers in Cambodia claimed he could further improve the design of the new gasifier with dry gas cleaning system supplied by TERI. As the heat exchanger used in the improved gasifier needs to operate at higher temperature, there would be a need to import a certain quality of material for producing the heat exchanger.

63. As for the long-term impacts of the project initiatives, some of the challenges to the sustainability of the SBCS identified during the evaluation mission are highlighted below:

    a. The poor knowledge and lack of understanding of the SBCS operators, and their low technical capability to maintain the system in working order; in several locations the clamps connecting to the battery were broken after some period of use as a result of which the solar panel as well as the battery charger were not being used.

    b. While the project addressed the issue of good quality charging of the batteries, there is no way to control the level of discharge of the batteries; the users always try to get the maximum energy from the batteries, thus reducing the storage capacity and operational life of the batteries drastically. Many new and expensive batteries are reported to last one year or less whereas a battery with good charge and discharge protection should be functional for at least 3-5 years.

    c. Once the batteries stop functioning, many users do not have sufficient capital to purchase a new one. The decreasing number of batteries being charged at a SBCS affects the economic viability of the SBCS operation.

    d. It was also noted that some of the villages where the SBCS were commissioned had got access to grid electricity. The SBCS had become redundant except for a very few poor families who continued to use the facility because they could not afford to get grid connection. Since lack of access to grid electricity was one of the important criteria set by the MME for recommending a particular village for installing the SBCS, it showed a lack of coordination between MME and the national power utility Electricity of Cambodia (EDC).

    e. Similar issues were faced by some REEs operating mini-grids with biomass and agro-industrial residues in remote areas that now had access to the grid thanks to aggressive government initiative to extend the grid to the extent possible. For example, the REE supported by UNIDO in the earlier project had to abandon the village it served because of the extension of

the utility grid; it had to relocate the gasifier-based power plant to another new site after negotiating the export of on-site electricity generated to the national grid.

3.4. EFFICIENCY

64. As no financial data of the project was shared with the evaluator, it is not possible to comment on the cost-effectiveness of the project. The project team reports that the co-financing received from the operators of SBCS and REE amounted to US$36,528. It was agreed that the project would contribute 50% of the capital investment of the SBCS, with the remaining 50% to be covered by the SBCS operator as repayment by instalments to the SBCS vendor/supplier. On the other hand, since the project has covered the entire of cost of manufacturing, transporting and installing the improved gasifier-based power plant, it is assumed that the contribution of the REE was only for the development of the civil structure at the site.

65. The initial period for project implementation was 2 years whereas it was extended by one more year. This is quite normal for a project that involves numerous stakeholders and implementation of activities in remote areas. Moreover, the restructuring of the ministry created some uncertainties and delays in 2014 and there was also a change in the project management at UNIDO office in Phnom Penh as well as at UNIDO Head Quarters. But the delay of the project does not seem to have had any adverse impact on the project's cost-effectiveness.

66. A project time schedule was included in the project document, it was revised on a half-yearly basis according to the progress made by the project and modified work plans were proposed by the project team.

67. The main cause of the delay has been the construction, erection and commissioning of the improved gasifier incorporating the dry gas cleaning system. Following the scoping mission conducted by TERI in the first half of 2014, TERI was unable to commission the improved gasifier even after 2 years.

3.5. SUSTAINABILITY OF PROJECT OUTCOMES

68. The information and impressions gathered during the terminal evaluation lead to several questions regarding the sustainability of project outcomes. In spite of the significant progress made by Cambodia over the last few years to extend the utility grid to enhance access to electricity to many more villages, many villages in remote areas and many villagers at the base of the pyramid will still lack access to electricity for meeting their basic needs and for productive activities. The SBCS

model adopted by UNIDO and other agencies is unlikely to provide a sustainable solution to the potential beneficiaries in the villages. Moreover, the high dependence on donor funding to reduce the cost of the SBCS and pass on the benefit to the end users will not help in rapid scaling up of the SBCS because of the decreasing donor support. Further, the non-inclusion of battery discharge controller results in higher costs being incurred by the end-users and short battery life.

