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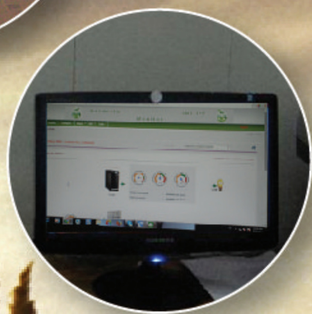
Ministry of Health & Family Welfare



EVALUATION OF SOLAR HYBRID PHOTO-VOLTAIC SYSTEM IN PRIMARY HEALTH CENTRES IN MAHARASHTRA

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Evaluation of
Solar Hybrid Photo-voltaic System
in Primary Health Centres in Maharashtra

April 2016

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Ministry of Health & Family Welfare
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MESSAGE

Public Health Delivery system is rapidly expanding in India. With the inception of NRHM in 2005, Ministry of Health and Family Welfare (MoHFW), Government of India has made significant investments to improve access to health services by the beneficiaries. The investments are continuing in consultation with state and district authorities to facilitate construction of new health facilities, with required set of equipment and trained human resources. In last 10 years, the number of facilitates to provide many RCH and life-saving services has reached close to 28,700 Community Health Centres (CHC) and Primary Health Centres (PHC).

Modern health care services require increasing use of medical equipment which are mostly electrical and electronics sensitive equipment which require good quality and reliable electricity supply. However, the non-availability of a reliable electricity grid supply, especially in the rural areas, is a significant constraint on the quality of service delivery in India's health sector. Energy security should be considered as essential for any health facilities and more focus should be provided towards the utilization of green and sustainable energy.

Experience of Health Department of Government of Maharashtra in using hybrid solar photovoltaic system as captured by this study in scaling up and replicating among 407 primary Health Centres is exemplary in terms of improving the health services and developing a reliable renewable energy supply system over 5 years.

The clean energy system deployed in Maharashtra is technically mature and robust for meeting the energy requirements of the health centres in the rural and other locations in India. All mission directors (NHM) should review the report and are strongly encouraged to use clean energy technology to improve the health delivery services. This would also help the Government of India to meet the Sustainable Development Goals 3 and 7 on improving health services and clean reliable sources of energy.

As the system is replicated in the other states, I hope National Cold Chain Resource Centre will play the central role for developing technical specifications, implementation plan and quality assurance of the system.

I congratulate the Maharashtra Government's effort in developing the indigenous solar hybrid system, which is providing energy security to the health facilities and is well aligned with the 'Make in India' initiative of the government. I also appreciate support of UNICEF, UNIDO and NCCVMRC for carrying out the evaluation.

(Ms. Vandana Gurnani)

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Prof. Jayanta K. Das, MD
Director

आरोग्यम् सुखसम्पदा

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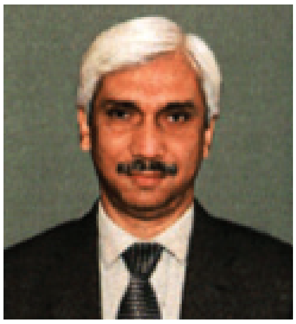
National Institute of Health & Family Welfare

Foreword



India is witnessing an expansion of its public health system with more and more medical services being provided through the vast network of Primary Health Centres (PHC). In accordance with the Indian Public Health Standards (IPHS) of the Government of India, all PHCs should have continuous electricity supply in order to sustain and maintain the wide variety of services provided.

Sustainable and uninterrupted electricity supply has been one of the major constraints in the optimum functioning of the PCHs and, as a consequence, on the public health system as a whole. It is also true that conventional grid electricity has not been able to keep pace with the growing demand and the Government of India is increasingly looking to harness alternative sources of power, an important source being solar power.

It is with this background that this study assumes special significance as it explores the various facets of utilizing an alternative source of power (the Solar Hybrid Photo-voltaic System) in order to meet the urgent demand for continuous electricity in our PHCs.

The study starts off with a basic assumption of the electricity load required in a typical PHC and goes on to explore the actual supply through the system along with its attendant benefits. This study provides key insights into the process of establishing such a SHPV system and clearly elicits its advantages, not only for the cold chain system, but also for the overall functioning of the PHC. The study also attempts to highlight the perception level impact on the end user after provision of continuous electricity to PHCs.

I take this opportunity to congratulate the Ministry of Health & Family Welfare in taking up such a vital component of health services delivery and also UNICEF in supporting this worthwhile endeavor. I also wish to acknowledge the pivotal role played by the National Cold Chain & Vaccine Management Resource Centre (NCCVMRC) in planning and implementing this study.

I sincerely wish that the findings of this study drive a greater uptake of alternative models of power sources and that we are ultimately able to deliver the full complement of services offered by our primary health centers.

(Jayanta K. Das)

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Foreword

Over the past several years, the continued partnership between the Government of India and UNICEF has led to strengthening of the country's health system. Availability of 24x7 quality electricity is a minimum requirement for the efficient functioning of a health facility. This is an important clause under the Indian Public Health Standards (IPHS) Guidelines for Primary Health Centres, as well. Ensuring continuous electricity supply using a clean energy source, in order to improve and expand the scope of health service delivery, would also assist the Government of India to progress towards the Sustainable Development Goal (SDG) 3.

In 2008, the Government of Maharashtra initiated a project to improve immunization coverage in tribal areas by increasing cold chain points and powering them through available grid electricity and solar energy. UNICEF provided the concept and design for the hybrid solar power system to the Maharashtra Government, which subsequently utilized KfW funds to pilot 58 hybrid solar power systems in the identified tribal PHCs. This system was gradually refined and improved to take the load off the entire PHCs with an in-built real-time monitoring system. Currently, over 407 health facilities have installed hybrid solar power systems through the National Health Mission resources.

Other states and possibly other developing countries may emulate the example set by the Maharashtra government. They can adopt energy security of health facilities and move beyond the immunization programme by using the hybrid solar power system. UNICEF health experts from South East Asia are already considering to replicate this model, after visiting the PHCs in Maharashtra in October 2015.

Under the 'Sustainable Energy for All' Initiative, the UNIDO South Asia office in India joined hands with UNICEF to contribute to this study. We acknowledge UNIDO's support in bringing out the report.

This assessment report highlights the importance of renewable energy sources and their integration within the PHCs. This is to provide uninterrupted power supply and enhance the quality and safety of a holistic health service delivery. It reviews the unique initiative led by the Department of Health, Government of Maharashtra, and notes its relevance, effectiveness and impact on health services. The results speak about the impact. Between 2010-2014, visits by outdoor patients doubled, indoor patients increased ten-fold, trauma and life-saving cases treated at PHCs increased 38 per cent, life-saving medical help given for snake, scorpion and dog bites, increased two-fold and laboratory procedures increased eight times. Installation of hybrid solar power systems in PHCs has helped improve Operation Theatre (OT) and newborn care services. At the same time, it has reduced annual electricity bills by 30 per cent; and electricity is available 24x7. Moreover, a conducive environment has been created for both the medical staff and patients. Patients have reported that, with round-the-clock electricity, the PHC is easily accessible any time of the day.

We are confident that the findings would form an important component of the evidence required to frame policies and investments at the national and state levels, in the near future. These are vital for a robust health system. A reliable 24x7 electricity provision would facilitate the use of electrical appliances and e/telemedicine; and thus ensure safe and high quality health service.

We congratulate the Government of Maharashtra for developing an effective high-quality hybrid solar system, which is providing much-needed energy security to remote tribal health facilities in the state. We appreciate the Government's initiative in carrying out these periodic assessments and thank the MoHFW for providing an opportunity to UNICEF for supporting this endeavour.

Louis-Georges Arsenault
UNICEF Representative to India

Foreword

In 2011, the UN General Assembly declared the year 2012 as the International Year of Sustainable Energy for All (SE4All) and established three global objectives to be accomplished by 2030 to: ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; double the share of renewable energy in the global energy mix. Energy deficit in India affects an estimated 306 million people, which is the highest among developing countries in Asia and Africa, and drags India's human development indicator. The deficit also has adverse effects on the delivery of various services which are dependent on the availability of electricity, such as education, health, water supply and sanitation in the rural areas.

In response to the call for action by the UN Secretary General's Initiative on Sustainable Energy for All (SE4All) and in view of the pressing needs of India to address the available, accessible and affordable energy provision, the UN Country Team (UNCT) in India formulated a Task Team in 2014. Leading this Task Team, United Nations Industrial Development Organization's (UNIDO) worked with UN agencies in India for increasing UN agencies' engagement to promote sustainable energy issues in their collective and strategic work in the country. Discussion around the various possibilities of collaboration among UN agencies provided useful insights on how to link the outcome of UN programmes with the core areas of SE4All. This provided a unique opportunity for the UNCT India to map out the programmes and activities of UN agencies that directly and indirectly contribute to and/or can benefit from the goals of SE4All. The information was consolidated in a Compendium, *Sustainable Energy for All – Work of UN Agencies in India,* in 2014.

The consultations among the UN agencies as well as Government counterparts opened up new ways of identifying localized problems due to the lack of or insufficient energy access, where the UN's intervention could add value. Further, it facilitated the identification of cross-cutting issues where combined UN efforts can be applied to provide the opportunities for better energy production, for increased availability of and improved access to energy at household and community levels.

One of the cross-cutting areas identified was "Health" for which UNICEF and UNIDO agreed to work and evaluate together the effectiveness of the use of Solar Hybrid Photo-voltaic (SHPV) system in the Primary Health Centres (PHCs) in Maharashtra. By jointly participating in the evaluation exercises initiated by Ministry of Health and Family Welfare, Government of

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Regional Office for South Asia

India, the UNICEF - UNIDO team looked at the issues such as suitability of design and features in respect of service delivery needs at PHCs, operational reliability as well as qualitative and quantitative assessment of benefit to the health programme. The specialized expertise of both agencies were mobilized in this exercise, i.e., UNIDO reviewed the adequacy of technical specifications of SPV system and its operation and maintenance issues, while UNICEF along with its government counterpart reviewed the impact of solar energy use on the health related issues. As a result, the report has come up with ample empirical evidence for scaling-up and provides direction on how to disseminate the most feasible models.

The report shows how SE4All could be applied on the ground and assist the country's initiatives in increasing its effectiveness and efficiency of energy provision. Ensuring continuous electricity supply and using a clean source of energy for the improved delivery of health service would assist the Government of India in enhancing their attainment of SDG 3 (to ensure healthy lives of people and promote well-being at all age levels) and SDG 7 (to ensure access to affordable, reliable, sustainable and modern energy for all by 2030).

I wish to commend the proactive involvement of the State Government of Maharashtra in scaling-up the deployment of clean sources of energy. The State Government has already expressed its commitment to spread this model to 407 Primary Health Centres in Maharashtra over the next 5 years. It is reported that the current configuration of SHPV system is sufficient to meet the electricity requirements of Primary Health Centres in the event of grid outage for up to five days.

I sincerely hope that the findings presented in this report could also support the similar endeavours both at the national level and among other Indian States to increase the clean energy application and improve the quality of health services delivery across India.

(Ayumi Fujino)
UNIDO Representative in India and
Regional Director for South Asia

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Acknowledgments

The Solar Hybrid Photo-voltaic System in Primary Health Centres Assessment was possible through the continuous guidance and generous support of the Immunization Division, Ministry of Health and Family Welfare (MoHFW), Government of India. We specially thank Dr. Rakesh Kumar, Joint Secretary, Reproductive and Child Health and Dr. M.K. Aggarwal, Deputy Commissioner, Universal Immunization Programme, MoHFW for their support for this initiative. We especially acknowledge Dr. Satish Pawar, Director, Health Services for his candid remarks on the background information and benefits to state's health department.

We are grateful to UNICEF and UNIDO for providing high quality technical support and leadership to bring out this report. We further acknowledge the pivotal role played by Dr. Vitthal Bandel, Coordinator, National Cold Chain Resource Centre for his association with this initiative and providing technical and historical insights. We especially thank National Cold Chain and Vaccine Management Resource Center, under the National Institute of Health and Family Welfare, which functioned as the secretariat for carrying out this evaluation.

A special mention needs to be made of all staff of National Cold Chain Resource Centre and officials of state, district and primary health centres in Maharashtra, officials of Directorate of Health Services and National Health Mission officials for providing feedback on the system use and remote monitoring mechanism and also facilitating the evaluation team's field visits. Generous financial assistance through GAVI-Health System Strengthening is greatly appreciated.

Acronyms

AMC	Annual Maintenance Contract
CE	Conformité Européene (European Conformity)
CCE	Cold Chain Equipment
CHC	Community Health Centres
CMC	Comprehensive Maintenance Contract
FRU	First Referral Unit
GPRS	General Packet Radio Service
GSM	Global System for Mobile (communication)
GOI	Government of India
ILR	Icelined Refrigerator
INR	Indian Rupees
IPD	Indoor Patient Department
IEC	International ElectroTechnical Commission
KfW	Kreditanstalt für Wiederaufbau (German government owned development bank)
LED	Light Emitting Diode
MoHFW	Ministry of Health and Family Welfare
NCCVMRC	National Cold Chain and Vaccine Management Resource Centre
NCCRC	National Cold Chain Resource Centre
NCCTC	National Cold Chain Training Centre
NHM	National Health Mission
NIHFW	National Institute of Health and Family Welfare
NRHM	National Rural Health Mission
PQS	Performance Quality and Safety
PHC	Primary Health Centre
RCH	Reproductive and Child Health
RDSO	Research Designs & Standards Organization
RMNCHA+	Reproductive Maternal Newborn Child and Adolescents Health
SE4All	Sustainable Energy for All
SNCU	Sick New-born Care Unit
SHPV	Solar Hybrid Photo-voltaic System
UPS	Uninterrupted Power Supply
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

Credentials

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Executive Summary

Background

The Public Health Delivery system is rapidly expanding in India. With the inception of National Rural Health Mission (NRHM) in 2005, Ministry of Health and Family Welfare (MoHFW), Government of India has made significant investments to improve access to health services. The investments continue in consultation with state and district authorities to facilitate construction of new health facilities with requisite equipment and trained human resources. In the last 10 years, the number of Community Health Centres (CHCs) and Primary Health Centres (PHCs) providing many Reproductive and Child Health (RCH) and life-saving services has reached almost 28,700.

As the Reproductive Maternal Newborn Child Health and Adolescent (RMNCHA+) initiative has gained momentum since 2013, the requirement of adequate infrastructure and skilled manpower to deliver health services has increased. Further, since 2014, MoHFW has focused more on health assurance and improving quality of service delivery through health facilities, using and offering more sophisticated services which require continuous electricity supply for efficient service delivery. Services offered go beyond primary prevention and also include clinical services. As per the Indian Public Health Standards (IPHS), even First Referral Units (FRUs) require continuous electricity supply.

Due to geographical locations and other resource constraints the availability of electricity, water and human resources among CHCs and PHCs has not been consistent across locations. This affects delivery of health services and lowers beneficiaries confidence of finding a facility functioning at odd hours or when needed.

There are innumerable instances where quality of power supply has affected electric and electronic equipment needed in the pathology laboratory for testing, functioning of operating room and new-born care units at a health facility.

This report summarizes the findings of the Evaluation Mission conducted in Maharashtra from September 21-26, 2014, to understand the impacts of "Solar Hybrid Photo-voltaic Systems in Primary Health Centre" (hereinafter referred to as the Project) which received a grant funding of Rs. 353,000,000 (INR Three hundred and fifty-three million) from the National Health Mission of Government of India. The project is a successor to the earlier initiative of Deputy Director of Health Services (DDHS), Pune on strengthening "Cold-Chain Equipment (CCE) in vaccine delivery" which focused on improving the operation and functioning of CCE using solar hybrid photo-voltaic systems to maintain required temperature and reduce wastage and non-availability of vaccines in rural areas through Primary Health Centres.

Context of Evaluation

UNICEF is working with MoHFW to strengthen the health system through the establishment of functional institutions; development and support in implementation of Management Information System (MIS) for programme planning and monitoring; strengthening of immunization supply chain; ensuring continuous electricity for vaccine safe keeping; and contributing to conceptualization of the electricity supply through renewable energy.

Since 2010, UNICEF has carried out advocacy with MoHFW about the advantages of using solar energy in health facilities over and beyond the immunization programme, based on initial results of hybrid photo-voltaic system of Government of Maharashtra. UNICEF supplied exclusive solar refrigerators for the immunization programme in 2010. These faced many operational challenges since the primary health centre itself did not have a reliable grid electricity supply. Therefore, the solar refrigerator did not result in strengthening the health delivery system especially in the remote inaccessible areas where these were installed. Additionally, all the solar refrigerators procured by UNICEF were imported and availability of spare parts became another challenge to operation and maintenance. In comparison, the Solar Hybrid Photo-voltaic System (SHPV) installed by the Maharashtra Government in PHCs allowed the existing cold chain equipment (ILR and deep freezer) to be used.

Several supportive supervision visits by officials of Ministry of Health and Family Welfare, State Health Department officials and partners have confirmed the benefits of these systems. Discussions between UNICEF and MoHFW led to a decision to conduct an assessment to generate evidence on the usefulness of the system and its benefit in the delivery of health care system. UNICEF, with the consent of MoHFW, prepared the composition of the team, and engaged UNIDO, which had the expertise required for carrying out the evaluation. MoHFW formed a core group under the Chairmanship of Director NIHFW to carry out the study with technical support of UNICEF and UNIDO. Refer Appendix A.

Solar powered light and electronic message board at Out Patient Department in PHC, Nagothane

UNICEF and MoHFW held several rounds of discussion and agreed to objectively assess the benefits of solar hybrid systems used in the PHCs in Maharashtra. During a meeting between MoHFW and UNICEF on 12 December 2013, it was agreed that UNICEF would conduct an assessment of the impact made by solar-hybrid power supply made on the health services. It was subsequently agreed by MoHFW to take technical support of UNIDO in carrying out the evaluation under Sustainable Energy for All initiative.


Solar panels on roof of PHC, Nagothane

United Nations Industrial Development Organization's (UNIDO) South Asia Regional Office in India, led the effort on increasing UN agencies' engagement by establishing a platform to promote sustainable energy issues in their collective and strategic work in India.

This provided a unique opportunity for the UN Country Team to map the programmes and activities of several UN agencies that directly and indirectly contribute to and/

or can benefit from the goals of SE4All. The consultations opened up new ways of identifying localized problems due to the lack of or insufficient energy access, where the UN's intervention could add value and further identified four cross-cutting issues where combined UN efforts can be applied to provide energy and development at household and community levels. These cross cutting issues are: (a) livelihood, (b) natural resource management, (c) sanitation, and (d) health.

This joint evaluation by UNICEF, UNIDO and National Cold Chain and Vaccine Management Resource Centre (NCCVMRC) was undertaken under the aegis of SE4All to study the impact of access to modern energy services in the health sector and provide independent feedback to MoHFW on the way forward.

The UNIDO technical expert led the preparation of an evaluation framework using the template used in the evaluation of international projects implemented by UNDP and UNIDO. The evaluation questionnaire was prepared by UNIDO in close consultation with UNICEF. This was discussed with National Institute of Health and Family Welfare (NIHFW) and finalized. Finally, UNICEF and NIHFW officials decided members of the team, who were sensitized about the nuances of this particular evaluation before the team went for field assessment.

Objectives of Evaluation

The objectives of this evaluation were to Assess:

- Suitability of design and features in respect of service delivery needs at PHCs;
- Operational reliability (including after sale service/ downtime) and user friendliness of the system for non-technical staff at the health facility level;
- Qualitative and quantitative benefits to the health programme;
- Results of a Strengths Weaknesses Opportunities and Threats (SWOT) study analysis and provide suggestions for scale-up to the state and central governments considering the vast country-wide need to strengthen health systems.

Methodology of Assessment

A core group of 10 professionals from MoHFW, NIHFW, NCCVMRC, UNICEF and UNIDO was constituted to prepare specific terms of reference for the evaluation; prepare the questionnaire and sampling framework; and undertake the evaluation.

The evaluation questionnaire was prepared by UNICEF and UNIDO based on the objectives of the study and in consultation with MoHFW and NIHFW, based on previous studies of the cold-chain and vaccine management in the health sector, and evaluation methodology used by Global Environment Facility (GEF) for renewable energy projects.

In Maharashtra, the SHPV systems are installed throughout the state in 407 PHCs which are spread across 28 out of 31 districts. Therefore sampling was done to provide a representative finding for the state based on the Effective Vaccine Management sampling tool which is used for various studies. Out of 407 PHCs that have SHPV systems, a sample size of 40 was agreed upon which provides about 90 per cent confidence interval with 12.5 per cent margin of error. Factors that were considered while selecting individual PHCs included version (vintage), RMNCHA+ district score, and location of the PHC (tribal and non-tribal).

