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FINAL REPORT

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ENVIRONMENT: SOLAR ENERGY PROJECT

Impact Evaluation

Prepared For

HDFC
WITH YOU, RIGHT THROUGH

Table of Contents

List of abbreviations

AMC	Annual Maintenance Contracts
ASHA	Accredited Social Health Activist
BEST	Brihan Mumbai Electric Supply and Transport
C&I	Commercial and Industrial
CERE	Centre for Environmental Research and Education
CHC	Community Health Centre
CSR	Corporate Social Responsibility
DAC	Development Assistance Committee
DRE	Decentralized Renewable Energy
GDP	Gross Domestic Product
GHG	Green House Gas
GW	Giga Watt
HC/HC	Health centres
JVF	Jai Vakeel Foundation
KWp	Kilo Watt Peak
NGO	Non-Government Organization
OECD	Organization for Economic Cooperation and Development
OPD	Outpatient Department
PHC	Primary Health Centre
RE	Renewable Energy
RTS-PV	Rooftop Solar Photo-Voltaic Power Systems
SDG	Sustainable Development Goal
SWH	Solar Water Heaters
SWP	Solar Water Pumps
UNFCCC	United Nations Framework on Climate Change Convention

I. Executive Summary

Solar based decentralized energy systems are being increasingly adopted for the several positive effects associated with them. While rooftop solar plants (RTS) are best known to bring large savings in electricity bills, solar water pumps (SWP) and solar water heaters (SWH) provide hot water more easily, in energy poor areas. This impact evaluation study attempts to quantify the socio-economic benefits that have accrued to beneficiary institutions via interventions undertaken by HDFC's CSR initiatives within Karnataka, Odisha and Maharashtra. In Karnataka, 200 primary health centres (PHCs) and community health centres (CHCs) were installed with SWP and SWH, 35 PHCs and CHCs in Odisha were equipped with SWH, and 3 institutions in Maharashtra were equipped with RTS. Total grant support of Rs 6.57 cr was provided.

Rooftop Solar in Charitable and Government Institutions: This study details benefits accrued from RTS installations to the beneficiary institutions in Maharashtra which are namely 1) Jai Vakeel Foundation, Mumbai (JVF), 2) Adhar Badlapur, Mumbai (Adhar) and 3) Maharashtra Police Wireless Training Centre, Pune (DPW). RTS systems totaling 202.435 kW capacities were installed in FY 2019-2020 and FY 2020-21, on one or multiple buildings within these institutions. This report undertook an in-depth study with 2 primary objectives namely 1) estimating economic savings from RTS installation and 2) understanding current maintenance of the RTS systems. Based on data collected

- Savings in e-bills are computed between 40%-50% per month. Savings are higher for higher capacity projects, due to higher generation
- Organizations have been able to use the savings to expand their social service delivery, which was earlier constrained by lack of funds availability
- Annual carbon emissions reduction of 232.4 MTCo2e is estimated
- Site visits conducted confirmed that the panels are well maintained by internal staff
- In view of the findings, while no immediate actions are recommended, this study recommends Annual Maintenance Contracts (AMC) with expert maintenance contracting agencies, such that panel degradation which could happen over time can be avoided (which will get more pronounced over the years)

Solar Water Pumps and Water Heaters in Health Centres: The benefits of solar energy installation were reaped by both the health centres and patients in the districts of Raichur, Yadgir, Koppal, Haveri in Karnataka and Sambalpur in Odisha. 146 SWP of 1.2kW capacity each and 161 SWHs of 300-500 litres capacity each were installed.

- Improvement in services was brought about by hot water supply which helped with sanitization and sterilization of the entire facility, cloths, instruments and medical equipment.
- Hot water supply not only helped sanitize but also helped in maintaining hygiene at the health centres, since water was now available 24X7
- Water supply is now adequately available for patients and staff members (working as well as dwelling on the premises)
- There is increase in patient footfall by median of 55 per health centre

- Patients are seen most content with maternal services (72% of the surveyed)
- Every health centre visited reports an increase in delivery cases since installation, a few have also reported as much as 20-35 per month
- Availability of water and hot water has increased patients' contentment with various healthcare services provided by the health centres. Since patient's adherence to medical prescriptions is directly linked to high rates of patient satisfaction, the project plays a positive role in patient health

Figure 1: Panels of solar water heater and water pumps at a PHC in Haveri, Karnataka

II. Renewable Energy in India

i. Sustainable Development Goal Number 7, Greenhouse Gases (GHG) Emissions and Climate Change: Call for Immediate Action