Table 3. The breakdown of the cost of solar electricity supplied by the SBCS

Capital Investment			
Battery voltage	12	V	
Battery capacity	50	Ah	
Battery energy	600	Wh	
Energy available from battery	480	Wh	
Battery cost/kWh delivered	80	US$/kWh stored	
Life in charging cycle	175	cycles	
Useful energy delivered	84	kWh/battery	
Battery cost/kWh delivered	0.95	US$/kWh	77%
Solar charging			
Battery voltage	12	V	
Battery capacity	50	Ah	
Energy to charge battery	600	Wh/day	
Solar panel size	133.33	Wp	
Solar system cost	2.75	US$/Wp	
Solar system cost/battery	366.67	US$/battery charged	
Solar system economic life	10	years	
	3000	Charging cycles	
Solar system cost/charge	0.12	US$/cycle	
Solar system value	0.20	US$/kWh	16%
O&M Cost			
SBCS operator cost	0.07	US$/kWh	
SBCS Maintenance cost	0.01	US$/kWh	
Total O&M Cost	0.08	US$/kWh	6%
Total Supply side cost	1.24	US$/kWh	

69. It is estimated that there are at least 1,000 BCS in operation with diesel generators in Cambodia and consumers pay more than US$1 per kWh for charging shallow-cycle lead-acid batteries. This project has helped to replace diesel generators in only 8 BCS with solar power plants. Moreover, the UNIDO model is

based on 50% subsidy and has resulted in an average of 16% reduction in battery charging cost. Neither does the project answer the question regarding the funds necessary to scale up the few pilot units that were set up with donor support nor does it address the issues of short battery life and the high battery replacement cost incurred by the end-user due to the absence of discharge controller.

70. Using the cost figures shared by the project team, calculations were done to derive the different shares of the solar electricity used by the households thanks to the SBCS. As shown in the calculations of Table 3, while the life cycle cost of electricity generated by the solar plant is around US$0.20/kWh, the life cycle of the battery is calculated as US$0.95/kWh. If one also includes the Operation and Maintenance (O&M) service provided by the rural entrepreneur, one finds that the battery cost alone represents 77% of the solar electricity, whereas the cost share of solar charging represents only around 16%.

71. As a follow-up of a similar project that helped to support the creation of 6 SBCS, the project could have learned from the experience and looked for other alternatives such as solar home system or solar micro-grid that considers the overall management of the energy from the supply to its use. In fact, there are several other initiatives in this direction in Cambodia, supported by various agencies such as the Asian Development Bank (ADB), the World Bank (WB) and French Agency for Development (AFD), involving several private players and NGOs.

72. For example, AFD's four-year Solar Microfinance Programme implemented by SNV in partnership with a number of partners aims to broaden access to energy for 25,000 households in off-grid locations through the market-led installation of solar home systems. This Solar Microfinance Programme collaborates with three leading Cambodian Microfinance Institutions (MFIs), which will develop Cambodia's first dedicated solar microcredit offer for their customers in order to lower the initial investment barrier for rural households. The programme will also manage the accreditation and verification process for solar products and suppliers.[9] Thanks to the involvement of the key stakeholders and appropriate

[9] http://www.snv.org/update/largest-solar-market-development-programme-launched-cambodia

business model, the programme can expect to benefit a large number of rural population and once the business model has been tested and successfully proven, the local financial institutions as well as the equipment suppliers are going to play an active role to scale it up further for the benefit of many others who lack access to energy in Cambodia.

73. As for the improved gasifier with dry gas cleaning system, the evaluator was not able to get any cost figures except for the fact that it was costlier than the present technology which is already considered as not affordable to end-users. No cost-benefit analysis is available for the system being imported, by taking into consideration the capital investment, fuel cost and overall power generation efficiency of the gasifier-generator system. TERI was contacted to provide some cost figures and assess what would be the approximate cost of the system if it was manufactured in Cambodia but no response was received in spite of sending reminders.