The evaluation of Solar Hybrid Photo-voltaic System in PHCs was carried – out under the following major headings:

1. Relevance of SHPV for providing reliable health services in remote rural areas
2. Effectiveness in increasing PHC operation and medical services
3. Efficiency in improving PHC function and service delivery to the community
4. Sustainability in the form of financial, institutional, social and environmental for replication
5. Impact in providing enabling environment for improving health services

The study team carried out quantitative and qualitative assessments and collected data from the field based on interviews and records maintained by the PHCs. The information and data gathered by team members from field visits was consolidated and reviewed for consistency and accuracy by the core group members.

Assessment of Project Outcomes

The project was able to achieve the overall objective of providing uninterrupted power to Primary Health Centres (PHCs), ensuring the functioning of cold chain equipment and other equipment, using a combination of battery-inverter and SHPV system which is provided to charge the batteries. Grid power is used as a back-up source for charging batteries during non-sunshine days in monsoon.

> "We are able to provide continuous good quality electricity in tribal health facilities. This has helped to provide quality health services in remote health centres."
>
> Dr. Satish Pawar
> Director Health Services
> Government of Maharashtra

- With the installation of SHPV, PHCs have started operating round the clock (or 24x7) as they have an assured source of power supply which greatly helps the medical staff on duty, such as Medical Officer, Medical Assistant, nurses and other staff, to focus on their work.
- In-door patients spend a longer time in the PHC and receive medical care, especially post-surgery or post-delivery. Continuous availability of electricity and full medical facilities are encouraging the local rural population to visit PHCs, which have begun to match the facilities provided by private clinics.
- No equipment failure has been reported from PHCs in which SHPV systems have been installed, although failure of medical equipment is common in PHCs that are dependent on grid electricity with fluctuating voltage conditions. There are significant cost-savings for the state health department as annual expenditure on replacement of medical equipment or its components has reduced.
- PHCs that are operating with a SHPV system consider it an essential basic requirement to provide necessary medical services to the local population.

The installation of SHPV system was in response to fulfill a local need to improve the vaccine storage through cold chain equipment in PHCs. The SHPV underwent design upgrades to overcome the limitations of the original system and the design has matured overtime. The installation and design upgrades were funded by the Government of Maharashtra using the support of National Health Mission (NHM) and technical support was provided by National Cold Chain Technology Centre (NCCTC) based in Pune.

From 2008-09 till date, SHPV systems have been installed in 407 PHC in 29 districts of the state. These SHPV systems are being monitored by the State's Health Department unit in Mumbai. Out of these 407 SHPV systems, 72 are covered with 5-year warranties followed by 5-year comprehensive maintenance contracts with the suppliers, thereby ensuring that each SHPV system purchased remains fully functional for a minimum 10-year period with proper maintenance and replacement of parts as required from time to time. This also shows ingenuity in overcoming the challenge of financial constraints faced by government departments in receiving technical support and after sales service in maintaining such systems in remote rural areas on an on-going basis.

Key Findings

The investigating team consolidated its findings after the site visits and observed that one of the key-attributes to improvement in services, staff motivation and client confidence was the continuous availability (24x7) of good quality electricity supply throughout the year in the sampled PHCs. The environment for medical staff posted in the PHCs is conducive to working in the evening and night, when emergency health services are mostly needed. Following are the key findings of the evaluation team:

1. Maximum interruption in grid electricity supply happens during the monsoon season, with 56 per cent PHCs experiencing outages of over four hours. The remaining 44 per cent of PHCs which receive electricity for more than 20 hours, experience voltage fluctuations during the evening which harms medical equipment. With the help of SHPV system 24x7 electricity has been provided in 407 PHCs, which are designated as IPHS centres.
2. Department of Health Services Government of Maharashtra, has innovatively included a 5 year comprehensive maintenance contract and 5 year extended warranty clause to overcome the constraint of operation and maintenance of the system. This has ensured that the PHC will have a functional SHPV system for a minimum of ten years.
3. Since the regulated electricity at constant voltage and frequency was provided to critical and sensitive medical equipment through an inverter, no breakdown or failure of medical equipment, including cold-chain equipment, was reported from the time SHPV system was installed, as reported by the evaluation team.

> The breakdown rate of medical equipment in PHCs having SHPV systems has reduced significantly. For instance, OT lamps needed to be replaced every six months but now we rarely receive a request for replacement once in 3 years.
>
> As a result, the state government is considering provision of better equipment in the PHCs for further improving the quality of health services.
>
> Dr. Satish Pawar
> Director Health Services
> Government of Maharashtra

4. Between 2010 and 2014, sampled PHCs reported two–times increase in outdoor patients, 10–times increase in indoor patient visits, 38 per cent increase in trauma and life-saving cases being treated in PHCs, life-saving intervention provided for snake, scorpion and dog bite increased by 2–times and laboratory procedures increased by 8–times.

5. Seventy-one (71) per cent of sampled PHCs reported improved health services for new-born care unit and 22 per cent reported improved OT services.

6. Continuous and reliable power availability 24x7 has increased PHC staff's ability and confidence to attend to patients, perform emergency procedures as well as deliveries anytime. Staff from 81 per cent of sampled PHCs informed that erratic and inadequate power supply had earlier affected the delivery of critical health services like conducting deliveries, undertaking emergency surgeries, resuscitation of newborns and emergency treatment in cases of road traffic accidents, snake bites and poisoning.

7. Clients in 95 per cent of sample PHCs agreed that health services were greatly improved due to 24x7 availability of electricity in the PHC. Clients in 44 per cent of sampled PHCs reported that they felt safe bringing children to the health facility. Visitors in 95 per cent sampled PHCs reported that the health facility was easily accessible anytime in 24 hours.

8. PHCs with SHPV system reported 30 per cent reduction in annual electricity bill along with 24x7 availability of electricity.

9. Safety and security of the PHC staff, especially the female staff, increased during night hours. The PHC remains fully illuminated even at case of grid power failure and remains accessible for local population even at odd hours of the night.

10. Stay of indoor patients, especially post-delivery or after surgery has been positively influenced by availability of reliable and continuous power. The general wards are fitted with LED lights, fans and mobile charging facilities.

11. All the sampled PHCs had functional pathology labs and were able to conduct tests for malaria, tuberculosis in addition to routine microscopic tests conducted in a health centre.

12. All the sampled PHCs were able to send daily reports to the state health directorate due to functional office equipment and Internet connectivity even during power outages.

13. The SHPV vendors are essentially system integrators based in Maharashtra. All the components used are commercially available in India. This reduced the cost of after-sales service including spare parts. The technical specifications of SHPV system have evolved with learnings from the field and have reached maturity with stable design and configurations to meet different service requirements and different conditions of grid electricity of the PHCs.

14. Existing configuration of SHPV system and its technical specifications were found to be adequate for providing electricity in the entire PHC for 3 days and upto 5 days for running cold chain equipment in case of continuous grid failure and non-availability of sunshine. This ensures energy security of the health centre. The remote monitoring feature being used in the most recent version of SHPV system has helped the government also to keep a daily track of the health of each individual SHPV system. A comparative study of different options of back up power system along with lifetime cost is included in Appendix D.

Due to continuous electricity availability and staff motivation the sampled PHCs were able to handle emergency cases effectively, which otherwise would be referred to the district health facility or nearest higher centre. Based on the above it is evident that most health facilities require good quality 24x7 electricity to function at optimal capacity and serve the population, particularly in rural areas.

Key Recommendations

Observing the benefits SHPV system is delivering in PHCs, it is recommended that the concept of powering PHCs with a clean source of energy, as demonstrated by SHPV unit, needs to be replicated among remaining PHCs in Maharashtra.

In August 2015, the Ministry of New and Renewable Energy issued a letter urging all central government ministries and departments, state government departments, institutions and organizations to install grid connect solar rooftop system on the buildings to generate clean energy. (Refer Appendix B)

Additionally, Ministry of Health and Family Welfare needs to make policy changes to allow procurement and installation of SHPV systems in Primary Health Centres throughout the country using resources of National Health Mission, mobilizing Corporate Social Responsibility CSR funds, and forging long-term public-private collaborations.

The effort of replication in scale-up in other states should begin with:

1. Exposure visits for state health officials to PHCs with SHPV systems coordinated by Government of Maharashtra.
2. An agency like National Cold Chain Resource Centre (NCCRC) should be appointed as the nodal center to coordinate between interested states, Government of Maharashtra and MoHFW.
3. The role of NCCRC needs to be defined as a technical support organization to assist state governments in procurement, installation, commissioning and post-commissioning follow-ups with suppliers of SHPV systems.
4. NCCRC, while assisting Government of Maharashtra in the procurement of SHPV systems, may also assist other states in developing specifications based on the local requirements and provide technical support in the procurement process. The typical procurement of SHPV system should mandatorily include at least a 5-year warranty followed by 5-year comprehensive maintenance contract.
5. NCCRC in consultation with interested states must identify multiple system integrators within the state and organize a national consultation workshop on the requirement of health facilities.
6. Use of energy efficient appliances such as super-efficient ceiling fans and LED based lights in PHCs will help to extend the duration of back up power supply.

Way Forward

Energy security of health facilities should be the prime consideration while planning for its establishment. Goal 3 and Goal 7 of the Sustainable Development Goals, to which Government of India is a signatory, requires the health and clean energy challenges to be overcome by 2030. This calls for a long term work-plan for phasing–in of clean and sustainable energy sources and improving health services. The evaluation provides the following way-forward:

1. Certain percentage of health budget should be earmarked for accelerating deployment of clean energy sources in health centres in a phased manner.

2. Indian Public Health Standard (IPHS) should be amended to include clean energy source for providing back-up power to health facilities.

3. NCCRC should be designated as the National Secretariat to work for adoption of clean energy in the health sector with support from other line ministries and development partners.

4. Increased use of clean energy sources in the health sector, as concluded in the evaluation study, provides a two-pronged approach to MoHFW to address PMO's 'Make in India' initiative as well as move decisively towards attaining Sustainable Development Goals 3 and 7. This would also help to fulfill Government of India's target to install 40,000MW grid-connect solar roof top systems by 2022.

SECTION 1 INTRODUCTION

In rural Maharashtra, where power outages averaging 6 to 8 hours daily are common, ready availability of solar power in primary health centres across four districts has improved the local community's access to basic health services, especially safe child birth and immunization. The unique green electrification project, initiated by the state government in 2008, has been supported by UNICEF.

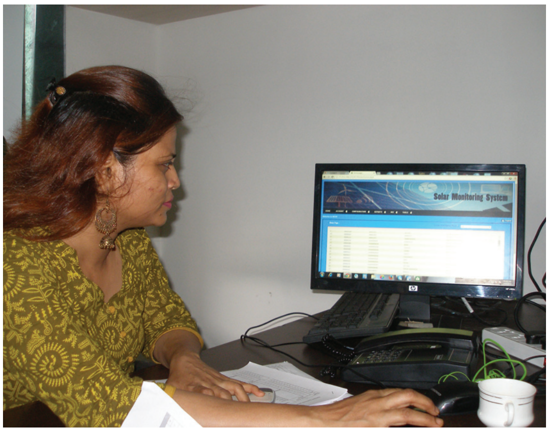
1.1 Background

Ministry of Health and Family Welfare (MoHFW), Government of India has made significant investments to improve access to health services since the inception of National Rural Health Mission (NRHM) in 2005. The investments continue in consultation with state and district authorities to facilitate construction of new health facilities, with requisite equipment and trained human resources. In the last 10 years the number of Community Health Centres (CHC) and Primary Health Centres (PHC) providing many (Reproductive and Child Health (RCH) and life-saving services has reached almost 28,700. As the Reproductive Maternal Newborn Child Health and Adolescent (RMNCHA+) initiative has gained momentum since 2013, the requirement of adequate infrastructure and skilled manpower to deliver health services has increased. Further, since 2014, MoHFW has focused more on health assurance and improving quality of services delivered through the health facility.

The immunization programme of India is delivered through outreach sessions that are located in villages and receive vaccines from cold chain points located in CHCs/PHCs. Improved immunization coverage also requires a functional cold-chain point with an effective vaccine delivery system and skilled vaccinators. As per the report of Coverage Evaluation Survey 2009, 60 per cent of the immunizations in India are conducted in outreach sessions. Functionality of a cold chain point depends on functionality of the Ice Lined Refrigerator (ILR) and deep freezer for vaccine storage, which require at least 20 hours of electricity supply in a day. In India, 60 per cent of the health facilities receive less than 20 hours' of electricity supply. Therefore, adequate and reliable good quality electricity is required to strengthen immunization system delivery.

The tribal districts in Maharashtra were lagging behind in making the cold-chain points functional due to the absence of reliable grid supply. To address the issue, in 2008, Health Equipment Maintenance and Repair unit (HEMR) of State Health Transport Organization (SHTO), Pune, Government of Maharashtra, with technical support of UNICEF, piloted a programme to strengthen immunization coverage in the tribal districts which have erratic and poor quality grid supply. The concept of designing the system to operate the cold chain equipment through solar photo-voltaic system due to the constraints in the availability of grid electricity, emerged as a solution for strengthening the immunization programme. The dual power supply functionality was considered to optimize the size of the solar photo-voltaic system since the grid electricity availability in the rural areas also varied according to seasons.

The initial concept and design were provided to SHTO by UNICEF's technical expert under its Cold Chain Strengthening programme with Ministry of Health and Family Welfare. The trial version (version 0) was piloted in October 2008 and designed to operate only cold chain equipment. On observing the benefits of the system, Department of Health and Family Welfare (DHFW), Government of Maharashtra, decided to augment the capacity of the system to



On-line monitoring of SHPV systems

Joint Secretary, RCH, MoHFW reviewing SHPV system in a PHC near Pune

include additional critical equipment and lighting of primary health centres. With this modification, version 1 of Solar Hybrid Photo-voltaic (SHPV) system design was finalized.

Based on user feedback and demand for better capacity and features, the SHPV system has undergone several changes and has incorporated a set of features that benefit any type of power situation, i.e. grid power supply available for 4-6 hours or more, or no grid availability at all. To troubleshoot equipment in remote locations or to remotely change its settings, the equipment is fitted with a Global System for Mobile (GSM) communication module that facilitates continuous monitoring of its functional status and can change settings remotely, using a computer and mobile network connection.

Government College of Engineering, Pune provided technical support for design, improvements and testing. This system has been made ready for replication in different operating conditions.

Several supportive supervision visits by officials of Ministry of Health and Family Welfare and State Health Department, as well as partners confirmed the benefits of SHPV system. Discussions between UNICEF and MoHFW led to a decision to conduct an assessment to generate evidence on the usefulness of the system and its benefit in the health delivery system Refer Annex A. UNICEF, in close collaboration with UNIDO, developed the evaluation tool and questionnaire which UNIDO which is used in programme evaluation. These were further customized in discussions with National Institute of Health and Family Welfare (NIHFW), Community Health Administration Department to capture health service related issues. The evaluation tools and questionnaire were finalized for data collection through field visits and interviews.

Adequacy of technical specifications of the SHPV system and comparison with diesel based power back up system was reviewed by UNIDO while the health system related issues at PHC were evaluated by National Cold Chain and Vaccine Management Resource Centre (NCCVMRC), which is a part of NIHFW, and UNICEF.

1.2 Evaluation

1.2.1 Purpose of the Evaluation

Project evaluations assess the efficiency and effectiveness of a project or programme in achieving its intended results. They also assess the relevance and sustainability of outputs as contributions to medium-term and longer-term outcomes. Projects can be evaluated during the time of implementation, at the end of implementation (terminal evaluation), or at a time after the project has ended (ex-post evaluation).

This report can be considered as a mid-term evaluation of Government of Maharashtra's on-going efforts to provide uninterrupted power supply in PHCs.

Under National Health Mission, many state governments have been spending significant resources on providing alternate power supply, mostly through diesel generators or the installation of uninterrupted power supply (inverter with battery pack). However, these are neither comprehensive alternate power solutions designed for the entire health facility nor these are backed by long-term comprehensive maintenance support service from the suppliers. Further these systems are not environment friendly and require dedicated manpower for operation and maintenance. Diesel generators also contribute to noise and air pollution in and around the health facility and require operation and maintenance funds, including manpower.

Several solar powered solutions for cold chain equipment were introduced around 2005 without properly understanding the requirements of health facilities. These systems had non-standard components and poor specifications along with inadequate after sales support that affected their reliability. The locations for installation were selected inappropriately which led to non-utilization of solar power systems.

Solar refrigerators supplied by UNICEF in 2010 for the immunization programme also faced many operational challenges since PHCs themselves did not have reliable grid electricity supply. Therefore, the solar refrigerators did not strengthen the health delivery system, especially in the remote inaccessible areas where they were installed. Since the solar refrigerators procured by UNICEF were imported, availability of spare parts also became an operation and maintenance challenge.

As a result of these poor outcomes, decision makers viewed investment in solar powered systems as a non-viable solution for alternate power supply. This led to decisions favouring diesel powered systems, despite the obvious disadvantages of high maintenance, requirement of human

> "Ours is a IPHS PHC, for which 24x7 availability of electricity is a prerequisite. Due to SHPV system, health services are provided without any hindrance as there is continuous availability of electricity staff does not even notice any power interruptions. Frequent failures of equipment such as suction machine, and OT lamp, due to erratic electricity supply have stopped.
>
> Patients visiting PHC during night are mostly emergency cases. With a SHPV system, the PHC staff is able to easily attend to such cases."
>
> Dr. Sachin Gomsale
> Medical Officer (Male) – Primary
> Health Centre Borli Panchataran

resources for operation and noise and air pollution in the health facility premises.

After 2008 and especially after 2010, several technological upgradations along with reduction in price of SHPV system and LED lighting have taken place globally and in India. As part of cold-chain strengthening, in 2008, Department of Health and Family Welfare, Government of Maharashtra worked with UNICEF and Kreditanstalt für Wiederaufbau (KfW) to introduce solar photo-voltaic power back–up systems in tribal rural health facilities for strengthening of the immunization delivery system. The penetration of solar powered systems in health facilities has spread from 52 at the time of introduction in 2008 to 407 by 2014. Government of Maharashtra plans to scale–up this system to the remaining 1,400 health facilities in the coming years.

Since 2011, UNICEF has been carrying out advocacy with policy makers at central and state governments about the benefit of solar hybrid systems in improving delivery of health services. UNICEF facilitated several visits to installation sites to witness the benefits and operational feasibility. A series of presentations were made in national level review meetings of cold-chain officers of the states in 2013. In addition to this, presentation was also made by the Deputy Commissioner (Universal Immunization Programme) in a meeting organized by Ministry of New and Renewable Energy (MNRE). Subsequently, MoHFW requested UNICEF to undertake an evaluation to assess the benefits of solar power systems installed in Maharashtra.

The first core group meeting was held in December 2013, at the National Institute of Health and Family Welfare (NIHFW). At the same time, the United Nations Country Team (UNCT) held a task force meeting on Sustainable Energy for All (SE4All), the initiative of the Secretary-General of the United Nations. The UNCT identified four themes for joint collaboration among UN agencies in India to promote the SE4All initiative, which included health as a one of the themes. Subsequently, UNIDO agreed to collaborate with UNICEF in carrying out the evaluation and document the application of renewable energy in health care as a unique example that fits the theme of Sustainable Energy for All.