In 2015, all members of the United Nations, developed and developing, adopted the 2030 Agenda for Sustainable Development, which has 17 sustainable development goals (SDG) at its core. Sustainable Development Goal 7 specifically focusses on increasing access to affordable, reliable, sustainable, and clean energy. At the same time, Sustainable Development Goal 3 aims to ensure that everyone has a healthy life and promotes well-being for all ages.

ii. India's Response to Climate Change and Brief of State-Wise Strategies (With Focus on Karnataka, Odisha, and Maharashtra)

India has designed a multi-fold strategy to deal with climate change, in which renewable energy (RE) features prominently. The country aims to reach net zero emissions by 2070, reduce carbon emission intensity of its GDP by 45% by 2030, and plans to meet 50% of its electricity requirements from RE sources by 2030 (PIB/Cabinet, 2022).[1] Several states have replicated this strategy at the state level, with their own variations. The government has now committed to 500 GW of RE by 2030.[2]

Karnataka has adopted both climate mitigation and adaptation approaches, and promoted utility scale renewable energy projects (located on large open land strips), decentralized RE projects (on rooftops), undertaken capacity building on the use of solar energy, and created awareness of treated water, forestation and preservation of species.[3] The state of **Odisha,** is more vulnerable to the effects of climate change such as rise in sea levels, frequent and heavy winds and rainfall, intensive storms, and rising greenhouse gas emissions (Odisha State Action Plan on Climate Change (Phase-II), 2018)[4]. The state targets to integrate various RE resources, in the state energy mix. **Maharashtra's** climate change strategy focuses on agriculture, water, health, forests, rural development, **urban development**, disaster management and energy.[5]

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[1] Pib.gov.in. 2022. Cabinet approves India's Updated Nationally Determined Contribution to be communicated to the United Nations Framework Convention on Climate Change. [online] Available at: <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1847812> [Accessed 19 September 2022].

[2] Investindia.gov.in. 2022. Renewable Energy in India - Indian Power Industry Investment. [online] Available at: <https://www.investindia.gov.in/sector/renewable-energy> [Accessed 16 September 2022].

[3] TERI. (2013, December 9). Karnataka State Action Plan on Climate Change. Retrieved from Department of Ecology & Environment, Government of Karnataka: http://moef.gov.in/wp-content/uploads/2017/08/Karnataka.pdf

[4] 2018. Odisha State Action Plan on Climate Change (Phase-II). [online] Forest & Environment Department, Government of Odisha, p.23. Available at: <https://climatechangecellodisha.org/pdf/State 20 Action 20 Plan 20 on 20 Climate 20 Change 202018-23.pdf> [Accessed 19 September 2022].

[5] T E R I. 2014. Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC); New Delhi: The Energy and Resources Institute. 306 pp.

Whether at a national level or state level, dealing with climate change calls for immediate action. Adopting and increasing the use of renewable energy will help India achieve sustainable development goal 7 directly, with spill-over impacts on SDG3.

One of the many reasons for India's RE plans is the need to eradicate energy poverty, which can be done successfully using RE (Bhide & Monroy, 2010)[6]. The government of India has a focused policy and regulatory regime that pushes growth in the renewable energy sector, as it is both cost efficient and scalable. Amongst the many benefits, wide-scale adoption of Decentralized Renewable Energy (DRE) systems save operational costs of adopting institutions in the form of solar water pumps, solar water heaters and solar rooftop PV plants.

- Solar Water Pumps (SWP): A solar water pump is an application of photovoltaic technology which converts solar energy into electricity to run the pumping system. Such applications are useful in remote areas with no/low grid based power supply.
- Solar Water Heaters (SWH): Solar Water Heaters, collect the sun's energy to heat water in overhead storage tanks. Such applications are useful for domestic use, and in medical centres that need access to hot water for medical service delivery.
- Rooftop Solar Photo-Voltaic Power Systems (RTS-PV): RTS systems are now hugely popular in India, especially in institutions that have large energy demands. The biggest benefit is savings in electricity bills, which can then be used for other business purposes.

RTS as decentralized systems have the advantage of being modular (small scale), and provide energy independence from the grid, thereby making them a large contributor in the urban energy transition pathways.

iii. Rooftop Solar Energy

India's rooftop solar market growth presents an interesting story. Owing to high capital cost commitment and the political economy around distribution tariffs, RTS solutions were preferred and afforded only by the Commercial & Industrial (C&I) consumers. C&I consumers in India pay heavily for consuming electricity, cross subsidizing energy consumption by domestic and agricultural consumers, and hence benefit the most from *prosuming* (producing part of energy that is consumed). Therefore, the first few years between 2017 – 2020, C&I adoption of RTS has been at the forefront of India's solar story (Mukherjee, 2022)[7]. After 2020/2021, however the policy focus has moved to promoting non-commercial or residential rooftops, which is yet to pick up pace.