74. While the improved dry gasification system is proposed to minimize the environmental pollution from the operation of the gasifier system, the operator may not be in a position to pay for the incremental cost of the system and may not wish to make the incremental investment with the fear that it may result in a higher cost of the electricity generated. In this specific project, UNIDO has covered all the costs, hence neither the technology supplier nor the beneficiary is concerned about the cost factor. But leaving aside the technical aspects of operating the improved gasifier, it is likely to be a challenge to spread the use of such improved system unless there is a mechanism to enforce the regulation to adopt the technology for minimizing the environmental impact, and propose innovative financial mechanism to make the gasifier system more affordable.

75. Hence, unless the above issues are seriously considered and institutional measures adopted at the ministerial level, all the project initiatives may not be sustainable.

3.6. ASSESSMENT OF MONITORING AND EVALUATION SYSTEMS

76. The project document has a section on monitoring, reporting and evaluation. However, whatever has been proposed in this section has not really been followed in a rigorous manner. For example, the project document mentions about the formation of a Project Steering Committee (PSC) which will meet twice a year to review the progress report, evaluate the implementation and endorse the work program submitted by the Project Management Office. In reality, there is no record of the formal creation of a PSC though the project coordinator made it a

point to update the concerned official in the MME regarding the progress made by the project and sought advice for the next steps of action.

77. The bi-annual progress reports were not always very precise and did not provide a clear picture of the actual progress made by the project. Though the timeline of activities was revised and presented in the bi-annual report, the reporting was found to be not very objective. For example, a year after the launching of the project, the progress report for the period January-May 2014 reports 80% progress in achieving the progress objectives while reporting at the same time that neither the work on improved gasifier had started nor was any partnership agreement established between village communes and BCS owner regarding co-financing of the SBCS.

78. There seem to have been some lapse in 2014 due to the change of project coordinator. The report of the first half of 2015 prepared by the new coordinator who assumed responsibility at the end of 2014 seems to suggest he was not briefed adequately about the manner of reporting the progress made by the project. The work plan shows that the gasifier would be commissioned within 2-3 months whereas in reality there was no progress in any of the activities related to the Output 1 (enhanced capacity of selected institutions and gasifier manufacturers). The delay was undoubtedly due to poor response from TERI, as substantiated in the next bi-annual report prepared by the project coordinator.

3.8. ASSESSMENT OF PROCESSES AFFECTING ACHIEVEMENT OF PROJECT RESULTS

79. The weaknesses pointed out in the project document highlight the poor preparedness in project formulation. Though the project document had identified several partners as stakeholders, there appears to be no consultation with these stakeholders prior to the starting of the project. This is reflected in the report prepared in January 2014, which mostly covers the efforts made at stakeholders mapping without really starting concretely any of the activities outlined in the project Logical Framework Matric (LFA).

80. Furthermore, the results of the stakeholder mapping have not been put to much use. There is no further evidence of any interaction and consultation with these stakeholders who are actively engaged in areas similar to those covered by the project. The meeting held with SNV showed that though UNIDO was aware of similar initiatives undertaken by SNV for developing standards to improve the quality of gasifiers, there was no formal collaboration and exchanges between Netherlands Development Organization (SNV) and UNIDO in this domain.

81. There also seemed to be some ambiguity regarding the enhancement of capacity of local institutions and gasifier manufacturers during the initial stage of project implementation. While the project document clearly states that TERI will be providing technical assistance, the report for the period July-December 2013 mentions the project team proposing the local designing and fabrication of the demo gasifier to be installed at a rice mill on condition that the rice miler will use that gasifier to generate electricity to run the mill and ultimately sell excess power to the community.

82. It is a pity that there was no scope for the local manufacturers and institutions to get any hands-on exposure during the fabrication of the improved gasifier that was overseen by TERI. This sort of involvement would have allowed the local manufacturers to have a better understanding of the engineering details of the improved gasification system and also get a good grasp of the extent of modifications that could be achieved in terms of local manufacturing with the materials available in Cambodia.