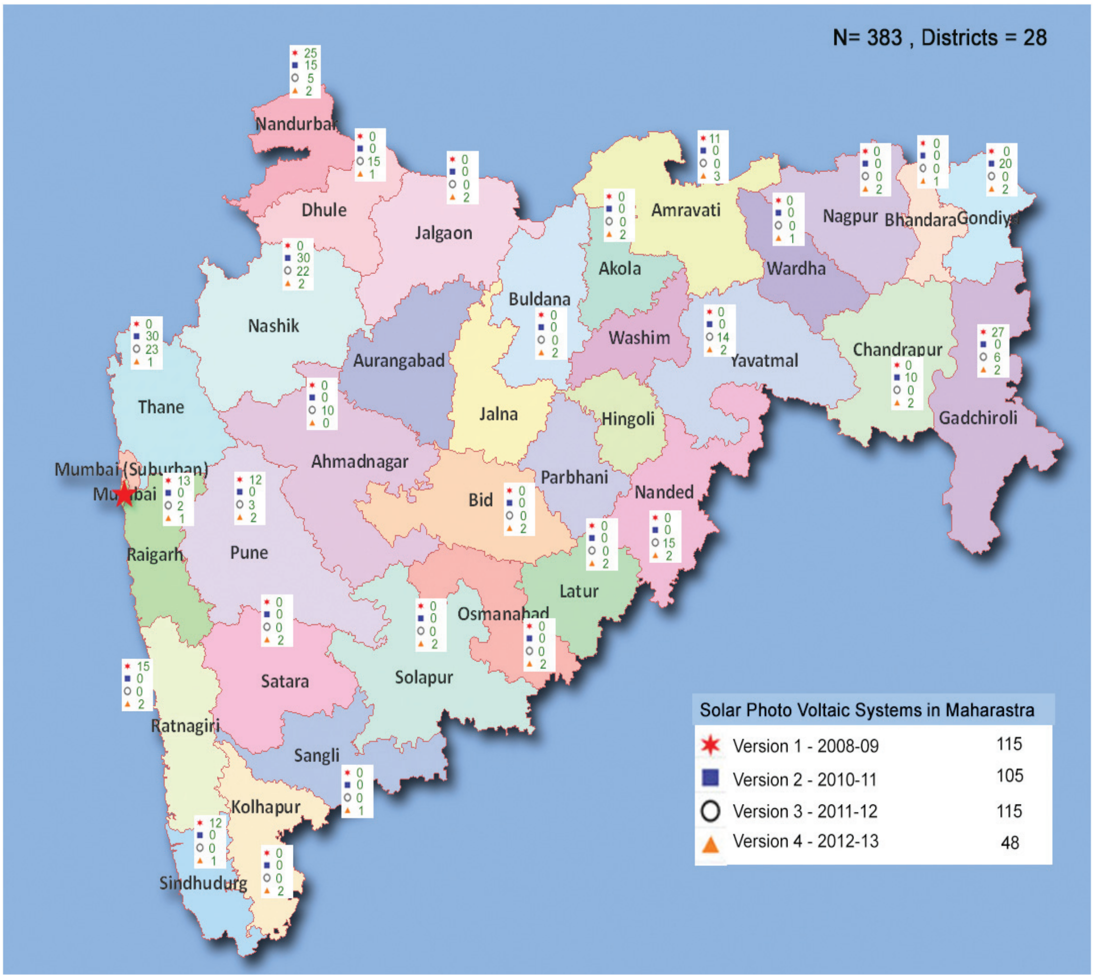
1.2.2 Objectives of Evaluation

The objectives of this evaluation are to:

- Assess suitability of design and features in respect to service delivery needs at PHCs;
- Assess operational reliability and user friendliness of the system for non-technical staff at health facility level;
- Provide qualitative and quantitative assessment of the benefits to the health programme; and
- Conduct SWOT analysis and provide suggestions for scale-up to the Central and state governments, considering the large need across the country for strengthening the health systems.

Outputs from this evaluation are expected to provide guidance in charting future directions for state and country wide scale-up and deployment of SHPV systems in health facilities as a National Mission Initiative.

Districts of Maharashtra with different versions of SHPV in health facilities (as of April 2013)



1.2.3 Evaluation Methodology

The methodology adopted for this evaluation includes:

1. **Constitution of a core group:** A core group of 10 professionals from MoHFW, NIHFW, NCCVMRC, UNICEF and UNIDO were tasked to prepare specific terms of reference for the evaluation, prepare questionnaire, sampling frame work and undertake the evaluation.

2. **Preparation of an evaluation questionnaire:** An evaluation questionnaire was prepared in consultation with MoHFW, NIHFW, UNICEF and UNIDO based on the objectives of the study. It drew from previous studies of the cold-chain and vaccine management in the health sector as well as the evaluation methodology used by Global Environment Facility (GEF) for energy projects.

3. **Selection of sample PHCs:** Since SHPV systems were installed in 407 PHCs located in 28 out of 31 districts, sampling was done to provide a representative finding for the state, based on Effective

Vaccine Management (EVM) sampling tool which has been used for various studies. Out of 407 PHCs that have SHPV systems, a sample size of 40 was agreed upon that provides 90 per cent confidence interval with 12.5 per cent margin of error. The following factors were considered while selecting individual PHCs for the field visits:

a) ***Vintage of SPHV system*** based on its configuration and communication technology (also referred as version). Since four versions have been deployed since 2008, samples were carefully prepared for equal representation of each version with 10 numbers of each version (25 per cent of overall sample);

b) ***Locations of PHC*** in tribal and non-tribal districts;

c) ***RMNCHA+ score*** of the district. The score is a composite indicator of health services with a maximum score of 1 as the best indicator of the district's performance on health parameters. The lowest 10 performing districts with scores less than 0.482 were selected for assessment based on availability of all the four versions of SHPV systems.

4. **Formation of evaluation teams:** Based on the total sample size of 40, eight evaluation teams were formed and each team evaluated two to six PHCs over a period of a week. The teams comprised NIHFW faculty, UNICEF and UNIDO specialists, NCCVMRC consultants, and MD students of NIHFW.

5. **Quantitative and qualitative evaluation:** Strategies for quantitative and qualitative evaluation were used during field visits to health facilities including observation; semi-structured interviews; data collection from PHC records; and interaction with users, especially where examples of saving lives were available and attributed to the availability of electricity/ staff at odd hours.

6. **Interactions:** Were held with staff delivering health services such as lady health visitors, auxiliary nurse mid-wives, nurses, lab technicians, data entry operators, IPD and OPD patients and their attendants, Medical Officers in-charge of health facilities, district Chief Medical Officer and District Immunization Officer, state officials including Director of Health Services and vendors.

7. **Data analysis and development of recommendations:** These were done along with NIHFW faculty and core group members.

8. **Debriefing:** Debriefing to Deputy Commissioner – Universal Immunization Programme, MoHFW was done by UNICEF. A similar debriefing of the findings was provided to the Maharashtra state government. Details of sites visited and the team members is presented in Appendix C and a list of people interviewed is included in Appendix D. The evaluation questionnaire sample is presented in Appendix E. Appendix F and G provide system details and its technical specifications.

Table 1: Sampling based on RMNCHA+ district score and vintage of SHPV systems

		Number of locations and version type					No of sites selected for assessment				
District	**RMNCHA+ Performance**	**V1**	**V2**	**V3**	**V4**	**Total**	**V1**	**V2**	**V3**	**V4**	**Total**
Dhule	0.3739	-	-	15	1	16	-	-	3	1	4
Nandurbar	0.4333	25	15	5	2	47	4	2	-	0	6
Latur	0.4529	-	-	-	2	2	-		-	2	2
Solapur	0.4609	-	-	-	2	2	-		-	2	2
Nagpur	0.4614	-	-	-	2	2	-		-	2	2
Nashik	0.4634	-	30	22	2	54	-	4	1	1	6
Raigad	0.472	13	-	2	1	16	2	-	2	-	4
Thane	0.4721	-	30	23	1	54	-	4	2	-	6
Pune	0.4788	12	-	3	2	17	4	-	2	-	6
Buldhana	0.4806	-	-	-	2	2	-		-	2	2
Beed	0.4823	-	-	-	2	2					
Satara	0.488	-	-	-	2	2					
Yawatmal	0.499	-	-	14	2	16					
Wardha	0.504	-	-	-	1	1					
Nanded	0.5045	-	-	15	2	17					
Jalgoan	0.5116	-	-	-	2	2					
Chandrapur	0.5139	-	10	-	2	12					
Osmanabad	0.5188	-	-	-	2	2					
Gondia	0.5228	-	20	-	2	22					
Ratnagiri	0.5239	15	-	-	2	17					
Ahmednagar	0.5296	-	-	10	-	10					
Amaravati	0.5476	11	-	-	3	14					
Kolhapur	0.5503	-	-	-	2	2					
Sangli	0.5724	-	-	-	1	1					
Akola	0.5782	-	-	-	2	2					
Bhandara	0.6012	-	-	-	1	1					
Gadchiroli	0.6019	27	-	6	2	35					
Sindhudurg	0.6189 4	12	-	-	1	13					
Total		115	105	115	48	383	10	10	10	10	40

Colour code: – score below 0.481 – score below 0.597, – above 0.598

SECTION 2

SHPV SYSTEM DESCRIPTION AND DEVELOPMENT CONTEXT

Primary Health Centres (PHCs), usually located in remote areas, cater to the poorest of the poor. This facility in Thane district is one of the 407 PHCs that have 24x7 solar photo-voltaic based back-up power to keep the general wards, out patient department (OPD), labour room, pathology laboratory and the operation theater running even during a blackout.

2.1 Concept Development

The SHPV systems initiative which started in 2008–09, with funding support of KfW and technical support of UNICEF, proceeded in four distinct phases.

- During the first phase (2008–09), 115 SHPC systems were installed in PHCs.
- During the second phase (2010–11), an additional 105 systems were installed.
- During the third phase (2012–13), 105 systems were installed.
- During the fourth phase (2013–15) another 72 systems were installed.

In each phase, the learning gained in the operation of the SHPV systems was used to improve the technical specifications and design configuration for the following phase. Overall, during the six years a total of 407 SHPV systems have been installed in PHCs. The table below shows the addition in SHPV system installation, the version and its capacity.

Table 2: SHPV systems installed year-wise

Year	SHPV installed	Version	Solar Panels Capacity	Remark
2008-09	63	First	160Wp	Industrial grade lead-acid batteries
2009-10	52	First	160Wp	Industrial grade lead-acid batteries
2010-11	105	Second	270Wp	Industrial grade lead-acid batteries
2011-13	115	Third	5,280Wp	GSM enabled for remote monitoring
2013-15	72	Fourth	5,280Wp	GPRS enabled for continuous web-based monitoring at the centralized location
Total	**407**			

2.2 Objectives of SHPV System Project

The objective of the project was to provide uninterrupted power supply in primary health centres through a hybrid system of grid–fed and SHPV systems to ensure operation of cold chain equipment for storage of essential vaccines and medicines, and to augment the functioning of the PHCs' services in rural areas.

2.3 Problems that SHPV System Project Sought to Address

Maharashtra has about 1,811 PHCs. Most of these are located in villages where electricity is not available typically for 6 to 8 hours and during monsoon months for 10-12 hours daily. The quality of grid electricity is poor and there are frequent voltage fluctuations which, in some locations, become as low as 140 Volts during evening hours. This hampers the proper functioning of lights and fans and damages medical equipment used in PHCs. Large fluctuations in voltage also effects the working and life of cold chain equipment especially the ILR, deep freezer and sophisticated electronic medical equipment like new-born care stabilization unit, pulse oximeter, radiant warmer, photo therapy unit, Electro Cardio Gram (ECG) machine, and laboratory equipment used for storing vaccines and essential medicines.

In the event of long power outages, which make the ILR and deep-freezer non-functional, preserving the vaccines becomes critical to ensure that the overall health parameters of the population served by the PHC show continuous improvement. Considering the practical scenario in which every rural location experiences power outages and poor quality grid electricity, two alternative solutions emerge. The first solution is to use solar powered refrigerators and deep-freezers for vaccine storage, which are expensive[1] imported equipment with imported[2], costly and limited spares and costly maintenance services. The second alternative is to use conventional ILRs and deep-freezers and provide back-up power to these units as well as critical health equipment required for 24x7 essential health services.

> Staff are motivated to work and stay in the PHC premises.
>
> Work efficiency has improved, staff and public security has improved, people are motivated to visit the PHC even at night.
>
> Dr. Sachin Gomsale,
> Medical Officer (Male) – Primary Health Centre, Borli Panchataran

To address the issue of non-availability of grid supply, Department of Health Services, Government of Maharashtra through KfW support and UNICEF technical support initiated the project of SHPV system installation and commissioning in the tribal/ rural areas. The Director of Health Services, Government of Maharashtra needed a system, which could:

- Be cost effective;
- Serve as a practical, feasible electrical backup system using green energy; and
- Fulfill the need of providing uninterrupted power for existing cold chain equipment.

In response to these requirements UNICEF conceptualized and designed the SHPV system to meet:

- World Health Organization's Performance Quality and Safety (WHO-PQS) norms for five day "No-Sun, No-Grid autonomy"
- Certification requirements of IEC / CE / RDSO
- Daily energy consumption of one ILR and one deep freezer

In the pilot phase, 52 SHPV systems were installed in PHCs across the state with KfW support and subsequently another 63 were installed with support of GoM.

2.4 Objectives of SHPV System Project

The objective of the project was to provide uninterrupted power supply in primary health centres through a hybrid system of grid fed and SHPV system to ensure operation of cold chain equipment for storage of essential vaccines and medicines, and augment the functioning of the Primary Health Centre's services in the rural areas.

2.5 Main Stakeholders

The main stakeholders of SHPV initiative in Maharashtra are listed in the order of ownership and involvement:

1. **Department of Health:** Responsible for extending the medical services throughout the state, including supply of medicines, essential vaccines, and operation and maintenance of health

[1]As compared to conventional ILR and deep freezer, solar powered ILR and deep freezer cost eight times more

[2]Spare parts for approximately 300 solar power ILR and deep freezer are currently being imported with UNICEF support

facilities such as PHCs, CHCs, block and district hospitals

2. **KfW:** Funding agency, which supported the initial pilot of SHPV systems in 63 PHCs. Government of Maharashtra used KfW funds for procurement of SHPV system using the standard tendering process.

3. **UNICEF:** Provided technical support to Government of Maharashtra's Department of Health in designing the SHPV system that met WHO norms for operation of vaccine cold-chain equipment along with other critical health equipment; and setting–up of National Cold Chain Training Centre in Pune which provided inputs in planning of installations and designing the configuration of SHPV system. Since 2011, UNICEF has carried out advocacy with Government of India and state governments for installation of SHPV systems in health facilities to leverage National Health Mission resources.

4. **SHTO:** Health Equipment Maintenance and Repair unit of SHTO received complete technical support in design, development and commissioning of SHPV system project and implemented it for GoM.

5. **Vendors:**

   a. Datum: A Pune based system integrator that has installed and commissioned 292 solar PV systems. It is currently maintaining 72 systems of version 4 and working on augmentation of 69 SPV systems of version 1.

   b. Megatech: A Chennai based system integrator that has installed and commissioned 292 solar PV systems. It is currently maintaining 72 systems of version 4 and working on augmentation of 69 SPV systems of version 1.

FINDINGS

This children's ward in a rural health centre comes fitted with proper medical equipment and even a working television to keep the little ones distracted from their suffering. Mothers attending to their ailing children feel a sense of comfort and security as they are assured of good quality treatment and care. Solar based back-up power has helped the PHC to function 24x7 and has led to increased visits of villagers in the neighbourhood for proper medical treatment.

This section presents the findings of the evaluation carried out in 40 health facilities that had SHPV system installed during the past six years. The findings also capture the qualitative and quantitative information from the site visits and interviews of all the stakeholders including equipment suppliers.

3.1 Evaluation Parameters

As suggested by UNIDO, and agreed by the core group, the framework used by Global Environment Facility (GEF) in the evaluation of energy and environmental projects was used. The evaluation of SHPV Systems in PHCs was based on:

1. **Relevance of SHPV system for providing reliable health services in remote rural areas:** How does the solar hybrid photo-voltaic system relate to one of the main objectives of NHM to provide reliable health services in remote and inaccessible areas?
2. **Effectiveness in increasing PHC operation and medical services:** The extent to which the SHPV system has been effective in increasing PHC operation and medical services.
3. **Efficiency in improving PHC function and service delivery to the community:** Has 24x7 availability of electricity improved operational efficiency of PHCs and benefited the community?
4. **Sustainability in the form of financial, institutional, social and environmental for replication:** What are the financial, institutional, social and/or environmental benefits to sustain long–term results?
5. **Impact in providing enabling environment towards improving health services:** Are there indications that the application of SHPV system has contributed to or enabled progress towards improving health services?

3.2 Initiative in Health Centres of Maharashtra

The initiative has been greatly assisted by setting a clear goal of providing 24x7 stable electricity supply to the critical health equipment to strengthen the immunization programme. This was subsequently expanded to cover other essential health services in tribal areas. Following are the observations of the reviewers based on the field visits to PHCs, meetings with Medical Officers, staff and patients, as well as review of the records, registers, log books maintained by the centres.

3.2.1 Stakeholder Participation

SHPV system project's major stakeholder was Department of Health (NHM), Government of Maharashtra and PHCs in tribal and rural areas. Other key stakeholders in the initial stage were KfW, which provided the funding for the pilot, and UNICEF, which provided technical support. Another, stakeholder was College of Engineering, Pune which provided continuity to the design development and testing of SHPV system. At a later stage, NCCRC became a key stakeholder and interfaced with UNICEF and Government Maharashtra, PHCs and vendors. NCCRC also acted as the national technical resource centre for providing technical support to other state governments for introducing solar photo-voltaic systems in PHC.

3.2.2 Management Arrangements

The SHPV system was implemented by Government of Maharashtra's Department of Health with NCCTC as a technical support unit which developed the technical specifications for procurement of the systems. NCCTC was involved in the technical evaluation of proposals and provided technical support like pre-dispatch inspection of material, on-inspection after installation and commissioning of Solar Hybrid Photo Voltaic Systems support during the implementation phase. The project was implemented using NHM funds provided to the state by the MoHFW. The Project's overall coordination, supervision, monitoring and clearance of the detailed work plan was carried out by Senior Consultant and Coordinator at NCCTC, Pune.

3.3 Project Implementation

The project has been greatly assisted by a clear project objective and technical specifications and procurement processes of the state government. Also, the SHPV system was implemented by State's Department of Health with SHTO (HEMR) and NCCRC as a technical support unit which developed the technical specifications for procurement of the system. NCCRC was involved in the technical evaluation of proposals and offered its recommendations to the Health Department. The project was implemented using NHM funds provided to the state by the MoHFW. The Project's overall coordination, supervision, monitoring and clearance of the detailed work plan was carried out by NCCTC, Pune.

The clearly defined objective and engagement of SHTO (HEMR) and NCCRC in the initial phase and state NHM unit helped in roll-out, gathering feedback, and improving the system design. During the entire period of 6 years since the beginning of the initiative and during the time of assessment, the objective of improving health services through 24x7 electricity supply remained highly relevant.

3.4 Project Outcomes

3.4.1 Ownership and Drive

The ownership of the SHPV system is with the Department of Health, Government of Maharashtra. The initiative is driven by Government of India's National Health Mission with technical support of UNICEF.

3.4.2 Mainstreaming

Government of Maharashtra has a clear vision to upscale the initiative and extend the SHPV system using a small portion of NHM resources, to all the rural health centres where electricity reliability is less. The state government is exploring options to add SHPV systems in more PHCs through public-private partnership and funding from corporate social responsibility.

The SHPV system has been completely relevant since it began in 2008 as the issue of erratic power supply is prevalent throughout the state and across the country, especially in rural areas. Ensuring reliable electricity supply in PHCs has helped in augmenting the services and availability of vaccines and drugs in rural areas which also helps the state and central government in achieving some of the key objectives of NHM.

3.4.3 Rating the Initiative Outcomes

The project outcome is rated based on the scale followed by GEF to assess the outcome of similar development oriented projects.

The evaluation team collectively rated this initiative as **Highly Satisfactory,** on the basis of performance data, stakeholder interviews conducted during field visits and improvement in quality of health services provided.

Table 3: Rating system used by Global Environment Facility for performance of projects

Rating	Explanation
Highly Satisfactory	The project has no shortcomings in the achievement of its objectives
Satisfactory	The project has minor shortcomings in the achievement of its objectives
Moderately Satisfactory	The project has moderate shortcomings in the achievement of its objectives
Moderately Unsatisfactory	The project has significant shortcomings in the achievement of its objectives
Unsatisfactory	The project has major shortcomings in the achievement of its objectives
Highly Unsatisfactory	The project has severe shortcomings in the achievement of its objectives

The overall project sustainability is ***Likely.*** This is primarily due to the strong commitment of Department of Health Services; continuing support of MoHFW through NHM programme; and UNICEF's advisory support for strengthening Cold Chain Equipment. Other stakeholders in the initiative, namely, NCCTC and equipment suppliers have been engaged through Comprehensive Maintenance Contracts for the next 10 years to ensure that the SHPV system is functional.

> When patients visit, they expect all possible services to be provided regardless of the time of the day.
>
> Due to SHPV system, uninterrupted supply is assured, therefore the staff does not waste time on logistical issues of electricity, and is devoted to attending the patients.
>
> We are no longer apprehensive about conducting a delivery any time during day or night.
>
> Dr. Aruna Bambere
> Medical Officer
> (Female) – Neral PHC

SECTION 4

KEY FINDINGS

Solar based power supply has helped to convert PHCs into '24x7 PHCs'. This has a significant impact on routine immunization activity in the villages. These days, Rohini Aher, who works as an Auxiliary Nurse Midwife in a PHC, always has a ready supply of vaccines and other life-saving medicines, which she safely stores in the deep freezer powered by solar hybrid photo-voltaic system.