Almost half of the country's 40 GW RTS target can be met through residential rooftop systems, however there are several deterrents to overcome for this market to expand. Using the roof space for drying

[6] *Bhide, A., & Monroy, C. R. (2011). Energy poverty: A special focus on energy poverty in India and renewable energy technologies. Renewable and Sustainable Energy Reviews, 15(2), 1057-1066.*
[7] *Mukherjee, M. (2022). India's Ongoing Rooftop Solar Journey 2017-2022. Oxford Institute for Energy Studies. Retrieved from https://a9w7k6q9.stackpathcdn.com/wpcms/wp-content/uploads/2022/11/Indias-Ongoing-Rooftop-Solar-Journey-2017%E2%80%932022-ET20.pdf*

clothes, or keeping it vacant for future other purposes points to a significant 'space loss aversion' amongst residences (Graziano, Fiaschetti, & Atkinson-Palombo, 2019)[8]. Further, the lack of information on systems costs, benefits, maintenance, and adoption models is more widespread in residential consumers. However, a sector where RTS installations can make a real difference is public sector institutions such as government buildings, and service delivery institutions. As on date, adoption from the public sector has been low on two accounts namely a) the grid based power supply to such institutions are at lower rates and b) the knowledge of benefits of RTS is lacking.

[8] *Graziano, M., Fiaschetti, M., & Atkinson-Palombo, C. (2019). Peer effects in the adoption of solar energy technologies in the United States: An urban case study. Energy Research & Social Science, 75-84. doi:https://doi.org/10.1016/j.erss.2018.09.002*

III. Study Introduction and Methodology

i. Introduction to the project sponsor and implementation partners

HDFC Ltd (project sponsor), Housing Development Finance Corporation Limited (HDFC) is a major housing finance provider in India. HDFC Ltd's CSR initiatives are undertaken through direct partnerships with non-profit organizations and through its primary implementing agency, the H T Parekh Foundation (Foundation). The CSR projects undertaken by HDFC Ltd are located across the country in areas of Education, Healthcare, Environment and Persons with Disabilities.

SELCO Foundation (implementation partner) works around different geographies to create and strengthen the ecosystem for last mile sustainable energy solutions across varied contexts. One of the primary sectors of focus is healthcare. SELCO Foundation has developed a range of renewable energy solutions that are tailored to the needs of healthcare facilities, including solar-powered lighting, refrigeration, medical equipment, and solar driven appliances. The organization works closely with healthcare providers to understand their needs and to design customized solutions that meet their specific requirements. One such solution is to provide solar water heater and solar water pump to the health centres of four districts in Karnataka and one district in Odisha. This project is fully funded by HDFC CSR. The total implementation duration of this project was 3 months, from 1st January 2022 to 31st March 2022.

CERE, the Centre for Environmental Research and Education (implementation partner) is a Mumbai based not-for-profit organisation established in 2002 that works to promote environmental sustainability through research and innovation, formal education, government and corporate partnerships and publications. For the intervention, grant support was given for RTS at 3 institutions in Maharashtra.

ii. Research Methodology

To evaluate the impact of solar energy installations (SWP and SWH), this study adopted a cross-sectional mixed method design that involved utilisation of both quantitative and qualitative primary data collection tools. Additionally, for the purpose of evaluating the impact of RTS panels in selected sites, on-site visit and qualitative interactions with relevant stakeholders at those sites was undertaken.

Quantitative and Qualitative Sample Size

To accurately capture the impact of the intervention, sample size needs to be sufficient, which in turn depends on the power i.e. efficiency to detect and measure change. Using a two-sample probability sampling formula, 37 health centres were included in the sample. Quantitative structured interview tools were administered with the help of a trained field team. Data was collected from facility managers, maintenance contractors, care providers as well as end-users at all facilities. Since the facilities under study are not distributed equally among Karnataka & Odisha, DI used Proportionate sampling (sample is proportional to the number of state-wise interventions) to allocate the sample size.

Table 1: Quantitative sample distribution for health centres

S. No.	State	Number of health facilities	% of facilities among total	Proportionate sampling
1	Karnataka	200	200/235 = **85%**	85% * 37 = **~33 facilities**
2	Odisha	35	35/235 = 15%	15% * 37 = **~4 facilities**
Total		**235**		**37**

The study included responses from 370 end-users including 10% non-response rate. Given that a total of 37 institutions were included in this study, 10 end-users from each facility were included in the sample. Apart from care providers, maintenance contractors, facility managers and end users, qualitative depth interviews were also conducted with 2 ASHAs (Accredited Social Health Activist) per district. The sampling method followed in qualitative interactions was non-probabilistic (purposive). A detailed breakup of the sample size, its distribution, location and the tools used are represented below in Table 2:

Table 2: Quantitative And Qualitative Sample details

Location	Institution	Type Of Solar System Installed	Total Sample	Tools Used
Maharashtra, Navi Mumbai	Adhar, Badlapur (by CERE)	RTS	1 admin	Semi-structured questionnaire having both quantitative and qualitative questions, plus photo documentation and observational notes.
Maharashtra, Pune	Directorate of Police Wireless (by CERE)	RTS	1 admin	
Maharashtra, Mumbai	Jai Vakeel Foundation (by CERE)	RTS	1 (Official)	
Karnataka • Raichur • Koppal • Haveri • Yadgir Odisha • Sambalpur	Primary Health Centres and Community Health Centres (by SELCO)	SWP + SWH	37 health centres • 10 end-users • 1 facility manager • 1 maintenance contractor • 1 care provider	Quantitative structured tools with end-users + Semi-structured questionnaire having both quantitative and qualitative questions with the stakeholders mentioned, plus photo documentation, additional observational notes.

IV. Impact analysis for Rooftop Solar

i. Introduction to the study sites

Solar rooftop systems, which are de-centralized solar power plants, are gaining popularity on several accounts. For end consumers, these benefits are primarily in the form of savings in current electricity consumption costs, reduced reliance on diesel generations to ensure energy security, reduced individual carbon footprint and most importantly insulation from increasing costs of grid based power supply (Sharma, 2015)[9]. Given the pronounced benefits and a lucrative investment environment, HDFC CSR installed solar rooftops on several government institutions, such that the identified beneficiaries could reap economic and social benefits from these projects. Amongst the several projects implemented, this study focuses on 3 institutions where rooftop solar projects were commissioned in the FY 2019-2020. The details of these institutions appear below:

Jai Vakeel Foundation, Mumbai (JVF): Jai Vakeel Foundation (JVF) is a 70+-year old Non-Governmental Organization (NGO) working with the intellectually disabled, providing a holistic approach to the management of individuals with Intellectual Disability. It caters to over 3,000 individuals annually, across age groups and varying levels of intellectual and other associated disabilities such as autism, epilepsy, cerebral palsy and visual or hearing impairment. The main objective of installing RTS at JVF was to provide savings from electricity bills which could then be re-directed to sponsor student education and skilling. The organization is now host to RTS capacities of 48 Kilo-Watt (KW) which are installed on 3 buildings, commissioned in the year 2020.

Adhar Badlapur, Mumbai (Adhar): Started in 1990, this centre provides care for the mentally challenged, aged between 18 – 80 years. Rooftop solar systems are installed in 2 buildings within the centre, totalling to 40kW capacity (20kW each, commissioned in 2 phases) commissioned in 2021. Both the systems are off-grid and connected to a battery system, which provides self-sufficiency to the centre. This is especially helpful for the centre, since it is located in a remote area, with frequent disruptions to grid based power supply. The main objective of installing RTS at Adhar was again to provide savings from electricity bills, which can be re-directed to fund resident beneficiaries living and medical costs.

Maharashtra Police Wireless Training Centre (DPW), Pune: Maharashtra Police Wireless Training Centre, is the only training centre for Technical Training in Maharashtra and is situated in the Police Wireless Headquarters on Pashan road, Pune. It was established in 1967. Since 2016 till date over 4000 officers and personnel have been trained in the fields of Communication, IT and advanced Technologies. This centre has the largest RTS system amongst the 3 organizations, totaling to 113 KW installed on 6 buildings. 5 of the systems were commissioned in 2019 and 1 in 2020.

[9] *Sharma, B. D. (2015). Rooftop solar PV power: Potential growth and issues related to connectivity and metering. IIT Delhi. Retrieved from https://www.iitk.ac.in/ime/anoops/for_15/photos/PPTs/Day-3%20IITK/Rooftop%20PV%20-%20Mr.%20B%20D%20Sharma.pdf*

Based on primary, in-depth interviews (and researcher's notes, and observational notes such as sites photos) detailed discussions with beneficiary stakeholders, this report contains a detailed narrative of the projects, current benefits accruing to the beneficiary organizations, highlights some of the problem areas with the projects, and also lists key recommendations, both for the current beneficiaries and future RTS projects, that may be undertaken by HDFC CSR.

ii Findings of Impact Assessment

This section provides site-wise details of solar rooftop projects executed.

a) Jai Vakeel Foundation (JVF), Mumbai

About: The organization houses more than 640 student beneficiaries. The age range of student beneficiaries is between 6-50 years, and they spent close to 6 hours per day at the centre, spending time in education and skilling. The centre employs more than 200 staff members, 4 of whom are residential and rest come from nearby areas within Mumbai. The centre does not consume energy 24*7, as the facility shuts down at 5pm (only 2 rooms consume 24*7). JVF was under a commercial tariff category, but recently changed to a public service tariff category, due to which electricity is now being consumed @ Rs 5/unit.