83. The country ownership in the project is found to be weak due to the low level of participation and commitment of the institutional partner, as observed during the different periods of project execution. The project coordinator has reported having met and briefed the ministerial counterpart but the response received suggests that the focus on developing an improved, efficient and less environmentally-polluting gasification systems was not in MME's agenda.

84. There has so far not been any discussion between UNIDO and MME regarding the policy measures that could be contemplated based on the learning from the project, in order to scale up the initiatives of UNIDO for this project.

85. The evaluator is aware of other energy access initiatives of several organizations in partnership and collaboration with MME. However, MME does not have a strategy to bring these organizations together so that the collective learning process will help to better define the future course of action in a coherent and sustainable manner.

3.9. GENDER MAINSTREAMING

86. The project document briefly mentions about the consideration of gender aspect through both solar PV and gasifier interventions. It reports that "by replacing malign fossil fuel use through both the technologies, indoor pollution at the household and industry level will be mitigated, thereby improving the health issues of women and girl children who spend most of their time inside home". It goes further to say that this intervention will help women earn additional income

through household productive activities during late evenings with the help of better lighting.

87. Since the focus of the project was to substitute diesel use by solar in the BCS and by biomass in the mini-grids, the base line itself considers that the households were not using fossil fuels at home. Hence it is not clear how the project intervention was going to address the health issues of women and girl children inside home.

88. There was no specific activity component in the project aimed at helping women earn additional income through household productive activities. Also, there is no mention of any survey done to assess whether the women really generated additional income through household productive activities at night.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

89. While the project on "Access to clean energy for productive uses in the off-grid areas and agro-based SMEs" has worked on achieving the expected outputs, there are several technical, financial and institutional issues that hinder its long-term impacts and sustainability. Some of these are highlighted below along with recommendations for more sustainable solutions.

90. **Technical issues associated with SBCS operation:**

    a. The design of the SBCS with dedicated solar panel and charge controller for each battery leads to sub-optimal performance of the SBCS.

    b. SBCS reduces the dependence on fossil fuel but in the absence of a discharge controller, it does not address the core issue of protecting the battery life, resulting in higher financial burden on the end-user and an unviable SBCS operation.

    c. Operators' technical knowledge and understanding of how best to operate the SBCS is limited, and they fail to appreciate the need for regular bookkeeping.

    d. The remoteness of sites results in poor availability of O&M services, adversely affecting the delivery of services at the SBCS.

91. **Technical issues associated with improved gasifier-based power generator:**

    a. Since the improved gasification system has been very recently commissioned, it is too early to discuss and comment on the technical issues associated with it.

    b. The local capacity to manufacture improved gasifier-based power generator could be better built by not only imparting classroom training but also involving local teams actively in the hands-on training during the designing, constructing and commissioning phases.

92. **Economic issues associated with SBCS operation:**

    a. Simple calculation shows that for every kWh of useful energy delivered, the investment in the SBCS is 4 times higher compared to the investment on a battery, whereas the life of the SBCS is at least 10 times higher than the battery.

b. The aim seems to be mainly on making the SBCS operation viable, without exploring ways to reduce the financial burden of the end-users for whom frequent replacement of batteries is not viable.

c. Access to affordable clean energy does not guarantee its productive uses and improved livelihood; support is needed in various forms to create a virtuous cycle of development that ensures sustainability of initiatives.

93. **Economic issues associated with improved gasifier-based power generator:**

a. Though the improved gasifier-based power generator was imported into Cambodia, it is useful to do a full exercise to assess what would be the cost of gasifier if it were to be built in Cambodia using the design of the improved system.

b. Fully subsidizing the cost of the improved gasifier-based power generator does not encourage more active and responsible participation of the beneficiary.

c. The improved gasifier-based power generator claims to be more efficient and more environment-friendly but at a higher cost; instead of passing on the cost burden to the end-users in the form of higher electricity tariff, there is a need to think of the economic model that will achieve the dual objective of reducing the cost of the electricity provided to the end-user and reducing the local and global emissions.