An evaluation matrix included in Appendix E, was used by the evaluation team to record findings from the field visit. Interviews of stakeholders were also conducted which reviewed the intervention on the basis of the following five criteria, which are elaborated in section 3.1:

a. Relevance

b. Effectiveness

c. Efficiency

d. Sustainability

e. Impact

Each of the above five criteria was assessed using specific parameters.

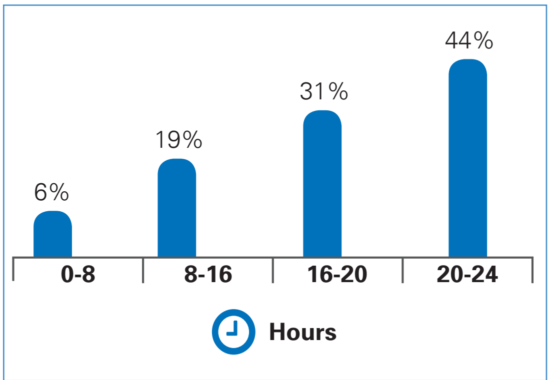
Relevance was assessed using the following three parameters:

a. Is the solar hybrid photo-voltaic relevant to the PHC?

b. Is the current design of SHPV system adequate for the services offered at PHC?

c. Has the system affected the motivation level of PHC staff?

Figure 1: Duration of electricity supply in the health facilities



A total of 40 PHCs were visited. The graph shows the details of electricity supply availability at the PHCs.

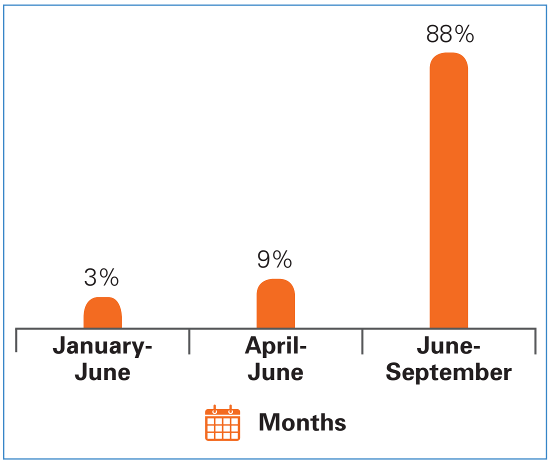
- About 44 per cent of PHCs get electricity supply for more than 20 hours.
- About 31 per cent receive electricity supply for 16-20 hours.
- About 19 per cent get electricity supply for 8-16 hours.
- About 6 per cent of get electricity supply for less than 8 hours.

From the above figure, it may be noted that about 56 per cent, or more than half of the PHCs in the sample do not receive electricity supply for 20 hours. This limits the functioning of health facilities which are designated as IPHS health facilities. As per this standard, 24x7 electricity supply is a minimum prerequisite.

> "Malaria, tuberculosis and pathology laboratory services are operational. Breakdowns of equipment are few and rare.
>
> Female staff no longer feels insecure or uncomfortable in staying and providing medical services in the PHC during evening and night.
>
> It is helping us in effective medical management."
>
> Dr. Aruna Bambere
> Medical Officer
> (Female) – Neral PHC

However, even for the 44 per cent of PHC which receive more than 20 hours of electricity, voltage in the majority of these sites is low (around 140 Volts), especially from evening to early morning. This can potentially harm sensitive medical equipment like fetal monitor, ECG machine office computer, operating theatre(OT) lamp, pulse-oximetre and suction machine.

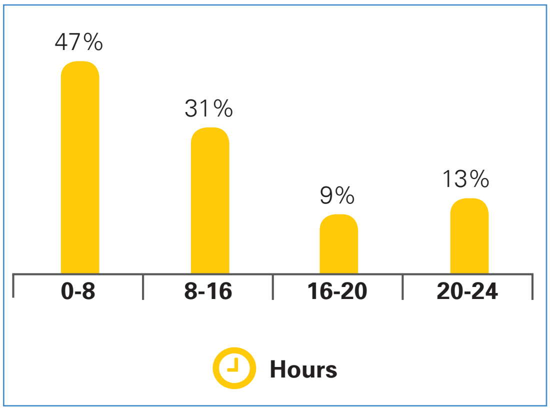
Figure 2: Seasonal power fluctuation experienced by the health centres



The graph in figure 2 shows the time of the year when PHCs experience maximum power cuts. It can be seen that the maximum power cuts are in the monsoon season and could be caused by broken power lines due to falling trees or due to thunderstorms.

During the monsoon season all the PHCs face power outages of varying durations. About 78 per cent of PHCs face power outages of up to 16 hours. The remaining 22 per cent of PHCs face power cuts of anywhere between 16 to 24 hours.

Figure 3: Duration of power outage during the monsoon



In addition to non-availability of electricity in 56 per cent of PHCs for 20 hours, the seasonal power outage, especially during the monsoon, makes the situation worse. The maximum numbers of hospitalizations occur during the monsoon season due to deliveries, acute gastroenteritis, diarrhoea outbreaks, snake and scorpion bites, road-traffic accidents, and public health issues due to natural disasters.

Since, availability of 24x7 good quality electricity supply is critical for functioning of IPHS standard health facility, even PHCs experiencing shorter durations of power outages (less than 4 hours) have confirmed that SHPV is relevant for smooth functioning of all its operations and service delivery.

Effectiveness was assessed using the following three parameters:

a. Has the SHPV system been effective in improving the overall function and services of PHCs?

b. Is it of benefit to the equipment and medical instruments installed in the PHC?

c. What are the observed limitations of SHPV system?

Key health service providers like medical officers, nursing staff and pharmacist, and lab technicians were asked if non-availability of electricity, even for a short duration, hampers their work of providing effective health services. Out of 40 centres covered, staff in 81 per cent of the PHCs responded affirmatively that the power outages affect the functioning of their service delivery, as reflected in the graph below.

Figure 4: Response of PHC staff on the Negative effect on medical services and equipment by erratic and inadequate power supply situation

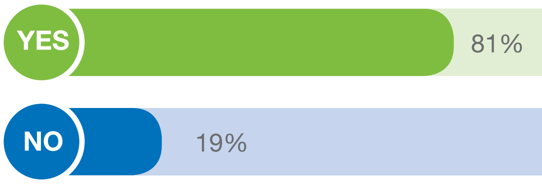
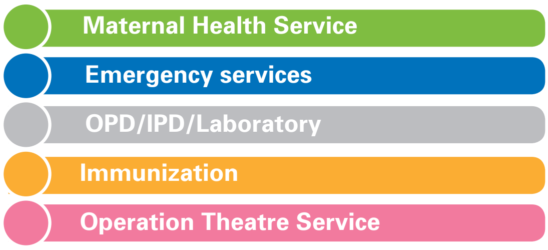


Figure 5: Following health service are most affected due to absence of electricity



Efficiency was assessed using the following three parameters:

a. Has the SHPV system been effective in improving the overall function and services of the PHC?

b. What is the benefit to the equipment and medical instruments installed in the PHC?

c. What are the observed limitations of the SHPV system?

Due to installation of SHPV systems in PHCs, better and on-time medical services are provided to patients. This is captured through interviews with various stakeholders of different levels including beneficiaries.

The following two figures show three-fold increase of OPD cases and a 10-fold increase in IPD cases in the sampled PHCs between 2010 (before installation of SHPV system) and 2014 (after installation of SHPV system).

Figure 6: Trend of OPD cases reported at PHC

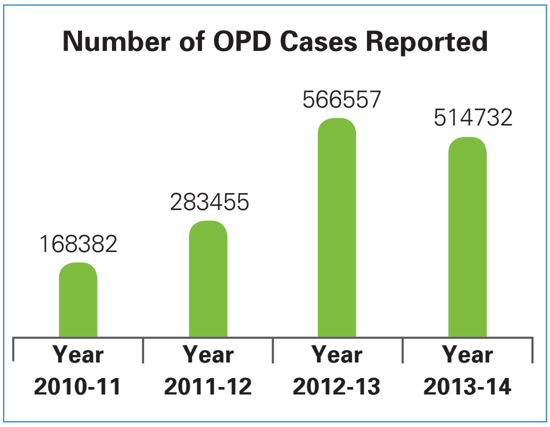
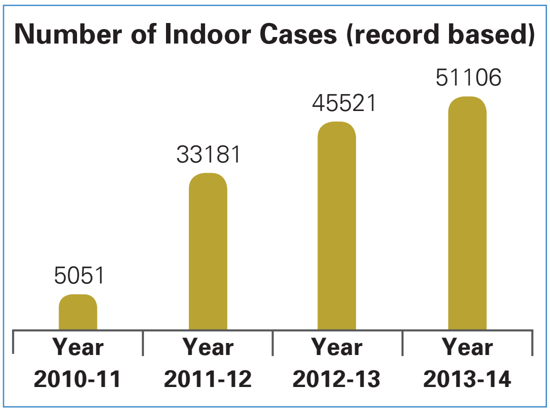
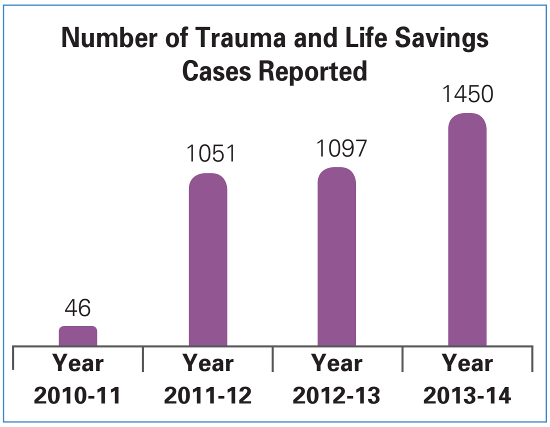


Figure 7: Trend of IPD cases reported at PHC



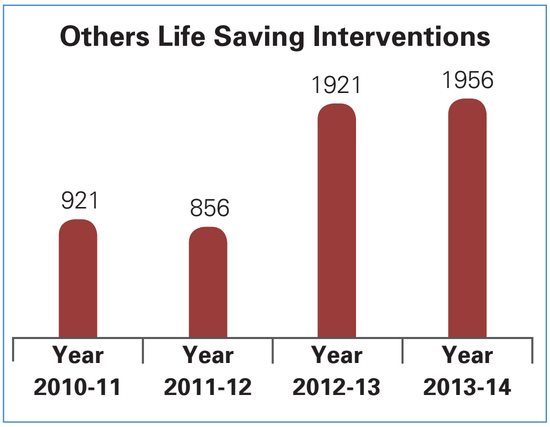
Between 2011 and 2014, 38 per cent increase is reported in trauma and life-saving cases being treated in the sampled PHC.

Figure 8: Trend of trauma and life-saving cases reported at PHC



Life-saving interventions provided for snake, scorpion and dog bite increased two-fold in the sampled PHCs.

Figure 9: Life-saving interventions due to reliable electricity at PHCs



The number of laboratory procedures performed in the PHCs increased eight-fold between 2010 and 2014 after the installation of SHPV system.

Figure 10: Number of laboratory procedures carried out in sampled PHCs

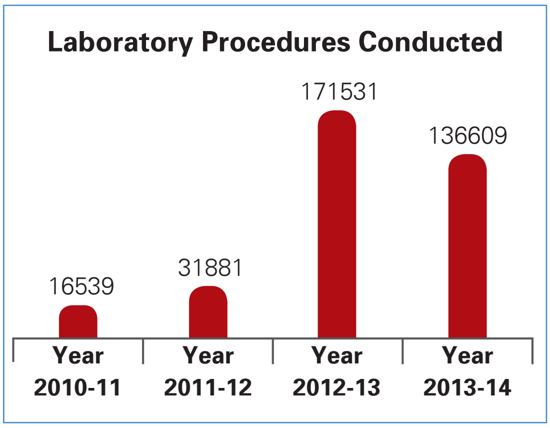
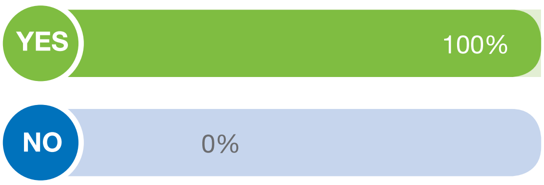


Figure 11: Recommendation for SHPV system to be replicated to other PHCs/ CHCs



All the staff at PHCs visited appreciated the SHPV system and have recommended provision of such systems to other PHCs.

Sustainability

Sustainability was evaluated on the following parameters:

a) Would the use of SHPV system be sustainable and stimulate replication?

The application of SHPV system in PHCs was standardized by NCCRC. Procurement processes now include a 5–year warranty and 5–year comprehensive maintenance contract arrangement. The state government replicated this in health facilities. Since version 4 showed reduction in electricity consumption and covers the functioning of the entire centre, this version has stabilized and is being used as a standard. The system is remotely monitored for its functionality status by the Office of Quality Control of NHM in Mumbai and by district health offices.

The entire SHPV system installation and commissioning is done by the vendor including routine maintenance visits to the PHC, once in 3 months. Further, the contract includes servicing provisions to attend to the complaint within 3 days in case of a serious malfunctioning in the system. The system, therefore, does not require dedicated manpower from the health facility for its operation. It is free from noise and air pollution and provides good quality electricity supply instantaneously during power fluctuations or outages. There is no operational cost involved in running of SPHV. This is a saving for the government.

With the market opening up for clean energy equipment suppliers, especially the SHPV system, the overall outlook of using SHPV systems is positive. Ministry of New and Renewable Energy is also committed to supporting state governments departments and institutions to set-up roof top solar photovoltaic systems. (Refer Appendix B).

The following graph shows the perception of the medical officers at the PHC on how the SHPV system installation has helped in improving patient care. The graph clearly shows that most Medical Officers agreed that the SHPV system has significantly helped to improve patient care.

Figure 12: Recommendation for SHPV system to be replicated to other PHCs/ CHCs

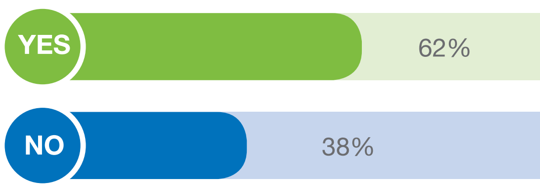
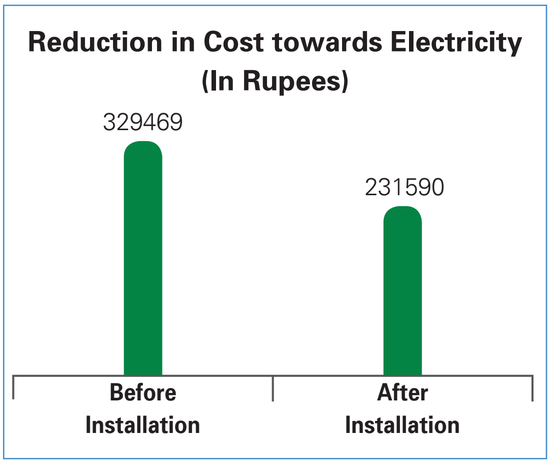


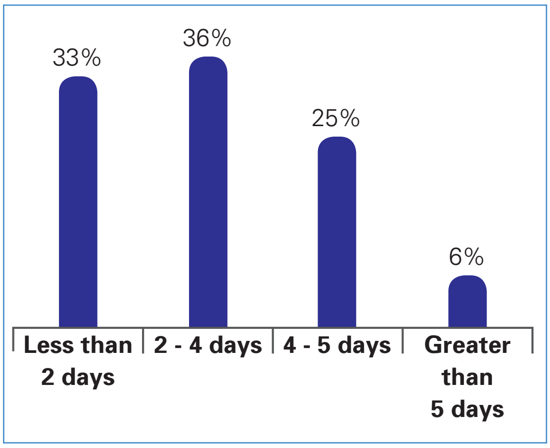
Figure 13: Reduction in annual electricity cost in sampled PHCs (In INR)



Of the 40 sampled PHCs, 10 PHCs which had installed version 4 of SHPV system reported a reduction of 30 per cent in annual electricity bill payments.

The following graph indicates how the duration of non-availability of sunshine has affected SHPV system performance. Non-availability of sunshine is primarily due to longer duration shadows of the trees near buildings and cloudy conditions during monsoon season.

Figure 14: SHPV systems affected due to non-availability of sunshine



Impact

The impact of application of SHPV system in PHCs was assessed based on the following:

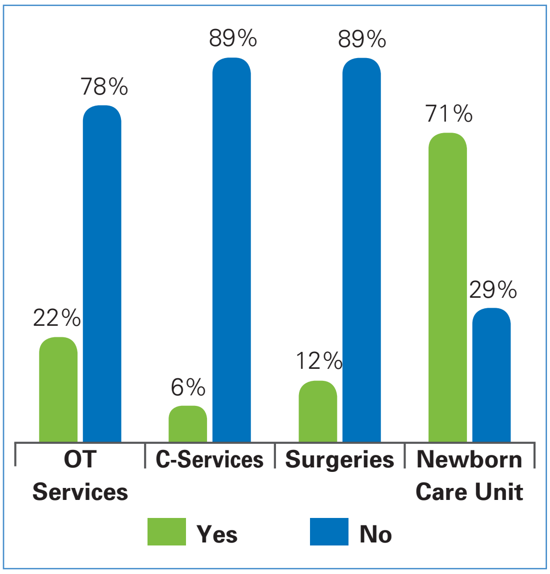
a. Are there tangible improvements in the services provided by PHCs ?

b. What are the indirect benefits that can be attributed to SHPV systems installation in PHCs?

The quality of health services has improved more than the quantity. Availability of 24x7 electricity has provided an enabling environment for the health service providers to work at odd hours without anxiety or apprehension of unscheduled power outages. This is especially true for female staff as it has allowed them to focus their attention on quality service delivery without worrying about logistic issues involved in arranging back-up power supply while attending to patient.

The following graph shows that installation of SHPV systems in PHCs has helped to improve all health services with significant contribution to OT and newborn care services.

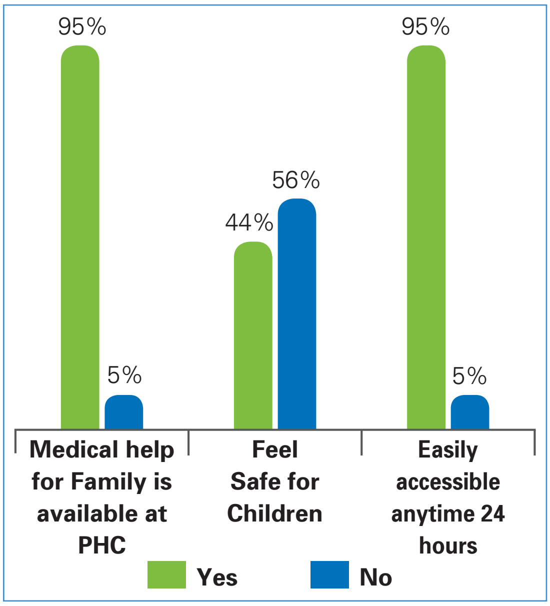
Figure 15: Improvement in health service delivery due to SHPV systems



The following graph shows that health services are greatly improved and patients have benefited due to availability of 24X7 uninterrupted power supplies to the PHCs.

This was possible due to installation and commissioning of SHPV systems in PHCs.

Figure 16: General perceptions among the population especially among women, about the functioning and services offered by the PHC.



For example, earlier while conducting a delivery, if there was a power outage, the staff had to organize alternate back-up power. This was a challenge for the female staff. After the installation of SHPV system, the staff is completely free from worries and stay focused on attending patients. They no longer notice power outages at the health centre.

> Before the SHPV system was installed in 2012, we used to face lot of logistical challenges, especially while attending delivery cases when there was power failure midway through the labour process.
>
> From the time SHPV system is installed with SHPV system, we are least bothered about electricity and focus fully on patient care.
>
> Reporting of cases of snake bite, scorpion bite and road traffic accidents has increased.
>
> Female Health Worker – Neral PHC

The following graph shows the responses of the PHC staff on how the SHPV system has helped them to improve medical services offered to patients by the PHC. It clearly shows that most Medical Officers agree that the SHPV system has helped to significantly improve patient care.

SPHV powered light in labour room

Figure 17: SHPV systems helped in improving the medical services offered by PHCs

SECTION 5

SWOT ANALYSIS

Heat sensitive medication, like the measles vaccine or polio drops, need to be stocked within a narrow temperature range of anywhere between two and eight degrees Centigrade, making it essential for the deep freezers in rural health centres to have uninterrupted power supply.