Capacity & Metering: Rooftop solar systems are installed in **3 buildings within the centre, totaling to 48.6 kW capacity** (10kW, 20kW and 18kW in each building respectively), commissioned in 2020. All the systems are under **net-metering** arrangement. All the solar systems at JVF received net metering approval from Brihan Mumbai Electric Supply and Transport Undertaking (BEST), their power supplier, shortly after project commissioning. JVF has access to generation numbers online via CERE. As expected, generation quantity shows seasonal variation, primarily in the monsoon season. CERE and Avesta Solar (project vendor) conduct **regular site visits** to check on the systems, which helps in receiving updated systems performance information.

Figure 2: Site visit at Jai Vakeel Foundation

Maintenance: The systems are maintained currently by internal staff appointed by JVF. Manual cleaning is conducted using water and cleaning mops, **every alternate day**, before 10AM. This is done in order to

take full advantage of generation from the solar system before peak generation hours set in (typically between 11 am to 4 pm).

Savings: Since the net metering was received in early 2020, JVF is already reaping the full benefits of energy cost savings. The average monthly e-bill ranges from Rs. 15,000 – Rs. 20,000 which is a **savings of 50%-60%** from before RTS installation.

These savings are being redirected to provide sponsorship to students towards medical, healthcare, and educational requirements. Since school fees are waived off for many students, savings from RTS help the organization fund such student's needs. Further, the RTS systems have **insulated JVF from frequent power cuts**, and thereby helped the centre improve in their service delivery. Additionally, it has helped JVF to reduce its carbon footprint which and get closer to its aim of a greener campus.

Savings from solar systems are depicted graphically in the figure below. As is evident, JVF has been able to save approximately 57% of its expenditure in monthly e-bills post solar installations.

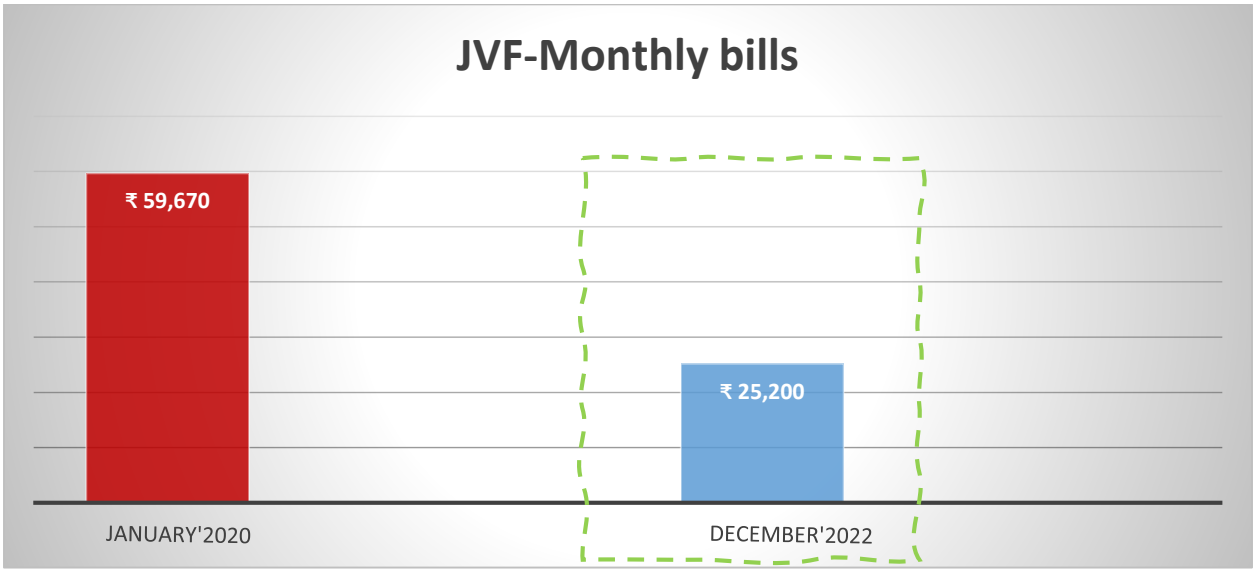

Figure 3: JVF E-bills (Jan 2020 and December 2022)

b) Adhar Badlapur, Mumbai

About: They currently house approximately 238 physically and mentally challenged residents. All the residents are full time residents and are visited frequently by their families. In order to take care of the patients, Adhar employs close to 175 staff members, 2 of whom stay full time at the centre and the rest travel from nearby localities.