4.2. RECOMMENDATIONS

94. The following recommendations are based on evaluation findings, mainly addressed to the national institutional partner and UNIDO:

a. Government should work in concerted manner with other key stakeholders such EAC and EDC to have a clearer picture of the geographical locations that have very little likelihood to have access to grid-quality electricity in the next one or two decades so that the efforts made to find suitable off-grid solutions were not in vein.

b. Government should be driving the whole clean energy access process rather than playing more of an advisory role; absence of greater engagement and high dependence on donor funding to solve the energy access issue in remote areas is unlikely to be sustainable. For example, government could create greater synergies among the various developmental actors in order to tackle the challenges in a more holistic

manner than encouraging dozens of isolated pilot programs that fail to operate much beyond project lives.

c. Based on the experiences gained through the implementation of pilot projects, both UNIDO and the government should look beyond the pilot/demonstration projects and develop policies that can help Cambodia sustain such initiatives with least support from the international community.

d. SBCS solutions are clearly not viable as they do not address the problem in a holistic manner: while the quality of battery charging is improved and solar replaces diesel, it does not address the issues of the rapidly decreasing battery capacity and life due to the absence of battery discharge control mechanism. There is also the issue of the need for frequent transporting of batteries from homes to the SBCS. Wherever possible, mini- or micro-grids should be favored to not only eliminate the issues associated with SBCS but also to encourage more productive uses that cannot always be fulfilled using small individual batteries.

e. The vision of electrifying all Cambodian villages in rural off-grid areas by using locally available renewable resources can only be achieved if government considers ways to bridge the huge differences in the cost of grid and off-grid electricity. It is also important to achieve more equitable development and contain the migration from remote villages towards cities. The best way to achieve this within the country without undue dependence on donor support is by developing revenue-neutral policies that lead to the generation of financial resources by charging a nominal surcharge on all those who avail low-cost and reliable electricity from the national grid in order to support the production of clean and affordable energy for the remotely-located population at the base of the pyramid. The principle is similar to the renewable feed-in-tariff that is widely used in different parts of the world.

f. As a signatory to the global climate protection, the Government of Cambodia is well entitled to seek necessary resources from the international community to cover the incremental costs of adopting technologies that can help to reduce the dependence on fossil fuels and abate the global environmental emissions.

ANNEX 1. EVALUATION TOR

Project Title: Access to clean energy for productive uses in Cambodia

PROJECT CONTEXT

The main objective of this project is to increase access to clean energy for productive uses in the off-grid areas and agro-based SMEs. The project is expected to:

(i) Increase access to clean energy for productive activities such as rice milling, ice making and other agro-processing in selected off-grid communities of the Battambang and Pursat provinces of Cambodia;

(ii) Enhance the capacities of the counterpart and the local fabricators of biomass gasifiers, leading to availability of locally manufactured high quality biomass gasifiers for agro-based SMEs.

This project is expected to increase the use of efficient and environmentally sound biomass gasifiers based on rice husk fuel in the agro-industries cluster in the Battambang and Pursat provinces and to generate a number of productive activities.

The project is contributing to the vision of rural electrification of the Royal Government of Cambodia, with the aim to electrify all Cambodian villages in rural off-grid areas by using locally available renewable resources for electricity generation by 2020 and to connect 70% of the rural households to grid quality service (24-hour mini-grids or national grid) by 2030.

OBJECTIVE AND SCOPE OF THE EVAUATION

The objective of the terminal evaluation of the project is to assess project performance (in terms of ***relevance, effectiveness and efficiency***), and determine ***outcomes and impacts*** (actual and potential) stemming from the project, including their ***sustainability***. The evaluation has the two primary purposes:

(i) To provide evidence of results to meet accountability requirements, and

(ii) To promote learning, feedback, and knowledge sharing through results and lessons learned between UNIDO and its partners.

The evaluation will identify lessons of operational relevance for future engagement to increase access to clean energy for productive uses in the off-grid areas and agro-

based SMEs. Based on the project's intended outcomes, the evaluation will assess if the project has helped in:

1) Building capacity of relevant institutions both in the public CSOs and private sector actors in improving access to energy for productive uses in the non-grid areas and SMEs in Cambodia?