Key observations from the Field Assessment

The evaluation team carried out a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the SHPV system project based on observations and data gathered during field visits.

Strengths

1. **Continuous power supply:** Power supply in PHCs is sourced through grid and SHPV system in the absence of grid supply. With continuous and reliable electricity supply round-the-clock (or 24x7) round-the-clock (24x7) availability to operation theater and critical equipment has ensured continuous functioning of critical services at PHCs.

2. **Reliability of equipment usage:** No breakdown or failure of medical equipment was reported from the PHCs where SHPV systems are installed. The power to critical medical equipment is provided through the solar inverter which gives regulated and constant voltage output. Hence, the breakdown or failure of the equipment due to voltage fluctuation is minimized and better life of the equipment is assured.

Consultation with Indoor Patients during evaluation mission

3. **Increased ability to provide services:** There is an increased ability of staff to perform deliveries and emergency procedures due to the 24 x 7 availability of reliable power supply. This has increased the PHC staff's ability and confidence to attend to patients, and perform emergency procedures as well as deliveries anytime.

4. **Increased safety and security:** PHC staff, especially the female staff, benefited from increased safety and security during night hours due to continuous availability of electric lighting. The PHCs remained fully lit in case of grid power failure and were accessible to the local population even at odd hours of the night.

5. **Indoor Patient Department (IPD) uptake increased:** Medical records showed increase in IPD patients at PHCs due to the availability of reliable and continuous power. LED lights and fans in the general ward continued to work during power outages and functioning of electrical equipment was not interrupted. Post-surgery or post-delivery patients received medical attention for 72 hours or more depending upon the case.

Use of light microscope for detection of malaria & TB

> Indoor patients used to shout at the staff during power interruptions and would leave the PHC. Now, patients stay for up to 72 hours in the comfort of continuous power supply.
>
> Staff does not face public grievances during power outages over which they do not have any control.
>
> Due to 24x7 electricity availability, report preparation can be done even at night when the work load is less.
>
> In the absence of a family member, a female indoor patient does not feel insecure, especially if she is alone in the ward.
>
> Female Health Worker – Neral PHC

6. **Visibility of PHC at night was enhanced.** PHC was seen fully lit even if the village was in darkness because of grid power failures.

> The PHC premises is illuminated when the entire village is dark during power cuts, Hence, patients feel safe coming to the health facility and are assured that they will receive medical services.
>
> Sometime children use the health facility premises for their studies during absence of grid electricity supply
>
> Beneficiary (patient)

7. **Health seeking behaviour increased:** The presence of 24x7 reliable services encouraged patients to seek services. Because of availability of continuous power, the ability of the PHC to perform and to offer services improved and more people from the surrounding areas are seeking health services.

8. **Improved laboratory services:** Laboratory services improved, especially those requiring light microscope like malaria and tuberculosis detection tests. Because of the availability of continuous and reliable power, laboratory functioning improved and tests could be carried out throughout the day.

> Since the microscope used is electrically operated, the work for testing malaria, TB, TLC, DC and peripheral smear can now be done even in the night.
>
> Number of slides tested have increased three times since the PHC installed the SHPV system.
>
> Lab Technician and Data Entry Operator – Nagothane PHC

9. **Increased motivation to provide services:** A few light and fan connection points were also provided in the staff

quarters for the safety and basic comfort of PHC staff staying in the quarters. This motivated them since they have to attend cases even late at night.

A functioning PHC OPD lighted by SHPV system with Medical Officer and patient during evening

10. **Increased efficiency of PHC staff:** Efficiency of PHC staff increased with more attention to patients and lesser towards operational issues during electricity supply interruptions. The staff on duty no longer had to worry about making alternate arrangements and remained fully focused on their work, thus saving time and increasing efficiency.

11. **Effective monitoring:** The system catered for real time web-based monitoring for SHPV systems. Version-4 Solar PV systems are provided with web-based monitoring which helps on-line status monitoring of the system that in turn helps with troubleshooting as well as providing guidelines for maintenance.

12. **Improved perception of services:** Patients, perception of service availability and quality at PHCs improved with the introduction of SHPV system. Increased numbers of patients now seek health services at PHCs instead of at private nursing homes due to the improved efficiency as the functionality and services offered in PHCs is of the same level.

13. **Increased utilization of available medical devices:** Medical equipment could be used without worrying about the non-availability of power due to electricity failure. SHPV systems have ensured 24x7 uninterrupted electricity to the PHC.

14. **No requirement of stabilizers for CCE:** The SHPV system provides regulated power output through the inverter. Therefore, medical equipment and cold chain equipment no longer need stabilizers.

A functional SNCU equipment powered by SHPV system

15. **Ability to handle 24x7 emergencies:** Continuous and reliable electricity availability improved the ability of the PHC to handle emergencies such as road traffic accidents, trauma, poisonings, snake and scorpion bites.

On-line reporting system with computer and broadband connection powered by SHPV system

16. **Reporting and MIS functions remain constantly online and functional:** Computer system at a PHC always remains ON for online reporting and creating and maintaining reports. Computer systems at PHCs are used round-the-clock and are connected (through Internet at many locations) for on-line reporting, creating and maintaining reports.

17. **Expansion of cold chain points beyond block *(taluka)* level.** Provision of uninterrupted power supply due to installation of SHPV systems has helped in expanding the cold chain points to PHCs.

18. **10-year warranty with Comprehensive Maintenance Contract (CMC):** The latest supply of SHPV system comes with 5 year warranty and 5 year CMC. Hence neither the PHC staff nor the state government's Department of Health Services, DHS, had to worry about the annual maintenance of the system and making budgetary allocation every year. It is a dedicated power station for 10 years.

19. **Indigenous components:** All components are indigenous and are available locally with the service providers for after sales service. Hence system downtime and time to carryout maintenance and repair is drastically reduced. The support provided by the service provider for system maintenance was found to be good.

20. **Maintenance of international standards:** All the major components like inverter, solar panels, and batteries were IEC/RDSO/CE certified ensuring international standards for the component/system.

21. The system evolved over six years and matured in terms of products and services. The project was implemented in four phases. In each phase, the learning gained in the operation of the SHPV systems was used to improve the technical specifications and design configuration for the following phase. Overall, during the six years a total of 407 SHPV systems were installed in PHCs.

22. SHPV system providing 24x7 electricity to the entire PHC has also helped to reduced the grid electricity consumption by 30 per cent.

Weaknesses

- The entire SHPV system has no moving parts and operates smoothly. However the lead-acid batteries need periodic maintenance and require visits of system provider once every quarter.
- Training of PHC staff on basic maintenance of solar panels, inverter and batteries is needed. This will help to attend to minor issues under the guidance of service providers and ensure longer up-time of the SHPV system.
- System of monitoring the services of the system-integrator by the health department needed to be made more robust.

Opportunities

- **Revision of IPHS standards** to include hybrid solar photo-voltaic system as a source of reliable electricity supply. Absence of continuous and reliable grid electricity in many states, especially in the rural areas provides an opportunity to upgrade existing PHCs in a phased manner through SHPV systems.
- **SHPV systems provide regulated power supply.** This is a method to overcome the challenge of frequent voltage fluctuations that affect the performance and breakdown of critical medical equipment. This is a major factor driving installation of SHPV systems.
- Preparedness of states to explore **alternative clean energy sources** for PHC functioning.
- **Safety** of medical staff on duty.
- **Prevention of wastage** of medicines/ vaccines or under-utilization due to inadequate storage facilities (savings to state and central government which procures medicines).

Challenges

- After sales service network coverage (especially in other states) will require developing a methodical implementation plan factor for the local operating conditions, requirements of PHC to allow vendors or system integrators time to develop their service base.
- Unrelenting support of the government is necessary to develop a system configuration and vendor base to meet service requirements in PHCs located in remote areas and hilly regions.

SECTION 6

RECOMMENDATIONS AND WAY FORWARD

Pinky Yelve, the staff nurse at a PHC in Pune district, gently places a newborn baby on a solar-powered phototherapy machine, which is used to treat neonatal jaundice, a common condition that can be fatal if left unattended.

Recommendations

Observing the benefits SHPV system is delivering in PHCs, it is recommended that the concept of powering a Primary Health Centre with a clean source of energy, as demonstrated by hybrid-solar photo-voltaic unit, needs to be replicated among PHCs in other states throughout the country.

Active participation of states will be necessary for India to progress towards achieving sustainable development goals. Following tasks are recommended to expand the base of SHPV system in the health sector service delivery.

The effort of replication and scale-up in other states should begin with:

1. Exposure visits for state health officials to PHCs with a SHPV system coordinated by Government of Maharashtra.
2. The role of NCCRC needs to be defined as a technical support organization to assist state governments in procurement, installation and commissioning as well as post-commissioning follow up with suppliers of solar hybrid systems.
3. The typical procurement specification for SHPV system should include at least a mandatory 5-year warranty followed by 5-year comprehensive maintenance contract. This will ensure that the SHPV system operates satisfactorily and provides service for at least 10–years.
4. NCCRC in consultation with states must identify multiple system integrators within the state and organize a national consultation workshop on the requirement of health facilities.

Way Forward

Energy security of health facility should be a prime consideration while planning for its establishment. Considering the Sustainable Development Goals, to which Government of India is signatory, Goal 3 and Goal 7 require the health and clean energy challenges to be overcome by 2030. This requires a long-term work plan for phasing-in of clean and sustainable energy sources and improving health services. The evaluation provides the following way forward:

1. A certain percentage of the health budget should be earmarked for accelerating deployment of clean energy sources in health centres in a phased manner.
2. Indian Public Health Standard (IPHS) should be amended to include clean energy sources for providing round-the-clock power to health facilities.
3. NCCRC should be designated as the National Secretariat to work for adoption of clean energy in the health sector with support from other line ministries and development partners.
4. Increased use of clean energy sources in the health sector, as concluded in the evaluation study, provides a two-pronged approach for MoHFW to address PMO's 'Make in India' initiative as well as to move decisively towards attaining 'Sustainable Development Goals 3 and 7' by 2030.
5. The scaling of SHPV systems will result in large-scale creation of demand for sustainable energy in other social sectors in the rural areas, which will result in skill development, network of after- sales

services and improving the parameters of various social programmes.

6. More in-depth quantitative study is required to establish the relationship between morbidity and mortality with improved health service delivery specifically due to reliable electricity supply.

> Cold chain and ice-pack preparation was better managed during the pulse polio programme.
>
> Female Health Worker – Neral PHC

SECTION 7

WAY FORWARD FOR STATES

This newborn baby in a small village in Thane district has got a new lease of life thanks to the solar powered baby resuscitation cup that is in working order at his local health centre. The availability of such essential services gives vulnerable babies a fighting chance for survival.

Given the benefits SHPV system is delivering in PHCs in Maharashtra, it is recommended that the concept of powering a health centre with a clean source of energy needs to be replicated among PHCs in other states throughout the country. Active participation of states will be necessary for India to progress towards achieving sustainable development goals.

Additionally, the states may prepare annual plans for integrating SHPV system in primary health centres in a phased manner starting with the remote rural health facilities or those locations which experience long duration of power outages and/or receive electricity at low voltage.

- The effort of replication in other states should begin with:
    - Exposure visits for state health officials to PHCs where SHPV system is working. As the Director of Health Services is based in Mumbai, one of the sites suggested for visit is the Primary Health Centre at Nagothane, on the main Mumbai-Goa highway.
    - Gradual roll-out of the scale-up plan in new states – starting with PHCs in locations that are easily accessible.
- Based on the Maharashtra experience, the supply contract should have at least a 5-year warranty followed by 5-year CMC.
- The states should define their minimum standard and configuration for a health facilities including installation of solar water heater of up to 500 litre per day capacity.
- PHCs should have a dedicated room within the premises for installation of the SHPV system.
- Use of appropriate lighting systems (LED), super-efficient fans for use with the SHPV system in the PHC. Increased use of maintenance free batteries which are specially suited for application in solar photo-voltaic system.
- Provision of 24x7 electricity to social sectors like health, nutrition and education should be promoted. This will help in achieving better health, nutritional and educational status for all since energy is a key motivating factor in improving the performance of institutions as well as individuals.

Stakeholder Consultation at PHC, Neral, Maharashtra

APPENDIX

"One year ago when we installed the solar power system at the health centre, it was nothing short of a miracle. It enabled us to perform surgical procedures with ease. There was a time when a power failure during an operation would leave us with no choice but to run around arranging for a generator". Shares a health officer from Pune district.

Appendix A

Constitution of Core Group to Assess SHPV System

Y-11030/1/2012-CC&V
Ministry of Health & Family Welfare
Government of India

Nirman Bhawan, New Delhi
Dated the 8th October 2012

Office Memorandum

Subject: Constitution of Committee to study the feasibility of Solar Photo Voltaic System (SPVS) as an alternative power source.

A committee is hereby constituted to study the feasibility of Solar Photo Volataic System (SPVS) in the immunization programme for running the cold chain equipment in areas with inadequate power supply. The Committee comprises of the following members:

Members		
1.	Dr. M. K. Aggrawal, DC (UIP), MoHFW	Chairperson
2.	Dr. Madhulika Bhattacharya, HoD, Dept. of CHA, NIHFW	Member
3.	Dr. Srihari Dutta, Health Specialist, UNICEF	-do-
4.	An International Expert to be sourced by UNICEF	-do-
5.	Mr. Manish Gangal, Health Officer Cold Chain, UNICEF	-do-
6.	Mr. Vipin Srivastav, State CCO, Govt. of Madhya Pradesh	-do-
7.	Mr. Paritosh, Panigrahi, Consultant: Immunization, MoHFW	Convener

This Issues with the approval of competent authority

(Dr. M. K. Aggarwal)
Deputy Commissionar (Imm)

Copy to:

1. **All Members of the Committee**
2. **Chief of Health, UNICEF,**
3. **PPS to JS (RCH)**
4. **PS to Director, NIHFW,**
5. **PS to DC (CH&I)**

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funs'kd
Prof. Jayanta K. Das, MD
Director

आरोग्यम् सुखसम्पदा

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National Institute of Health & Family Welfare

NIHFW/CHA/ National Cold-chain Assessment /2013
Dated: 01st january 2014

To

(List-1 attached)

Subject: Minutes of meeting for Pre-core Group meeting on National Cold-Chain Assessment and Assessment of impact Solar-Hybrid Power Supply System has made on Health Services Utilization

Sir/Madam,

Enclosed is the Minutes of meeting for Pre-core group meeting on National Cold-Chain Assessment and Assessment of Impact of Solar-Hybrid Power Supply System has made on Health Service Utilization held at NIHFW, New Delhi on 12th December 2013.

Thanking you,

Yours sincerely,
Sd/
(Jayanta K. Das)

Copy to:

1. Dr. Ajay Khera, Deputy Commissioner (CH & Imm.), Room No-205 'D', Ministry of Health and Family Welfare, Nirman Bhawan, New Delhi
2. Dr. Pardeep Haldar, Deputy Commissioner (Imm.), Room No-105 'D', Ministry of Health and Family Welfare, Nirman Bhawan, New Delhi
3. Dr. Srihari Dutta, Health Specialist, UNICEF, 73 Lodhi Estate, New Delhi - 110 003

(Jayanta K. Das)

बाबा गंगनाथ मार्ग, मुनीरका, नई दिल्ली- 110 067 / Baba Gang Nath Marg, Munirka, New Delhi– 110 067
दूरभाष (कार्या.) / Ph (Off.): +91-11-2610 0057, 2618 5696 फैक्स / Fax: 91-11-2610 1623
ई.मेल / Email: director@nihfw.org, director.nihfw@nic.in वेब साईट / Website: www.nihfw.org

Subject: Minutes of meeting for Pre-core group meeting on National Cold-Chain Assessment and Assessment of impact Solar-Hybrid Power Supply System has made on Health Service Utilization

List-1

1) Dr. Genevieve Begkoyian,
Chief of Health, UNICEF,
73, Lodhi Estate, New Delhi - 110 003

2) Dr. M.K. Agarwal,
Deputy Commissioner (UIP),
Room No-105 'D', Ministry Of Health and Family Welfare,
Nirman Bhawan, New Delhi

Minutes of Meeting

Pre-core group meeting on National Cold-Chain Assessment and Assessment of impact Solar- Hybrid Power Supply System has made on Health Service Utilization

Date: 12-12-2013

Venue: NIHFW, New Delhi

Participants:

Prof. M. Bhattacharya	:	**HOD, CHA Deptt. & Nodal officer (Immunization), NIHFW, New Delhi**
Dr. Srihari Dutta	:	**Health Specialist, Unicef**
Mr. Manish Gangal	:	**Health officer, Cold-Chain, Unicef**
Mr. Abhimanyu Saxena	:	**Training Coordinator, NCCVMRC**
Mr. Shashi kant Ray	:	**Software programmer, NCCMIS**
Ms. Dipti Singhal	:	**Program Assistant, NCCVMRC**
Mr. Harkesh Singh	:	**Technician, NCCVMRC**
Mr. Shashank Savita	:	**Technician, NCCVMRC**

1) Inauguration of NCCVMRC

- Inauguration of NCCVMRC (National Cold-Chain and Vaccine management resource center) at Animal house building of NIHFW may be done before 31st December 2013.

  Action point: Vision statement needs to be developed and list of invitees needs to be finalized by NCCVMRC

- Cold-Chain equipment needs to be procured for NCCVMRC including ILR/DF and WIC/ WIF. Unicef agreed to support NCCVMRC for cold-chain equipment.

  Action point: Unicef to be intimated for cold-chain equipment by NCCVMRC, NIHFW.

2) NVLMIS (National Vaccine and logistics management information system):

- Apart from NCCMIS, NVLMIS needs to be developed to capture real-time status of vaccine and logistics.

  Action point: Unicef to send offical confirmation to NIHFW to development NVLMIS.

- Existing MIS of Odhisha and Bihar (OVLMIS & BVLMS) can be scaled up to National Level and GMSD.
- NVLMIS may be developed within 3-5 monts.
- Unicef will issue the letter for selecting the agency for developing NVLMS.

3) Administrative issue of NCCVMRC staff:

- Exemption needs to be taken for the staff of NCCVMRC for TA/DA issues. Staff needs to be recognized as National resource person.
- One program assisant needs may be hired from finance/accounts background.
- Meeting for recruitment of staff needs may be proposed before January 2014.

4) National Cold-Chain Assessment 2013:

- National cold-chain Assessment needs may be done by NCCVMRC at NIHFW by 15th January 2014, funding will done by Unicef.

  Action point: NIHFW to send FACE-FORM to Unicef for conducting National Cold-Chain assessment.
- Core group comprising of NCCVMRC, NCCTC, UNICEF, WHO-NPSP, ITSU, MCHIP and others.
- One program assisant may be hired for National Cold-chain assessment for 3 months, funding will be done Unicef.
- Report of National Cold-Chain Assessment will be considered for the introduction of IPV in March 2014.
- Proceedings will be as follow.

Activity	Proposed Timeline
Formation for the core group	15th December 2013
Desk review of NCCMIS data/records and develpment of inquiry (verification data quality through site visit)	10th January 2014
Desk review of NEVM data sheet of the states	10th January 2014
Draft tool development for field visit and data collection	15th January 2014
States selection for assessment and validation of NCCMIS data quality	15th January 2014
Training of the core team members for the assessment	20th January 2014
Field visit for data collection	31st January 2014
Data compilation and analysis and cold chain space projection for new vaccine introduction	10th February 2014
Report writing	15th February 2014

5) Assessment of impact Solar-Hybrid Power Supply System has made on Health Service Utilization:

- *Assessment of impact Solar-Hybrid Power Supply System has made on Health Service Utilixation* may be done by NCCVMRC at NIHFW by 28th February 2014. Funding will be done by Unicef.