Capacity & Metering: Rooftop solar systems are installed in **2 buildings** within the centre, totaling to **40.38 kW capacity** (20kW each, commissioned in 2 phases) commissioned in 2021. Both the systems are **connected to a battery** system, which provides uninterrupted power supply. With these installations, the

centre has reached near maximum potential in RTS installation. Rest of the buildings that have spare roof are structurally weak and cannot support RTS installation. Both systems are under **net-metering** arrangement.

Maintenance: The systems are maintained currently by internal staff of Adhar. Manual cleaning is done **4 times a week**, using water and hand held cleaning mops (duration taken - approx. 1.5 hours). Cleaning is completed before 10 AM so as to take full advantage of generation from the solar system before peak generation hours set in (typically between 11 am to 4 pm).

Figure 4: Rooftop solar panels at Adhar-Badlapur

Uninterrupted power supply: Owing to the remote location of the centre, there are power supply disruptions from the grid. Hence, they rely on their rooftop system to **insulate them from grid supply disruptions** and improve their service delivery. It has helped save significant costs incurred on generator running cost (as compared to previously).

Savings: Savings of **45%** based on average of bills before and after net metering. Savings are being **redirected as financial support for resident patients**. In-house patients need monthly financial support to the extent of Rs. 20,000 per month. Some of the families are unable to bear the cost, owing to family financial position. The saved money is hence being directed to support such patients, where family support is lacking. There have been evidences of power supply sufficiency from the system, even during night-time (on account of the battery set-up). Savings from solar systems at the centre are captured below in the figure below.

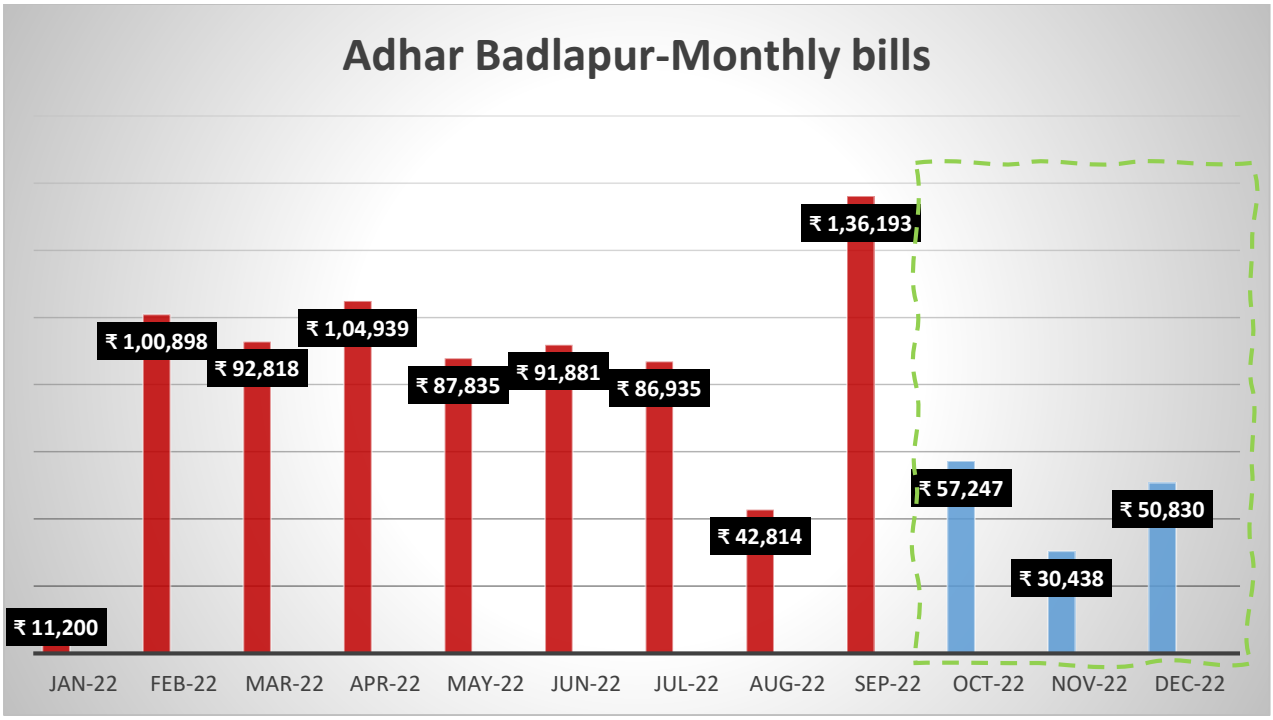

Figure 5: Adhar Badlapur E-bills (Jan'22- Dec'22)

c) Maharashtra Police Wireless Training Centre (DPW), Pune

About: The personnel at DPW perform important wireless communications, technical enhancements and other related work.