2) Promoting South-South cooperation for transferring and strengthening technical capacities of technology institutions, NGOs who are promoting RE technologies, RE equipment manufactuers and agro-industries in SME sector who generate high volume of agro residues and at the same time consume a large amount of diesel to fuel their production operations?

3) Promoting community managed model of micro/mini grid systems for increasing the access to energy for productive uses?

4) Replacing environmentally malign fossil fuels use through both the technologies, indoor pollution at household level and industry level is mitigated thereby improving the health issues of women and girl children who spend most of their time inside home

5) Assisting women to earn additional income through some household productive activities with the help of better lighting, even during late evenings

6) Supporting the Cambodian Government in formulating policies to increase access to clean energy for productive uses in the off-grid areas and agro-based SMEs?

7) Tackling some of the root causes such as quality and standards as well as lack of technical capability in improving designs preventing the widespread replication of such models?

OVERALL APPROACH AND METHODS

1. The evaluation will involve a participatory approach whereby key stakeholders will be kept informed and consulted throughout the evaluation process. Both quantitative and qualitative evaluation methods will be used to determine project achievements against the expected outputs, outcomes and impacts.

2. The findings of the evaluation will be based on the following:

    a. A **desk review** of:

        - Relevant background documentation.

- Project design documents, including outputs and activities and budget.

b. Annual Work Plans and Budgets or equivalent, revisions to the project.

- Project reports, progress reports from collaborating partners, meeting minutes, relevant correspondence etc.;
- Final report

c. Interviews (individual or in group) with key stakeholders.

d. Project management – present and former UNIDO staff.

e. Supported CSOs/SMEs

KEY EVALUATION PRINCIPLES

Evaluation findings and judgements will be based on **sound evidence and analysis**, clearly documented in the evaluation report. Information will be triangulated (i.e. verified from different sources) to the extent possible, and when verification is not possible, the single source will be mentioned. Analysis leading to evaluative judgements will be clearly spelled out.

The evaluation will assess the project with respect to **a minimum set of evaluation criteria** grouped in six categories:

(1) Strategic Relevance;

(2) Attainment of objectives and planned result, which comprises the assessment of outputs achieved, effectiveness and likelihood of impact;

(3) Sustainability and replication;

(4) Efficiency;

(5) Factors and processes affecting project performance, including preparation and readiness, implementation and management, stakeholder participation and public awareness, country ownership and driven-ness, financial planning and management, UNIDO supervision and backstopping, and project monitoring and evaluation; and

(6) Complementarity with the UNIDO strategies and programmes.

In attempting to attribute any outcomes and impacts to the project, the evaluator will consider the difference between *what has happened with and what would have*

happened without the project. This implies that there should be consideration of the baseline conditions and trends in relation to the intended project outcomes and impacts. This also means that there should be plausible evidence to attribute such outcomes and impacts to the actions of the project. In case adequate information on baseline conditions and trends is lacking, it will be clearly highlighted, along with any simplifying assumptions that were taken to make informed judgments about project performance.

As this is a terminal evaluation, the "*Why?*" question will be at front of the evaluator's minds all through the evaluation exercise, going beyond the assessment of "*what*" the project performance was. An effort will be made to provide a deeper understanding of "*why*" the performance was as it was, i.e. of processes affecting attainment of project results, providing the basis for the lessons that can be drawn from the project.