Action point: NIHFW to send FACE-FORM to Unicef for conducting Assessment of impact Solar-Hybrid Power Supply System has made on Health Service Utilization

- Unicef will depute a **Technical Resource Person from UNIDO** for the assessment.
- Proceedings for Assessment of impact Solar-Hybrid Power Supply System has made on Health Service Utilization

Activity	Proposed Timeline
Constitution of a core group of 8-10 people to plan specific terms of reference and information for the assessment, with objectives listed above.	31st December 2013
Orientation of the team around methodology and assessment tool/formats	15th January 2014
Secondary data analysis for selection of districts on account of RMNCH+A indicators, to select 10 districts for assessment.	15th January 2014
Field visit to health facilities with and without solar hybrid system in Maharhashtra, for observations and semi-structured interview and data collection from PHC records and also, interaction with users, especially where examples of saving lives are available and attributed to the availability of electricity/ staff at odd hours. 3-4 years data will be compared.	10th February 2014
Interaction with MoIC-Health Facilities, district CMOs/DIOS and state officials as well as vendor, CoE, Pune, and SHTO.	20th February 2014
Data analysis and development of recommendations for the report.	25th February 2014
Debriefing to MoHFW and finalization of report.	28th February 2014

Prepared by:

Training Coordinator
NCCVMRC

Verified by:

Nodal officer
(Immunization)

Approved by:

Director
NIHFW

Appendix B

Communication from MNRE

सत्यमेव जयते

Tarun Kapoor, IAS
Joint Secretary

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GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

D.O.No. 03/09/2014-15/GCRT 10th August, 2015

To,

All Central Government Ministries/Departments

All Central Government PSUs/Institutions/Organizations

All State Government Departments/PSUs/Institutions/Organizations

All Educational Institutions/Schools/Colleges

Principal Secretaries/Secretaries (Renewable Energy)

Heads of All State Nodal Agencies

All District Collectors/Deputy Commissioners

Sub: **Installation of Grid connected solar rooftop systems/projects on roofs belonging to various Central Government Ministries/Departments or to any of their Organizations/PSUs/Institutions, buildings of State Governments/State PSUs, State level institutions etc.**

Dear Sir/Madam,

Government of India has set a traget for installation of 1,00,000 MW solar power plants by the year 2022 out of which 40,000 MW has to come from grid connected solar rooftop systems. The price of solar power has fallen drastically in the last 2-3 years and it is economical to generate power through grid connected solar rooftop for commercial/industrial/institutional/residential consumers in many States, where the tariff is more than Rs.7.0 per unit. Payback period is about 5-6 years and the life of the plant is 25 years.

2. About 10 sq.m area is required for 1.0 kWp solar rooftop systems. There is huge roof space available in Govt. buildings including offices, PSUs buildings and institutions. Even if a part of this roof space is utilised for setting up rooftop solar power systems the thousands of MW of solar power can be generated besides saving money for the concerned Ministries/Departments. Some Ministries & their PSUs have also a lot of spare lands available which can be used for solar power genertaion.

3. **Benefits** of solar rooftop systems include reduced electricity bill, generating green power and reduction in carbon footprints. Wide range of capacity sizes are available as this is

Contd...

Block No. 14, CGO Complex, Lodi Road, New Delhi - 110 003
Tel.: +91-11-24360359 • Fax : +91-11-24367861 • E-mail : tarun.kapoor@nic.in

modular in nature etc. **Incentives** include 15% Government subsidy for selected categories, accelerated depreciation benefits for industrial and commercial buildings, bank loan at the interest rate of housing loan from Public Sector Banks, loan from IREDA at concessional interest rate for system aggregators, custom duty concessions, excise duty exemptions etc.

4. Recently, Reserve Bank of India has included renewable energy projects under priority sector lending for which bank loans up to a limit of Rs. 15 crore to borrowers will be available for renewable energy projects including grid connected solar rooftop and ground mounted systems. For individual households, the loan limit is Rs 10 lakh per borrower.

5. Department of Financial Services has advised all Public Sector Banks to provide loans for grid connected rooftop solar systems as home loan/ home improvement loan. So far, nine PSBs namely Bank of India, Syndicate bank, State Bank of India, Dena Bank, Central Bank of India , Punjab National Bank, Allahabad Bank, Indian Bank and Indian Overseas Bank have given instructions to their branches.

6. State Electricity Regulatory Commissions of 19 States/UTs namely Andhra Pradesh, Chhattisgarh, Delhi, Haryana, Karnataka, Kerala, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal, Andaman & Nicobar, Chandigarh, Dadra & Nagar Haveli, Daman & Diu, Lakshadweep, Pondicherry and Goa have notified regulations for net metering/feed-in-tariff mechanism, so far and others are to follow suit.

7. The grid connected solar rooftop projects can be installed through the following organizations:

i. Solar Energy Corporation of India (website www.seci.gov.in)

ii. Empaneled Channel Partners (list available at MNRE website www.mnre.gov.in)

iii. State Nodal Agencies for respective States (http://www.mnre.gov.in/related-links/)

iv Few CPSU's/Government agencies are working in this area and can be approached for advice and installation of systems **(Annexure)**

v. Government Departments can also directly avail subsidy from MNRE

8. You may indicate your requirement, online on MNRE website (www.mnre.gov.in) through a **'Installation Interest form'** duly filled up by you. A Solar Rooftop Financial Calculator is also available on this wbsite for your own assessment. Kindly visit MNRE website for further details on grid connected solar rooftop systems. Your request will be forwarded to respective agencies.

9. You are requested to take appropriate actions to install the grid connected solar rooftop systems in available roof space in the buildings and let your buildings to produce clean and green power

With regards,

Your Sincerely,

Tarun Kapoor

[Tarun Kapoor]

List of CPSU's/Government Agencies empanelled by MNRE for installation of Grid Connected Solar Rooftop System

Sl. No.	Name of the Company	Contact Details
1.	Rajasthan Electronics & Instruments Limited	Deepak Gupta DGM (RE) (M): 07727011714 Email: deepak.gupta@reil.co.in Tel: 0141-2470363, 271, 784 (Electronics) Tel: 0141-2470908 (RE) Fax: 0141-2470139 Email: reiljp@sancharnet.in 2, Kanakpura Industrial Area, Sirsi Road, Jaipur - 302012 - Rajasthan-India
2.	India SME Technology Services Limited (ISTSL)	Rajiv Kumar CEO Tel: 011-28525534 Fax: 011-28525535 Email: istsl@techsmall.com DFC Building, Plot No. 37-38 D-Block, Pankha Road, Industrial Area, Janak Puri, New Delhi - 110 058, India
3.	Kerala State Electronics Development Corporation Ltd. (KELTRON)	Ms. R. Grace Jenilet CGM (Head – Power Electronics Group) Tel: 0472-2888720, 999, 282 Fax: 0472-2888736 Email: keltronpeg@gmail.com Power Electronics Group, Keltron Equipment's Complex Karakulam-695564, Thiruvananthapuram, Kerala
4.	Gujarat Industries Power company Ltd.	S. N. Purohit Additional General Manager (O&M) Tel: 0265-2230185, 2232768, 2232213 Fax: 0265-2231236 Email: snpurohit@gipcl.com P.O. Petrochemical, Dist. – Varodara - 391346, Gujrat, INDIA

5.	Centre for Development of Imaging Technology (C-DIT)	Dr. Babu Gopalakrishnan Director Tel. (Direct): 0471-2380908 Tel: 0471-2380910, 2382137, 2383506 Fax: 0471-2478222 Emial: greentech.cdit@gmail.com, cdit@cdit.org Chitranjali Hills, Thiruvallom PO, Thiruvananthapuram, Kerla – 695027
6.	Central Electronics Limited (A Govt. of India Enterprise)	Anupam Tyagi Chief Manager (SPV-M) Tel: 0120-2895151 Fax: 0120-2895147-148 Email: spvesports@celsolar.com, cel@celsolar.com 4, Industrial Area, Sahibabad- 201010
7.	UP Industrial Co-operative Association Ltd. UP Govt.	Rajendra Singh, PCS Managing Director Telifax: 0512-2218894 Email: upicahh@yahoo.in Upika Bhawan, 117/418-B Sarodaya Nagar, Kanpur - 208 005, Uttar Pradesh
8.	Bharat Electronics Limited	Narendra Kumar K Sr. DGM (Mktg/Comps) Tel: 080-22195539/ 5662 Fax: 080-28382322 Email: narendrakumark@bel.co.in Jalahalli Post, Bangalore-560013
9.	PEC Limited	Manish K. Bainiwal General Manager Tel: 011-23314727 (M): 09650294349 Email: bainiwal@peclimited.com "Hansalaya", 15 Barakhamba Road, New Delhi - 110 001

Appendix C

Details of Field Visit

Table1: Solar Hybrid Assessment 2014 Plan of Field Visit

Team No.	Member 1	Site			Version
		Name of the District	Taluka	Name of PHC	
1.	Dr Vijay Kumar Dr. Ravindra Singh	Amaravati	Chikhaldara	Katkumbh	V1
			Chikhaldara	Semadoh	V1
			Chikhaldara	Salona	V1
			Nandgaon K	Loni Varud	V4
2.	Mr. Shashank Savita Dr. Ravindra Kumar	Chandrapur	Raiura	Chincholi	V2
			Raiura	Dewada	V2
			Saoli	Pathari	V2
			Chandrapur	Ghuguss	V4
3	Mr. Amit Namdeo Dr. Ravindra Singh	Gondia	Salekasa	Satsaon	V2
			Goregaon	TilliMohgaon	V2
			Devari	Mulla	V2
			Goregaon	Kurhadi	V4
4	Dr. Vijay Kumar Dr Arun Kumar Tiwari	Nandurbar	Akkalkuwa	Jamana	V3
			Akkalkuwa	Pimpalkhuta	V3
			Dhadgaon	RH Dhadgaon	V3
			Akkalkuwa	RH Akkalkuwa	V4
5	Dr. Vijay Kumar Dr Arun Kumar Tiwari	Nashik	Nashik	Rohile	V2
			Tryambak	Thanapada	V2
			Trvambak	Mulawad	V3
			Niphad	PHC Chandori	V4
6	Dr. Sanjay Gupta Dr. Joy Kumar	Pure	Ambegaon	Peth	V3
			Khed	Dehine	V3
			Junnar	Antall	V3
			Haveli	Loni kalbhor	V4
7	Mr. Sandeep Tandon Dr. Srihari Dutta	Raigad	Karjat	Kadav	V1
			Karjat	Nerul	V3
			Roha	Naghotane	V3
			Shriwardhan	Borlipanchatan	V4
8	Mr. Paritosh Panigrihi Dr. Mainak Chatterjee	Ratnagiri	Ratapur	Jaitapur	V1
			Ratnagiri	Pawas	V1
			Chiplun	Dadar	V1
			Ratnagiri	Sakharpa	V4
9	Mr. Paritosh Panigrihi Dr. Mainak Chatterjee	Sindhuchug	Kankawali	Phonda	V1
			Malvan	Achare	V1
			Devgad	Pada	V1
			Sawantwadi	Mangaou	V4
10	Prof Madhulika Bhattacharya Dr. Raj Kumar	Thane	Kalyan	Khadwal	V2
			Bhiwandi	Chimbipada	V2
			Bhiwandi	Dhabhada	V3
			Mokhada	RH Mokhada	V4

Appendix D

List of Persons Interviewed

This is a listing of persons contacted in Maharashtra during the field mission. The evaluators regret any omissions to this list.

Total number of meetings conducted: 42	
1.	Dr. Satish Pawar, Director, Health Service, Government of Maharashtra
2.	Mr Vitthal Bandal, Ph.D, Senior Consultant and Coordinator, NCCTC, Pune
3.	Dr. N.D. Deshmukh, District Health Officer, Pune
4.	Bharat Phalak, Greenbrilliance Energy Pvt. Ltd., Pune
5.	B.K. Agashe, StreamLine Power Systems Pvt. Ltd., Pune
6.	Atul Gupta, Megatech Inverters Pvt. Ltd., Pune
7.	Anil Pawar, Megatech Inverters Pvt. Ltd., Pune
8.	Mr. Durgesh Deshmukh, NCCTC, Pune
9.	Ms. Kanchan Pujari, NCCTC, Pune
10.	Dr. P. R Wakadkar, PHC Ghuggus Block Chandarpur, Distt, Chandrapur
11.	Dr. D. K. Muneshwar, PHC Dhaba Block Gondpipri, Distt, Chandrapur
12.	Dr. Korde, MO, PHC Jiwati Block Jiwati, Distt, Chandrapur
13.	Dr. Rawana Parveen, PHC Majri Block Bhadrawati, Distt. Chandrapur
14.	Dr L. P Badodekar, PHC, Dowwa, Sadak Arjuni, Distt. Gondia
15.	Dr. P.K. Dumbre, PHC, Shenda, Sadak Arjuni, Distt. Gondia
16.	Dr. Gund Ganesh, PHC, Pandri, Sadak Arjuni, Distt. Gondia
17.	Dr. P.L. Pawara, PHC Pimpal Khuta Block Akkalkuwa, Nandurbar
18.	Dr. Satpute, PHC RH Dhadgaon Block Dhadgaon, Nandurbar
19.	Dr. Pratap Chats, RH Akkalkuwa Block Akkalkuwa, Nandurbar.
20.	Dr. Ganesh Pawar, PHC Jamana Block Akkalkuwa, Nandurbar.
21.	Dr. Pushpa Bonkai, PHC Thanapada Block Tryambak, Nasik.
22.	Dr. S.B Bhoi, PHC Chandori Block Niphad, Nasik
23.	Dr. D.T Gavali, PHC Rohile Block Tryambak, Nasik
24.	Dr. Chatter, PHC Mulwad Block Tryambak, Nasik
25.	Dr. Dighe A G, PHC Aaptali Block Junnar, Pune
26.	Dr. Anitha M Reddy, PHC Peth Block Ambegaon, Pune

27.	Dr. Janardhan Jadhav, PHC Loni Kalbhor Block Haveli, Pune
28.	Dr. C.K. More, PHC Kadav, Block Kajrat, Raigad
29.	Dr. G.G. Wadge, PHC Nagothane, Block Roha, Raigad
30.	Dr. Sachin Gomsaley, PHC Borlipanchataran, Block Shrivardhan, Raigad
31.	Dr. Aruna Ramdas Bambere, PHC Neral, Block Karjat, Raigad
32.	Dr. Deepak A Patil, PHC Dewle, Block Sagmeshwar, Ratnagiri
33.	Dr. Subodh Ingle, PHC Pawas, Block Ratnagiri
34.	Dr. P.B. Adate, PHC Sakharpa Block Ratnagiri
35.	Dr. Satish Gujalwar, PHC Jakadevi, Block Ratnagiri
36.	Dr. Balazi Patil, PHC Achare, Block Malavan, Sindhudurg
37.	Dr. Umesh Patil, PHC Padel, Block Devgad, Sindhudurg
38.	Dr. N.R Masunkar, Sindhudurg
39.	Ms. Varsha Vijay, PHC, Khadwali, Block, Kalyan, Thane
40.	Dr. Sharad D. Patil, Referal Hospital, Mokhada, Block, Mokhada, Thane
41.	Dr. Sanjay Kakre, PHC, Chinebipada, Block Bhiwandi, Thane
42.	Dr. Ramesh Kakre, PHC, Somla, Block Palghar, Thane

Evaluation Questionnaire Sample

Evaluation of Solar Hybrid Photo-voltaic System in Primary Health Centres in Maharashtra

I. Socio-demographic profile of the site:

a. Name of the district:...

b. Name of the block:...

c. Name of the health facility visited:..

d. Location of the health facility:..

e. Terrain of the health facility:..

f. Category of health facility:..

g. Who handles cold-chain in the absence of primary cold-chain handlers? (Provide designation)...

h. Does the health facility have electricity supply? If yes, how many hours of grid electricity supply is available in a day (average)..

i. What is the voltage of electricity? ....

j. Is there an inverter present to provide back-up power?.............................

II. Date of evaluation: ....

III. Assessment period: 12 months; from September 2013 to August 2014

List services (priority for that particular area) which PHC is offering (Standard list to be prepared)

Standard list of equipment / medical instruments that are required to deliver these services and use electricity, and their approximate electrical load

List utilities/functions that are currently not run on SHPV system even though required for emergency medical care, and their approximate electrical load

List of standard equipment and services offered

Primary / Community Health Centre	Sub-District Hospital	Equipment Connected to SHPV	Services
1. Suction Machine Service	I. Suction Machine	Suction machine	A. Maternal Health
2. Radiant Warmer	II. Radiant Warmer		i. Labour room
3. Blood storage unit	III. Blood storage unit		ii. Blood storage
4. CCE (ILR and deep freezer)	IV. CCE (ILR and deep freezer)	ILR and deep freezer	B. Child Health Service
5. Operation Theater lamp	V. Operation theater lamp	OT lamp	i. Radiant warmer
6. Nebulizer	VI. Nebulizer	Nebulizer	ii. Suction machine
7. Foetal monitor	VII. Foetal monitor	Foetal monitor	C. Immunization
8. Fumigation machine	VIII. Fumigation machine	Fumigation machine	i. ILR and deep freezer
9. Computer Service	IX. Computer	Computer	D. Operation Theater
10. General Utilities	X. General utilities	Signage/display	i. Shadowless lamp
11. Fans (No. of points)	XI. Fans in hospital	Ceiling fans	ii. Electric cutter
12. Lights	XII. Lights in hospital	Indoor & outdoor LED lights	iii. Suction machine
13. Lights and fans in staff quarters	XIII. Fans and light in living accommodation for hospital staff		E. Out patient Department / Emergency Services
-	-		i. X-ray film viewer
-	-		ii. Needle cutter
-	-		iii. Autoclave

Evaluation Criteria	Questions	Indicators	Respondent	Method of verification
Relevance: How does the Solar-Hybrid Photo-Voltaic (SHPV) System relate to one of the main objectives of the NRHM, to provide reliable health services in remote and inaccessible areas?				
• Is the Solar-Hybrid Photo Voltaic System relevant to the primary health centres?	• What is the duration of electricity supply in this centre? • Which are the months when maximum power cut is experienced by the Health Centre? • What is the maximum duration of power outages during the worst months?	____________hrs per day ____________________ ____________________ ____________hrs per day		
	• Are the services offered at the PHC and medical equipment affected by erratic and inadequate power supply situation?	Yes ☐ No ☐		
	• What health services in the centre are affected due to the absence of grid power	Choose all the health services affected (most to least, first five highly relevant) A. ☐ B. ☐ C. ☐ D. ☐ E ☐		
	• How relevant is the SHPV in terms of supporting and facilitating functioning of PHC?	**Highly relevant** ☐ (all services are supported by it)		

		Relevant ☐ few services are supported by it) **Not relevant** ☐ (services can be carried out without SHPV)		
	• In the absence of electricity how are the services provided in this centre?	SHPV ☐ Diesel generator ☐ Battery and inverter ☐ No back-up power supply available ☐		
• Is the current design of SHPV system-based power supply arrangement adequate for the services offered?	• Does the PHC have an operational suction machine? If yes, is the suction machine used with SHPV?	Yes ☐ No ☐		
	• Does PHC require hot water? If yes, how is the water heated?	Electric geyser ☐ Boiler ☐ Kerosene stove ☐ Fuel wood stoves ☐ Other.................... ☐		
	• Does PHC have an autoclave? If yes, how is it operated?	Yes ☐ No ☐		
	• How is it helping you to work better?	Yes ☐ No ☐		

• Motivation level of PHC staff ?	• Do you recommend SHPV system to be replicated to other PHC/CHC? (Elaborate answer below)	Yes ☐ No ☐		
	• How is it helping you to work better?	Yes ☐ No ☐		
	If Yes, provide reasons Uninterrupted Electricity supply from SHPV:	Allows the centre to provide all essential services................. ☐ Provides the utility services for serving staff........................ ☐ Other reasons. .... ☐		
	• If No, provide reasons Does not assist in providing all the essential services	After sales service and maintenance of system is not promptly Frequent technical problems in the system and lack of trained staff at health centre................☐ Other reasons........................☐		
Effectiveness: The extent to which SHPV has been effective in increasing PHC operations and medical services?				
• Has the SHPV been effective in improving the overall functions and services of PHC?	• In what ways has the SHPV helped the medical services offered by the PHC?	Improved medical services ☐ Improved emergency services ☐	Reason based response	

	• Has reliable electricity supply due to SHPV led to increase in the number of patients/cases being attended by the PHC?	☐ Yes, there is an increase since the time SHPV was installed ☐ No, not much noticeable change		
	• Has reliable electricity supply due to SHPV led to increase in the number of patients/cases being attended by the PHC?			
• Ease of use of SHPV? (Administrative)	• How many staff members of PHC are handling the SHPV systems?	Number of staff		
	• Out of the assigned staff, how many staff members have undergone training on SHPV? • Who provided the training? (Name of the organization) • Were the trainings provided on-site or at a different location? • What has been the benefit from these trainings?	Number of staff and designation.................... Name:............................ ☐ Yes ☐ No Benefits:.......................		
	• Have the trainings and after-sales service by suppliers or system integrator helped in trouble shooting of SHPV?	☐ Yes ☐ No		
• Benefit to the equipment and medical instruments	• What is the rate of breakdown of electrical and electronic equipment at health centre after the SHPV was installed?	☐ Frequently ☐ Rarely		
• What are the observed limitations of SHPV?	• Is the SHPV performance affected by non-availability of sun shine for a period of...	☐ Less that 2 days ☐ 2- 4 days ☐ 4- 5 days		