Capacity: Rooftop solar systems are installed in **6 buildings** within the centre, totaling to **113.45 kW** capacity, 5 of which were commissioned in 2019 and 1 in 2020. All the systems are under **net-metering**, allowing pass through of full benefits to DPW. During project executions, site surveys for the entire campus was conducted and Avesta Solar (project vendor) provided technical proposal which was evaluated by CERE. After shadow analysis, 6 buildings were chosen which includes officers' mess, training centre and boys' hostel buildings.

Maintenance: One of the biggest concerns at the centre is **lack of staff availability**, because of which regular cleaning of solar panels is not being done. Due to this, future generation from the solar power plant may stand compromised.

Savings: DPW is able to reap sufficient benefits from the RTS projects in form of saved electricity consumption costs of **13%**. However, since the monthly e-bills are paid by the police headquarters in Mumbai, the resultant savings are not being used by the centre directly. Instead, decision on re-directed use of savings in to improved services, are beyond the ambit of the centre.

The figure below captures savings from RTS, when e-bills from 2020 (pre RTS) and 2022 (post RTS) are compared (FY 2020-21 not considered due to COVID lockdown):

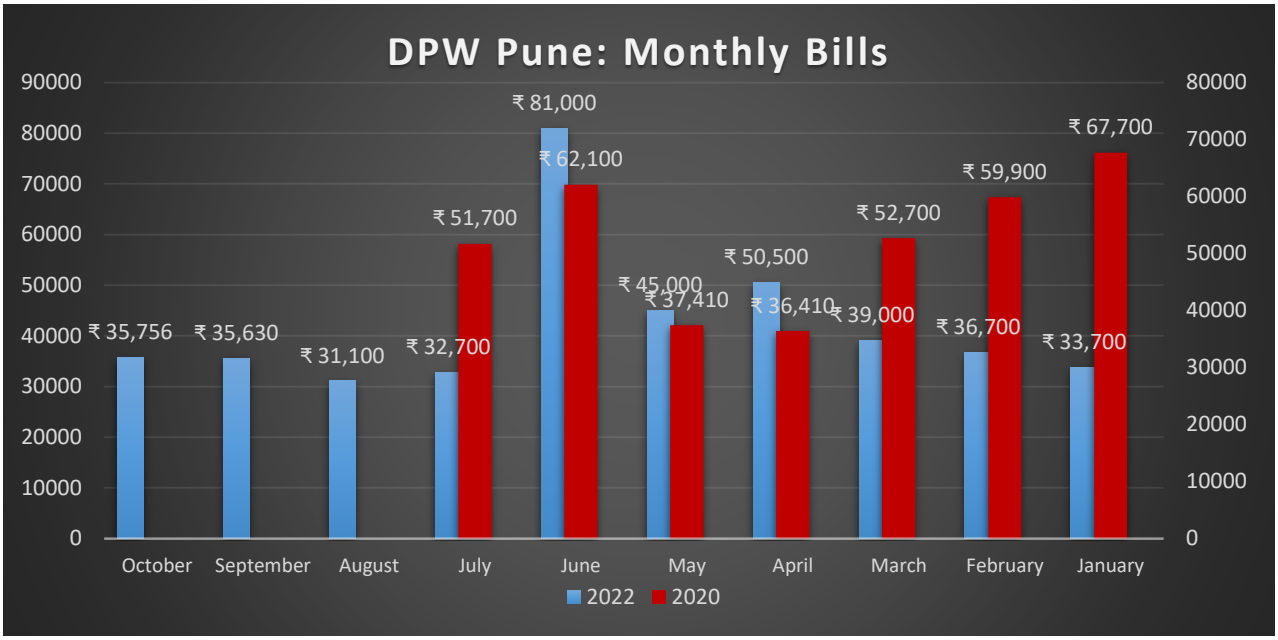

Figure 6: Savings at DPW Pune (2022 Vs 2020)

d) Carbon Emission Reduction

Based on the long term generation from RTS projects installed at the sites, this section verifies the calculations by CERE to compute carbon emissions avoided (shown in table below). The computations are made assuming 350 days of sun-shine in a year, with 4 hours or high solar radiation per day.