ANNEX 2. PROGRAM OF THE MISSIONS TO CAMBODIA

Mission 1 (10 – 16/01/2016)

Date	Activity	Contact	Logistics
Sunday, 10/01/2016	Arrival at Phnom Penh Airport Travel to Siem Reap by Road	UNIDO Project team	Overnight in Siem Reap
Monday, 11/01/2016	Siem Reap province: - Visit Charchuk gasification plant - Visit SBCS in Kampong Lpov commune, Battambang province	 Gasifier operator SBCS operator, district authorities and local people	Overnight in Siem Reap
Tuesday, 12/01/2016	Battambang and Pursat province: - Visit SBCS in Rukhakiri district - Visit SBCS in Beung Khna commune	 SBCS operator, district authorities and local people	Overnight in Pursat/ Kampong Chhnang
Wednesday, 13/01/2016	Kampong Cham: - Visit SBCS in Kang Meas district Phnom Penh: - Meeting at UNIDO Office - Meeting with former project staff	 SBCS operator, commune council and local people HUO Cambodia, and Project team Mr. Leuk Dana	Overnight at Phnom Penh
Thursday, 14/01/2016	Phnom Penh: - Meeting with solar equipment supplier (Eco Sun) - Meeting at the MME - Meeting at CKN Office - Meeting at the French Embassy - Meeting at Khmer Solar - Visit of solar dryer at CKN field site	 Mr. Sun Mao Mr. Toch Sovanna Mr. Im Saroen Ms. Tiphane Ferry, Mr. Serge Bellini and Mr. Didier Lecompte Mr. Ford Thai and Mr. Kunthap Hing Mr. Im Saroen	Overnight at Phnom Penh
Friday, 15/01/2016	Phnom Penh: - Meeting with former project coordinator - Debriefing at UNIDO Office	 Mr. Sok Bunheng Project team	Overnight at Phnom Penh

Saturday, 16/01/2016	Phnom Penh: - Meeting with Solar equipment supplier - Meeting with SNV Departure from Phnom Penh airport	Mr. Sun Mao SNV Biomass project coordinator	

Mission 2 (01 – 04/06/2016)

Date	Activity	Contact	Logistics
Wednesday, 01/06/2016	Arrival at Siem Reap Airport Visit to the gasifier site cancelled		Overnight in Siem Reap
Thursday, 02/06/2016	Flight from Siem Reap to Phnom Penh		Overnight in Phnom Penh
Friday, 03/06/2016	Phnom Penh: - Meeting with the local gasifier manufacturer - Meeting at UNIDO Office	Leang Than Co. Ltd. Project team	Overnight in Phnom Penh
Saturday, 04/06/2016	Departure from Phnom Penh airport		

ANNEX 3. DOCUMENTS REVIEWED

EAC, *Report of Power Sector of the Kingdom of Cambodia*, 2015

EDC & UNDP, *Cambodia Sustainable Energy for All: Rapid Assessment and Gap Analysis*, July 2013

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IED & CDEC, *SREP: Sustainable Rural Electrification Plans for Cambodia: Executive summary*, March 2011

IIS/MIH, Guideline: *Occupational Health, Safety and Environment for Biomass Gasifier Operation*, undated

KOICA, *Ex-Post Evaluation on the Project for Establishment of the Hybrid Power System in Cambodia*, December 2014

Puth Keat, *Detailed Designs and Cost Estimates of Solar Battery Charging Stations*, May 2014

Raman P., Ram N.K. & Gupta R., *A dual fired downdraft gasifier system to produce cleaner gas for power generation: Design, development and performance analysis*, Energy, 54, p. 302-314, 2013

TERI, *Rice husk gasifier based power generation system with dry gas cleaning equipment: Need for an improved gasifier system for power generation*, May 2015

TERI, *Capacity Building, Technical Services and Supply of Equipment for Biomass Gasification Project in Cambodia: Biomass gasifier fabrication manual*, October 2015

UNIDO, *Access to clean energy for productive uses, Factsheet, UNIDO, Report on Preliminary Assessment of benefits of Solar Battery Charging Station (SBCS)*, January 2012

UNIDO, *Rural Energy for Productive Use and Income Generation in Cambodia (brochure)*, 2012

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UNIDO, *Preliminary Assessment of benefits of Solar Battery Charging Station (SBCS)*, July 2013

UNIDO, Feasibility Report - *Solar Battery Charging Stations (SBCS) in Pursat and Battambang*, January 2014

UNIDO, *Access to Energy Project Achievement Brochure (draft)*, May 2016