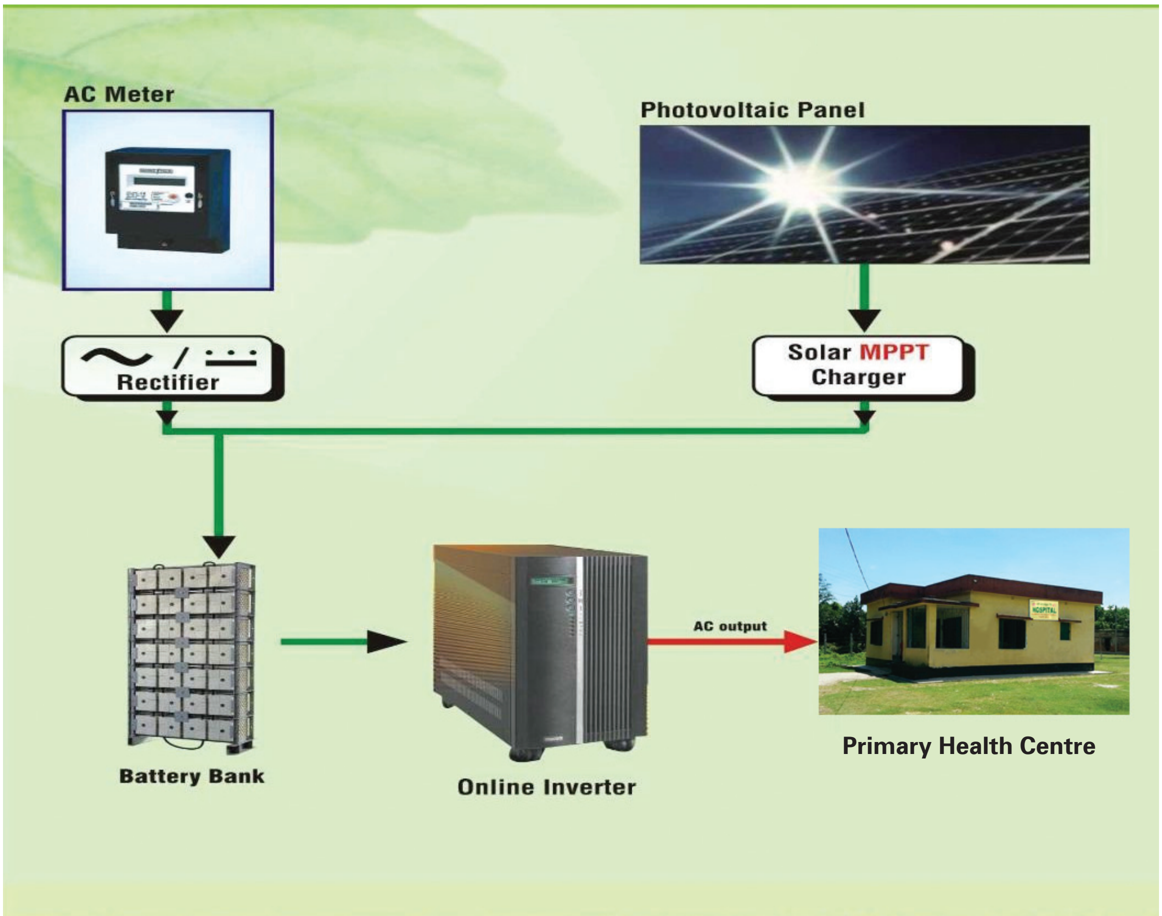
	What function/service of PHC is affected during such time? (Refer list of services on page 1)	____________ ____________ ____________		
	• Are there medical equipment/ instruments in PHCs which are currently not connected to the SHPV system but required for medical emergencies? (Refer list on page 1)	____________ ____________ ____________		
Efficiency: Has 24x7 availability of electricity improved operational efficiency of PHC and benefited the community?				
• Benefit to the community?	• Number of OPD cases? (Record based)	Services offered before installation:____________ ____________	Services offered after installation ____________	
	• Number of indoor cases? (Record based)	Before installation: ______ ____________	After installation ____________	
	• Trauma cases and live savings cases dealt by the centre?	Before: ____________ ____________	After: ____________	
	• Number of children receiving service from New Born Care Unit?	Before installation: ______ ____________	After installation ____________	
	• Cases of normal institutional deliveries/caesarean deliveries?	Before installation: ______ ____________	After installation ____________	
	• Other life saving interventions possible due to reliable electricity supply? Cases of snake, dog, scorpion bite	Before installation: ______ ____________	After installation ____________	
	• Family planning operations performed at the health centre? Number of tubectomy/number of vasectomy?	Before installation: ______ ____________	After installation ____________	
• Benefit to Health Centre staff?	• Retention of doctors and pharmacist?	Before installation: ______ ____________	After installation ____________	

	• Ability to store vaccines and blood	Before installation: ______ ______________________	After installation ___________________	
Sustainability: What are the financial, institutional, social, and/or environmental benefits to sustain long-term results?				
• Will the use of SHPV be sustainable and stimulate replication?	• How does the annual operating cost of SHPV. Compare with the annual operating cost of conventional energy supply (grid electricity + diesel)			
	• What is the typical cost of annual electricity consumption in the PHC?	Before installation: ______ ______________________	After installation ____________________	
	• What is the annual cost of diesel consumption in the PHC?	Rs. __________________	Rs. _________________	
	• Provision for training to the operators to attend minor technical issues in the SHPV? Has the training been institutionalized?	☐ Yes ☐ No		
	Are Comprehensive Maintenance Contracts (CMC) in place for different components of SHPV?	☐ Yes ☐ No		
	• Do these CMCs have service level agreements in place?	☐ Yes ☐ No		
	• Do you recommend replication of the SHPV systems to other PHC / CHC within the state? If so, why?	☐ Yes ☐ No	Reasons: ☐......Reliable electricity supply ☐......Improved vaccine delivery ☐....Increase in delivery of medical services	

Impact: Are there indications that the application of SHPV has contributed to, or enabled progress towards improving health services?				
• Are there tangible improvement/changes in the services offered by the PHC?	• What life-saving intervention is the PHC able to provide due to reliable electricity from SHPV?	Services offered before installation:____________ ______________________	Services offered after installation ____________________	
	• Is the PHC able to offer some medical services/facilities that are normally available at district HC? (Refer list on page 1)	☐........ OT service ☐........ C-section deliveries ☐........ Surgeries ☐........ New born care unit ☐........ Other: _________		
	• What is the population of PHC's service territory?	Population Figure: _______ ______________________		
• What are the indirect benefits that can be attributed to SHPV installation in PHCs?	• What are the general perceptions among the population, especially among women, about the functioning and services offered by the PHC (since the installation of SHPV)?	☐..........Medical help for family is now available at the centre ☐...............Feel safe for children ☐..............Centre easily accessible anytime in 24 hrs		
	• Any other indirect benefits that can be attributed to SHPV installation in PHC?	Give example:__________ ______________________ ______________________ ______________________		
• Impact at state-level general health data/ indicators due to SHPV use in PHC?	• Has improvement in services offered by PHC with SHPV led to any change at the state level health indicators? (Response from state headquarter)	☐ Yes ☐ No		

Appendix F

Solar Hybrid Photo-voltaic System Details



Simple schematic diagram of SHPV system

Present SHPV system installed in PHCs is designed with 50 per cent solar and 50 per cent grid energy for the required daily energy requirement, i.e. of 2.65 KWH. This design is highly flexible and can be modified for different combinations of grid and solar dependence (e.g. 80 per cent Solar + 20 per cent grid energy). This system can accommodate more cold chain equipment due to additional energy available with the present system. However, it would reduce the back-up time. (Presently it is 5-days as per WHO PQs norms).

The system designed has the following merits:

i. Inverter batteries are charged from grid as well as from solar panels, which helps to improve the reliability of the system and ensures its availability.

ii. The system is capable of providing electricity supply to ILR and deep freezers, general ward, laboratory as well as critical equipment in operation theatre and neo-natal care unit.

iii. Online monitoring of the system's functioning is possible due to a web communication module which is embedded in the system.

iv. Functional life of the SHPV system is minimum 10 years, which is the average time-span based on the life of system components. Life of inverter and solar panel is 20 years, whereas that of the battery is 5 years or 1500 charge/discharge cycles.

v. The system is integrated by local firms that are also suppliers of one main component of the SHPV such as solar panel or inverter. All the components of the system are commercially available in the Indian market. SHPV system, therefore, supports Prime Minister's 'Make in India' initiative.

vi. Local manpower and spares availability immensely helps in after-sales service and reducing the down-time;

vii. Some of the systems designed have remote monitoring facility. The features of this systems are:

- Inverter with GSM/CDMA connectivity by RS232 cable
- Periodical log of following data via SMS facility

i. Monitoring utility power to UPS

ii. Monitoring of battery level/percentage

iii. Monitoring of load voltage and frequency

iv. Monitoring of load level/percentage

v. Event log on fault condition

vi. Mains fail/fault

vii. Battery low alarm

viii. System fault/trip

ix. System overload

Some key features considered while designing of the system for health service as required to maintain Indian Public Health Standards (IPHS). For a health facility to fulfil IPHS, one of the basic requirements is to have 24x7 electricity supply. To ensure 24x7 electricity through SHPV systems, some of the key features considered during the design were:

- To cater to cold chain equipment for 5 days. Provide minimum 12 hours of continuous backup for the full critical load of the PHC and maximum 18 hours in the case of grid failure or no-sunshine;
- Various components of the SHPV system such as solar panel, inverter and batteries are standard products which comply with IEC standards and are commercially available in the Indian market.

Table 1 – Showing the Electrical Load Catered as per Requirement

Sr. No.	Description	Quantity & Consumption for 1.5 KVA	Quantity & Consumption for 2.4 KVA	Place of electrical point
		For small PHC (Infrastructure)	**For regular setup (Infrastructure)**	
1.	Lights	10x 18W = 180W	13 x 18W = 234W	Male ward, female ward, MO room, OT, office, pharmacist room, cold chain room, entrance light, labour room, corridor-3 & laboratory
2	Fans	2 x 75W = 150W	6 x 75W = 450W	Male ward, female ward, MO room, OT, office, pharmacist room
3	ILR	1 x 200W = 200W	1 x 200W = 200W	Cold chain room
4	Shadow less lamp	-	1 x 275W = 275W	OT
5	Computer	1 x 300W = 300W	1 x 300W = 300W	Office
6	Nebulizer	1 x 100W = 100W	1 x 100W = 100W	Labour room
7	Suction machine	-	1 x 150W = 150W	OT
8	Fumigation machine	-	1 x 100W = 100W	OT
9	Fetal monitor	1 x 100W = 100W	1 x 100W = 100W	Labour room
Total Electrical load		**1030 Watts**	**1909 Watts**	

General Assumptions for SHPV System Design

Inverter Efficiency = 90 per cent

Battery Efficiency = 95 per cent

Solar Efficiency = 80 per cent

Grid Availability = 40 hrs/week (6 hrs/day).

Solar availability = 6 hrs/day.

- Out of this daily energy consumption, ILR and deep freezer daily energy consumption is: 2.65 KWH with duty cycle: - 8 hrs/day.
- Solar panels will provide 50 per cent energy for charging the battery for daily energy requirement while the remaining 50 per cent will be provided by grid.
- Solar efficiency of 80 per cent will be interpreted as de-rating of the solar panel per year should not be more than 2 per cent per year over the period of 10 years. It means 100Wp panel should give 80Wp at the end of 10 years from the date of installation and commissioning.

Schedule-I

PV-AC hybrid power pack (50 per cent Solar + 50 per cent Grid)

The Objective

System availability can be greatly increased in situations where there is intermittent grid supply by having a power pack comprising solar PV panels, battery bank and an intelligent inverter (on-line) which feeds uninterrupted quality AC power to electrical loads taking energy from PV, grid or batteries as the case may be. Combining the best of both worlds, batteries will be charged from solar energy as well as from the grid by a multistage Float Cum Boost Charger integrated in the inverter.

KVA Rating	2.4
KW	1.92
DC Voltage	144
Power Factor	0.8
Diversity	60 per cent
Inverter Output Voltage (AC)	230
Battery	144 Volts, 300 AH
No. of Solar Panels	Can be decided by tenderer according to total solar wattage requirement
Solar Wattage	5280 Watts

The loads

Electrical loads from the lighting equipment, load of ice lined refrigerator and deep-freezer have been considered for requirements of a typical PHC or a district store. Energy consumption / load requirement figures are listed in the table as below.

Sr. No.	Particulars	Qty.	Approximate load
1.	Lighting load, loads of Ice lined Refrigerator and Deep-freezer	1 Job	1920 Watts

Sizing

The solar PV system is to be designed for the electrical load of 1920 watts

The following assumptions/ information are to be considered while designing the systems:

(i) Battery autonomy for no sun and no grid condition up to 24 hours

(ii) Maximum loss of load probability (LOLP) of 0– 0.15 per cent during August

(iii) Battery Maximum Depth of Discharge (DOD) is 80 per cent

(iv) All equipment operates at 230 V AC

(v) Grid electricity is available for 40 hours per week at sites

(vi) Maximum load shedding occurs during daytime

(vii) Grid power supply situation improves during July-August-September where as sun availability is limited during the said period

(viii) Grid voltage variation is from 130 Volts-270 Volts

Summary of Sizing

Technical Specifications of the components

Solar PV Array

Multi crystalline silicon solar module of suitable nominal voltage and peak power rating that meets the specifications and are certified according to international standards **IEC 61215 (EDITION-II)** or equivalent standards may be used. Modules must be supplied with a manufacturer warranty that Fabrication is in compliance with at least one of the above standards and a minimum warranty of TEN years must be available with degradation of power generation not exceeding 10 per cent over the entire 10 years period. The junction box should be equipped with bypass diodes. Series-connected photo-voltaic modules should be wired using reassembled solar cables and multi-contact plugs. Each module supplied should accompany an I-V curve certifying the rated power output and other technical information. Cable connecting panel to charge controller is to be routed through ISI mark flexible pipe with proper saddling /clamps.

Solar Panel Array Support Structure

Modules should be mounted on a non-corrosive support structure suitable for site condition (extreme site conditions to be taken into account) with facility to adjust tilt (0-30o) (or fixed). Support structure design and foundation or fixation mounting arrangements should withstand minimum horizontal wind speed (150Km/Hr) relevant to the site conditions and epoxy powder coated sheet metal fabricated on CNC Machine.

Technical Specification of Module mounting structure

Materials	MS or Aluminum Alloy
Coating	Hot Dip Galvanized with epoxy powder coating or anodized
Wind rating	150 km/hour
Fixing type	SS 304 fasteners
Protection	Theft resistant fixation

Anti-theft devices for security of solar panels

- Devices like solar panels are indeed very useful and costly but the issue of their security is one of the main concerns of the user.
- Recently, many incidents about the theft of solar panels have been recorded. In this type of theft the customer loses thousands of rupees in just one stroke. In view of this, bidder is expected to provide the anti-theft system for the solar panels.
- For example, it can be in the form of using lockable bolts for fixing of solar panel either on the roof or panel structure. The ultimate purpose of this is to make it difficult for somebody to take away the panel or in case the thief is successful in stealing the panel, it should be in such a bad condition (broken), that it will not be of any use.

MPPT Charge Controller

The Charge Controller should have temperature compensation for proper charging of the battery throughout the year. Adequate protection is to be incorporated under no load conditions, battery overcharge and deep discharge conditions. Protection should be provided against short circuit conditions. Full protection against open circuit, accidental short circuit and reverse polarity (auto resettable) should be provided. It should have LCD display which indicates Battery Voltage and Battery Charging Current.

Technical specification of MPPT Charge Controller

1.	Maximum Input Voltage	V DC	To be designed by the
2.	Minimum Input Voltage	V DC	tenderer as per
3.	Output Current From MPPT To Battery Bank / Load Max / MPPT	A DC	requirement
4.	Output Boost Voltage From MPPT To Battery	V DC	
5.	LCD Monitor Should Be Inbuilt To Show Battery Voltage	V DC	Required
6.	LCD Monitor Should Be Inbuilt To Show Battery Current	A DC	Required
7.	On Off Switch Provision On Front Should Be Inbuilt	Inbuilt	Required
8.	MPPT Output Should Be Isolated From Solar Input	Inbuilt	Required
9.	MPPT Should Not Take Any Power From Battery Bank When No Solar Input Power Is Available	Inbuilt	Required
10.	MPPT Should Have Isolation Between Solar Input & Battery Bank	Inbuilt	Required
11.	MPPT Should Have Battery Reverse Protection	Inbuilt	Required
12.	Fuse Should Be Connected In Series With Input & Should Have Provision For Spare Fuse	Inbuilt	Required
13.	MPPT Output Should Be Equivalent To Addition of number of MPPT Output Current if there are more than one MPPT	Inbuilt	Required
14.	Number of MPPT Required	NOs	To be designed by the tenderer as per requirement

Inverter

The single-phase Double Conversion On Line inverter shall provide AC power to the load. Simultaneously it will provide DC power to the battery bank and battery energy management will ensure that the battery will be maintained in fully charged condition with the help of Float Cum Boost Charger (Multistage Charging Technique) in all feasible circumstances. The inverter should be specifically designed to support AC loads of lighting load, loads of ice lined refrigerator and deep-freezer with high starting currents. There should be appropriate LED and LCD displays showing input as well as output related all annunciations with the help of LED and LCD display, refer to technical Specifications Sheet

Sr. No	Sr Specifications & Requirement For Solar Inverter with Built In Float Cum Boost Charger (FCBC/CVCC)	Unit	Parameter Value
1.	Nominal System Input Voltage From Grid	V AC	230
2.	Minimum Grid Voltage	V AC	130
3.	Maximum Grid Voltage	V AC	270
4.	Nominal System Input Frequency From Grid	Hz	50
5.	Minimum Grid Frequency	Hz	47.5
6.	Maximum Grid Frequency	Hz	52.5
7.	Fully Automatic Separately Settable FCBC/CVCC Charge Controller	Inbuilt	Settable
8.	Nominal FCBC/CVCC Output Voltage	V DC	144
9.	Float Voltage	V DC	163
10.	Boost Voltage	V DC	170
11.	Charger Capacity = Battery Charging + Inverter Input Current	Amp DC	To be designed by the tenderer as per requirement
12.	Battery Charging Current Limit Minimum	Amp DC	
13.	Battery Over Charging Voltage Limit V/Battery		
14.	Input Under Volt Protection	Inbuilt	Required
15.	Input Over Volt protection	Inbuilt	Required
16.	DC Over Volt Protection	Inbuilt	Required
17.	Auto Restart Protection	Inbuilt	Required
18.	Overload Capacity 200 per cent for 10 Sec, 150 per cent for 60 Sec, 125 per cent for 10 Minutes Built In Timer	Inbuilt	Required
19.	Output Capacity	KVA	2.4
20.	Output Power Factor	Lag	0.8
21.	Efficiency	per cent	90 per cent

22.	Output Voltage	V AC	230
23.	Output Voltage Tolerance	per cent	+/- 1
24.	Output Frequency	Hz	50
25.	Output Frequency Tolerance	per cent	+/- 1
26.	Output Voltage Waveform		True Sine Wave
27.	Control Method Real Time Wave Form Control (RTWC)	Using VLSI/uC	Required
28.	Output Voltage Wave Form Distortion	THD	< 3 per cent
29.	Operating Temp	deg C	0 To +50
30.	IEC Certification	62040-1 (PQS), 60068-2 (1,2,14,30) and 61683	Required

Annunciation & LED Indications of Input Status (On front panel of the Inverter)

1.	Input On	Inbuilt	Required
2.	DC On Inbuilt Required		
3.	CC Mode / Boost Mode On	Inbuilt	Required
4.	CV Mode / Float Mode On	Inbuilt	Required
5.	Rectifier / Charger Trip	Inbuilt	Required
6.	Input Under Voltage (UV)	Inbuilt	Required
7.	Input Over Voltage (OV)	Inbuilt	Required
8.	DC Over Voltage (OV)	Inbuilt	Required

Annunciation & LED Indications of Output Status (On front panel of the Inverter)

1.	Output ON	Inbuilt	Required
2.	Input Fail	Inbuilt	Required
3.	Alarm	Inbuilt	Required

4.	Battery Low	Inbuilt	Required
5.	System Trip	Inbuilt	Required
6.	Output Over Voltage (OV)	Inbuilt	Required
7.	Output Under Voltage (UV)	Inbuilt	Required
8.	Output Over Load	Inbuilt	Required
9.	Battery Low Trip	Inbuilt	Required

Meter & Switches on Front Panel of the Inverter

LCD to Display Following Parameters

1.	Manufacturers Name & Address	Display	Required
2.	Configuration of Inverter	Display	Required
3.	Input Voltage	Display	Required
4.	Input Frequency	Display	Required
5.	Input Faults / Warning	Display	Required
6.	Input Over Voltage(OV)	Display	Required
7.	Input Under Voltage(UV)	Display	Required
8.	Battery Charging Current	Display	Required
9.	Battery Voltage	Display	Required
10.	Battery Low Warning	Display	Required
11.	Output Voltage	Display	Required
12.	Output Frequency	Display	Required
13.	Output Load In Percentage	Display	Required
14.	Output Faults / Warning	Display	Required
15.	System Trip	Display	Required
16.	Output Over Voltage (OV)	Display	Required
17.	Output Under Voltage (UV)	Display	Required
18.	With Balance Time To Trip Output Over Load Should Display OC Timer Along	Display	Required

Switches on Front Panel of the Inverter

1.	Audible Alarm (Reset Switch)	Inbuilt	Required
2.	Inverter On/OFF Switch	Inbuilt	Required
3.	Inverter Reset Switch	Inbuilt	Required

Inverter Safety features

1.	MCB Switch Connected In Series With Input AC	Inbuilt	Required
2.	MCB Switch Connected In Series With Battery Input DC	Inbuilt	Required
3.	MCB Switch Connected In Series With Output AC	Inbuilt	Required
4.	All Wires Connected With Inverter Externally Should be Routed Through Cable Ties	Inbuilt	Required
5.	All Connections Should Be On Back Side	Inbuilt	Required
6.	All Connections / Connectors Should Be Covered With Transparent Acrylic Sheet	Inbuilt	Required
7.	Safety Standards (Warnings) As Per IEC & Should Be Clearly Mentioned On Back Side Of Inverter (I.e. High Voltage AC 230V)	Inbuilt	Required
8.	Care Should Be Taken For Battery Connections So That Short Circuit Should Not Happen. (Warning)	Inbuilt	Required
9.	Inverter To Be Serviced Only By Company Authorized Engineers Only (Warning)	Inbuilt	Required

Communication facility to be provided with Inverter (built in):

Facilities to be provided (in built) for inverter monitoring through GSM/GPRS System ##

INVERTER GSM/CDMA connectivity by RS232 cable (In built)

a. Periodical log of following data via SMS facility.

   i) Monitoring Utility Power to inverter/UPS.

   ii) Monitoring of Battery level/ percentage

   iii) Monitoring of Load Voltage & frequency.

   iv) Monitoring of Load level/ percentage

b. Event log on fault condition

   i) Mains Fail/Fault.

   ii) Battery Low Alarm.

   iii) System Fault/Trip

   iv) System Over load.

c. System control Via SMS

   i) System output Soft Switch OFF

   ii) SIM Information.

Event log and data log other than SMS facility shall be made available if PC is connected to communication port of inverter.

Purchase of SIM of the same shall be the responsibility of the tenderer and charge-recharge of SIM shall be managed by purchaser.

Centralized monitoring system will be installed at three different locations decided by the purchaser. All software, protocol and installation expenses will be in the tenderer's scope.

AC energy meters should also be installed to monitor the grid power consumption and load deliverance by the inverter both. This report must be submitted to the purchaser every quarter along with service report.

Battery Bank Specifications:

1.	Type of Battery :- VRLA/Gel	VRLA	Required
2.	AH Rating of Battery	AH	300
3.	Nominal Voltage Per Cell	V / Cell	2
4.	Number of Cell Per Battery	Cell / Battery	1
5.	Nominal Voltage Per Battery	V DC/Battery	2
6.	Float To Display Water Level & Gravity / Battery	Per battery	1
7.	Total Number of Batteries	NOs	72
8.	Minimum Charge & Discharge Cycles Expected	NOs	1,500
9.	Minimum Efficiency	per cent	>90
10.	Ambient temp	deg C	0 To +50
11.	Certification	IEC Or RDSO	Required
12.	Battery Cabinet:- well ventilated epoxy powder coated sheet metal fabricated on CNC Machine, closed lockable cabinet		Required
13.	Interlink Accessories		Required
14.	Wires Used Should Be of Copper Only Along With Cu Lugs		Required
15.	Nut Bolts Should Be Used of Lead Coated Only	Required	

Note:

1. The battery shall be VRLA.
2. The battery bank shall consist of required number of deep-discharge electrochemical storage cells, suitably interconnected as required. Parallel connections of storage cells are discouraged.
3. The cells shall be capable of deep discharge and frequent cycling with long maintenance intervals and high columbic efficiency. Automotive or car batteries shall not be accepted.
4. The permitted maximum depth of discharge (DOD) shall be 80 per cent
5. Unless otherwise specified the cycle life of the battery shall not be less than 1500 DC discharged cycles between the fully charged state and the permitted maximum DOD at the rate of C/10.
6. It should able to deliver 80 per cent of its rated capacity from fully charged position to DOD.
7. The cells shall include explosion proof safety vents.
8. The cells shall include the required number or corrosion resistant inter-cell required chemicals electrolyte packed in separate containers.
9. The cells shall be supplied in fully charged condition with appropriate packing.
10. Batteries shall be mounted in a well ventilated epoxy powder coated sheet metal fabricated on CNC Machine, closed lockable cabinet.

Cables

The size of the cables between array interconnections, array to battery charge control, battery charge control to battery, etc. shall be so selected to maintain the voltage drop and losses to less than 2 per cent in any part of the system. Necessary wiring for inverter and charge controller is to be carried out as per the single line diagram which will be provided at the time of award of contract.

Junction Boxes

The junction boxes shall be made to IEC standards for PV modules

Grounding/Earthing

All PV modules Inverter Output Neutral point must be isolated electrically with mains input, and solidly earthed with Earth Pit. A separate neutral strip should be provided. From this strip, 2.5 sq.mm. multistranded flexible PVC insulated copper wire needs to be distributed to internal wiring and other equipment. The entire system should be in compliance to the Indian Electrical Standard (IS-3043). It is also necessary to provide separate lightning arrester (with dedicated earthing).

Stand for inverter

Appropriate size, epoxy powder coated inverter stand fabricated on CNC Machine in MS sheet metal/ MS angle (with ground clearance of 18 inches) is to be provided.

Note: Necessary stickers for identifying different components of the system need to be provided (for e.g. System information, Inverter, Battery Bank, Mains ON/OFF, solar light points, user instructions (Marathi and English), supplier's name, contact details etc.)

Schedule-II

PV-AC power pack (100 per cent Solar)

The objective

System availability can be greatly increased in situations where there is intermittent grid supply by having a power pack comprising solar PV Panels, battery bank and an intelligent inverter (On-line) which feeds uninterrupted quality AC power to electrical loads taking energy from PV, grid or batteries as the case may be. Batteries will be charged only from solar energy alone as per the requirement.

KVA Rating	2.4
KW	1.92
DC Voltage	144
Power Factor	0.8
Diversity	60 per cent
Inverter Output Voltage (AC)	230
Battery	144 Volts, 500 AH
No. of Solar Panels	Can be decided by tenderer according to total solar wattage requirement.
Solar Wattage	12420 Watts
Solar Wattage	12420 Watts

Note: Other technical specifications of this schedule are same as that of Schedule- I

Technical Specifications common for schedule-I and II

Electrical Wiring & LED Lights as mentioned in the technical specification

The necessary wiring (isolated from the existing wiring) is to be carried out at public health institutions. The details of the wiring points (light + power) will be notified at the time of award of contract. However the material/components to be used for carrying out the wiring have to be as per the standards/norms specified below.

Guidelines for carrying out electrical work:

All electrical material shall conform to relevant standards as per BIS and shall carry ISI mark. Work shall be carried out as per the method of construction specified by BIS. Material shall be tested in an approved testing laboratory and shall qualify the relevant tests as and when directed.

Recommended Standards:

I.S. 732: 1989	Code of Practice for electrical wiring installations
I.S. 9537 (part 1): 1980	Conduits for electrical installations: General requirements
I.S. 694	PVC insulated cables for working voltages upto and including 1100 volts
I.S. 1913	General and Safety requirements for electrical light fittings / luminaries
I.S. 5216	Guide for safety procedure and practices in electric work
I.S. 10322	Luminaries for street lighting
I.S. 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
I.S. 3854	Switches for domestic and similar purposes
I.S. 1913	General and Safety requirements for electrical light fittings / luminaries
I.S. 10810: Part 63; 1993	Method for Test of cables, part 63 Smoke density of electric cables under fire condition
I.S. 13947	General requirement for switch gear and control gear for low voltages not exceeding 1000 V
IS 3043	Earthing
SP 30: 1984	National Electrical Code
SP 7 (Group 4): 2005	National Building Code

1. PVC Trunking (Casing – capping)

PVC Trunking (Casing – capping) ISI mark, 1.2 mm thick, minimum 25 mm width and above depending upon number of wires to be drawn with double locking arrangement.

2. Wire

PVC insulated wire of specified size, minimum FR grade insulation, copper conductor of electrolytic tough pitch (ETP) grade having insulation of 1.1 kV grade, ISI marked, of required colour coding.

3. Miniature Circuit Breakers (MCB)

MCB of specified poles and current rating ISI marked as per IS 8828: 1996 (IEC 60898) with hammer trip and watch mechanism 15 arc plates, 10 kA capacity with nominal rating of 240/415 volt

4. Distribution board suitable for MCB's

Horizontal/vertical type ISI marked as per IS 8623 of specified ways (poles), surface/ flush mounting, with double door suitable for 230/415 Volt

5. Cables

Cables shall be PVC/XLPE for LT of required construction, colour, shall carry ISI mark, IS no. manufacturer's name, size, duly embossed/screen printed at every meter and having the total count of progressive length in meter at each mark

6. Modular switch & sockets

– **Switch:** 1 or 2 way modular type switch 6/10 amp conforming to IS 3854

  - Finger-proof terminals for IP 20 protection against accidental contact Tunnel terminals preventing screwdrivers from slipping
  - Laser marking on mechanisms. Arrow showing the correct orientation of the mechanism
  - 30 mm long screws for adjustment in case the boxes are over-flushed Metal frame for cover plate, providing solid support to base
  - Plate made from highest quality polycarbonate

– **Socket:** Modular type 6 amp, 3 – pin plug shuttered socket

  - Cable connecting solar panel to charge controller is to be routed through ISI mark flexible pipe with proper saddling /clamps.

– **Inverter Output Electrical distribution** wiring size should be as follows: **Polycab** flexible copper wire in PVC casing as per following specifications:

  - For mains (Inverter Output to Distribution board):- (2CX 4) + (1C X 2.5) sq.mm. (PN+E)
  - For sub mains (Distribution board to switchboard):- (2CX 2.5) + (1C X 1.5) sq.mm. (PN+E).
  - For point wiring (Switchboard to individual point):- 2C X 1.5 sq. mm.

LED lights: As per requirement - All light points are to be catered with 9/12 /15 Watts LED fixtures (which will be housed in a weatherproof assembly (ABS material) suitable for indoor use, with a reflector) and 18 watts fixture (with IP65) for street light (with GI wall mounted pipe without pole). While fixing the assembly, the LED lamp should be held in such a way that area covered by LED light should be equally in front, left and right side. Power LED (Pure White color, IEC certified), 119 lumens (Minimum)/ LED, Driver: - Must operate on input voltage of 85 volts-270 Volts with input and output short circuit protection. THD should be less than 30 per cent. Efficiency should be minimum 90 per cent.

7. Earthing- As per IS 3043

- Depth:- 5 feet
- Plate:- GI of size 2 feet X 2 feet X 10mm
- Charcoal:- 50 Kg.
- Salt- 75 Kg.
- Watering arrangement:- 1.5 inch X 5 feet GI pipe with funnel.

1. Strip:- 25X3 mm X 8 feet GI strip with nut bolt.

8. From lightning arrestor:- 1C X 16 sq.mm. Copper flexible cable to ceiling level and from there 25 X3 mm GI strip to earthing pit continuously.

Technical Specifications common for Schedule- I and II

Schedule for poles for mounting array structure

Sometimes it is possible that the site conditions may not be feasible for mounting the array support structure on the rooftop of the public health institution. In this case, tenderer needs to consider following assumptions while fixing the array support structure.

[1] Array structure has to be fixed on pole. The size of each pole has to be min 4.5 meters in height and 4.5 inch diameter with thickness of 2.5 mm -3 mm with hot dipped galvanized.

[2] The number of poles required for the structure has to be designed by the tenderer.

[3] Entire pole structure has to be provided with proper RCC foundation. Array structure fixing nut bolts must be of SS 304.

Note: Tenderers are requested to furnish following information at the time of submission of tender document. This information will be based on the design submitted.

Sr. No.	Particulars	No of Poles Required
1.	2.4 KVA Solar PV System (50 per cent Solar+ 50 per cent Grid)	To be decided by the tenderer
2	2.4 KVA Solar PV System (100 per cent Solar)	To be decided by the tenderer

Appendix G

Comparison of Different Alternate Energy Sources

Comparative Study of Power Back Systems

Criteria	Diesel Generator (DG) Capacity 2.4 – 3 KVA	SPV S System Capacity 2.4 KVA (6 hours solar+ 6 hours Grid supply)
System Type	Mechanical and electrical	Electronics and electrical
Availability of system	Stand by, supplies power only during the condition of grid failure	Continuous, remains on-line and provides regulated power during grid supply, voltage disturbance, grid failure
Reliability	Depends upon regular servicing, replacement of genuine spare parts	High-reliability 99.9%, on-line web based system monitoring feature available and being used
Monitoring	Periodic visit of maintenance personnel of Original Equipment Manufacturer or its local representative	Web based remote monitoring of system, quarterly visit of service personnel, as per the service level agreement
System Operation	Man power required for operating the DG set; fuel required to be transported and stored safely; likelihood of fuel pilferage	No manpower required for operation. The entire system functions with and without availability of sun and grid supply.
Maintenance	Requires regular maintenance and servicing, replacement of consumable parts, lubricants and overhauling in few years;	Minimum maintenance required due to no moving parts in the system
Pollution	High level of noise and heat in the surrounding areas during running, emission of black smoke, soot; harmful for environment	Silent operation due to no moving parts, environmentally friendly operations
Cost	Low initial cost, high running cost due to diesel consumption and periodic maintenance of diesel engine	High initial cost, negligible maintenance cost except for battery replacement once in 5 years, which can extend to 7 years if well maintained
Cost per KWH	4 times higher compared to grid electricity price	40 to 50% higher than gird electricity price
System Life	10 years; overhauling of engine required	25 Years for solar panel; 5 to 7 years life of batteries

Details of the load in a primary health centre is provided in Appendix D, Table 1 while the factors considered in the sizing of back-up power system is mentioned in Appendix E.

Life-Cycle Based Cost Comparison of Power Back Systems

Included in Appendix F is a copy of letter issued by the Ministry of New and Renewable Energy (MNRE) 'D.O. No. 03/09/2014-15/GCRT' dated 10th August 2015 to all the Central Government Ministries/ Departments and all the state government departments, institutions and organizations regarding installation of grid connected solar rooftop systems on buildings belonging to Central Government or State Governments or state level institutions.

The table below provides the estimated lifecycle cost of owning and operating three different combinations of backup power systems for a PHC. The estimate use 2015-16 cost figures. The overall cost of solar photovoltaic system, has been arrived on the basis of cost of various components as per MNRE's letter No 5/23//2009-P&C (Pt.III) dated 3rd November 2014 regarding Central Financial Assistance (CFA) of 30% for "Off-grid and Decentralized Solar Application Programme".

All figures are in INR

	Description	SPV system with Grid supply	Standalone SPV system	Diesel Generator set
	System configuration	Solar panels – 5280Wp, Batteries – 2 volts, 300AH, 72 nos.	Solar panels – 12240Wp, Batteries – 2 volts, 500AH, 72 nos.	3 KVA, single phase generators
1.	Estimated Capital cost of SPV system[1] / Diesel Generator	792,000	1,591,200	160,000
1A	*Estimated Capital cost of SPV system with 30% Central Financial Assistance (CFA)*	*554,400*	*1,113,840*	*Not Applicable*
2.	Cost of batteries[2]	259,200	432,000	Not Applicable
3.	Number battery replacements in 25-year life of SPV system[3]	4	4	Not Applicable
4.	Cost of Inverter	65,000	85,000	Not Applicable
5.	Operating & Maintenance cost[4]	180,779	419,078	1,014,373
6.	Lifetime electricity generation	151,767 units in 25 years	351,824 units in 25 years	36,500 in 10 years
7.	**Lifetime ownership cost (Sum of No 1 + 2 x 3 + 4 + 5)**	**2,074,579**	**3,823,278**	**1,174,373**
8.	***Lifetime ownership cost with CFA***	***1,836,979***	***3,354,918***	***Not Applicable***
9.	**Cost of 1 unit of power**	**13.67**	**10.87**	**32.17**
10.	***Cost of 1 unit of power with CFA***	***12.10***	***9.51***	***Not Applicable***

Assumptions:

- Monthly electricity consumption in PHC: 900 units
- Tariff of commercial power supply in Maharashtra: INR 7.92
- Annual escalation in electricity tariff of 4% considered as per CERC, and
- Annual escalation in diesel price considered 7%
- The above estimate does not include cost of system installation, which varies as per location

[1]The cost of Solar power pack/Solar Power Plants with battery bank is estimated at Rs 150/Wp for system capacity of up to 10kW and Rs 130/Wp for system capacity of more than 10kW, as per MNRE letter referred above

[2]Estimated cost of 'Flooded Tubular Low Maintenance Lead Acid Batteries'

[3]CERC Petition No. SM/03/2016 dated 29th April 2016, refer Annexure 1, S.No. 2 'Useful Life',

[4]CERC Petition No. SM/03/2016 dated 29th April 2016, refer Annexure 1, S.No. 46 (e) 'Operation and Maintenance Expenses'

Solar Hybrid Photo-voltaic System

Recouping the Total Investment

A Solar Hybrid Photo-voltaic System (SHPVS) is a clean and green option to provide 24x7 electricity to a health facility and support its critical functions. The 24x7 electrical availability also makes it an ideal location to store vaccines at recommended temperature thus expanding the reach of immunization programme to under-developed and hard-to-reach areas. A SHPVS system can provide electricity to health facilities with no grid supply at all through an independent system as well can maintain a 24x7 electrical supply in health facilities with limited grid supply thus replacing the need of diesel generator generated electricity which is costlier and harmful for environment.

SHPVS have an high initial investment cost but a 'Recouping of Investment' calculation indicates that the cost can be recovered within the first 13 years by replacing the need of generators and the system is capable of supplying clean and green energy for additional 12 years beyond the first 13 years.

Total Installation cost of a SHPVS	Rs. 1,116,200
Total operational and maintenance cost including battery replacement in 25 yrs.	Rs. 958,379
Total cost	Rs. 2,074,579

Based on the calculation in Appendix F, a health facility with OPD, indoor, cold chain, Operation Theatre, labour room will have a 1920 watts power load. Considering a full power use for 8 hours and 40% power for remaining 16 hours, 28 units of electricity will be required every day translating to 2.5 lakhs unit in 25 year.

Units of electricity (KWH)= Power (in KW)* Duration (Hr)

Daily Unit Requirement= (1920 W* 8 Hours) + (1920*40%)* 16 Hrs)/1000

Daily Units Required= 16.64

Total Units Required in 25 Yrs.= 1.5 Lakh

As per the 'Life Cycle Based Cost Comparison of Power Backup System' by Ministry of New and Renewable Energy (MNRE) in their letter 'D.O. No. 03/09/201415/GCRT' dated 10th August 2015, the calculation is as below:

Units of electricity required per day for the defined health facility	28 KWH
Units supplied form Gird (50%)	14 KWH
Units supplied by alternate source (solar or Genset) (50%)	14 KWH
Units required per year from alternate source	5040 KWH

Units required in 25 years from alternate source	126,000 KWH
Cost of 1 unit electricity generated by diesel Genset	Rs. 32.17
Cost of 1 year of electricity generated by DG set	Rs.162137
Years required to recoup the total cost of SHPVS by replacing a diesel Genset	13 Years

The above figures indicate that the entire cost of a Hybrid SHPVS (initial installation, maintenance and battery replacement for 25 years) can be recouped within 13 years by replacing the diesel Genset. The Hybrid SHPVS also brings the following advantages:

1. Clean and Green energy
2. Power back in case of failure of grid supply or cloudy days
3. Pure sine wave electrical supply: This feature has direct impact on the performance of cold chain equipment as well as on all other electrical equipment in the health facility. The life of all devices increase and reduces the chances on breakdown.

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