Table 3: Carbon emissions avoided through RTS

Location	Capacity installed	Annual Generation	Generation in 10 years (15% reduction in generation potential)	Generation in 25 years (15% reduction in generation potential)	CO2e reduction annual	CO2e reduction 10 years	CO2e reduction 25 years
	(kW)	kWh	kWh	kWh	$MTCO_2e$	$MTCO_2e$	$MTCO_2e$
Director, Police Wireless, Pune- Phase 1	40.095	56,133	4,81,140	12,02,850	46.03	394.53	986.34
	20.25	28,350	2,43,000	6,07,500	23.25	199.26	498.15
	15.58	21,812	1,86,960	4,67,400	17.89	153.31	383.27
	8.91	12,474	1,06,920	2,67,300	10.23	87.67	219.19
	8.1	11,340	97,200	2,43,000	9.30	79.70	199.26
Jai Vakeel Foundation	20.25	28,350	2,43,000	6,07,500	23.25	199.26	498.15
	18.225	25,515	2,18,700	5,46,750	20.92	179.33	448.34
	10.125	14,175	1,21,500	3,03,750	11.62	99.63	249.08
Adhar - Phase I	20.91	29,274	2,50,920	6,27,300	24.00	205.75	514.39
Director, Police Wireless, Pune - Phase I	20.52	28,728	2,46,240	6,15,600	23.56	201.92	504.79
Adhar- Ph II	19.47	27,258	2,33,640	5,84,100	22.35	191.58	478.96
	202.435	**2,83,409**	**24,29,220**	**60,73,050**	**232.40**	**1,991.96**	**4,979.90**

These computations are in line with the recommended methodology as per Kyoto Protocol.

iii Recommendations:

- **JVF:**
  - Since there are evidences of miscreants (and since the campus is in the middle of open areas), JVF may investigate warranty conditions on the panels. This can be taken up with CERE and Avesta Solar.

- **Adhar:**
  - Adhar would benefit from installations of solar water pumps and solar water heaters. Solar water pumps can provide self-reliance in hot water supply at the centre, and help meet the high daily demand for water. Additionally, solar water heaters would be beneficial in providing hot water for their medical services. However the feasibility for solar water heaters will need to be assessed in advance, due to the structure of existing buildings.
  - Access to the sites is via a ladder. It currently meets the purpose for maintenance, however it can be structurally improved.
  - The centre does not have direct access to live generation data. The same can be provided such that the centre has live information on generation, and can take corrective action in case of lower than expected generation. Such information feedback also motivates consumers to undertaken more pro-environmental actions.

- **DPW:**
  - Since the biggest concern faced by the centre is lack of staff availability for panel cleaning, it is recommended that a 3rd party developer is engaged via an Annual Maintenance Contract (AMC). This is especially required since the centre has more than 100 KW project size to maintain. Alternatively, CERE/Avesta Solar may extend existing services, to maintain the panels at added cost. For larger projects (typically > 30 KW), it is recommended that the beneficiary institutions sign up for an AMC.

V. Impact Analysis of Solar Energy Water Systems at Health Centres in Karnataka and Odisha

i. Study context

Located within Raichur, Yadgir, Koppal, and Haveri, districts in Karnataka, and Sambalpur in Odisha, the health centres (hereon referred to as HC) serving these communities were included in the study. These are some of the lesser developed areas with less per capita income.

Visitors of the HCs belonged to the lower socio-economic stratum, living in villages that are remotely located and at a significant distance from the HCs. Thereby making it challenging for them to avail government healthcare and medical services that are free of cost. Majority of the patients or visitors find it prohibitive to visit HCs as they must take a day-off from work, which results in losing their wages. This could take a toll especially if the patient is struggling with a chronic issue. However, patients do not have any other option, which offers free medical and health services.

Non-compliance to prescribed health care remains a major problem in managing long-term illnesses in remote Indian areas (Balasubramanium et.al, 2018)[10]. Not complying or drop out completely from prescribed treatment, causes delay in diagnosis and symptom suppression. Patient's satisfaction, an indicator of quality of health facility, helps with patients complying with the prescribed treatment (Manzoor et al., 2019)[11].

Before the intervention, HCs did not have access to continuous water supply. Sometimes the staff had to fetch water that required time and physical effort. Moreover, fetching enough water for cleaning, sterilizing, sanitation and drinking, medical emergencies wasn't practical as that would require multiple trips and multiple staff members. With regard to hot water, the staff had to use a variety of measures to heat water including firewood, gas stoves, electric coil. The staff found it difficult to procure hot water for basic services such as conducting deliveries. In addition, the health centers also suffer from irregular electricity supply. As seen from the GESCOM data, there are scheduled outages in at least one district each month[12].

In words of a doctor present at an HC in Koppal,

> *"Earlier there were days when electric supply was cut for as much as 6-7 hours a day and there wasn't water, let alone hot water available. There wouldn't even be any cleaning. People would have to travel to the district hospital for services."*

[10] *Balasubramanian, A., Nair, S. S., Rakesh, P. S., & Leelamoni, K. (2018). Adherence to treatment among hypertensives of rural Kerala, India. Journal of family medicine and primary care, 7(1), 64.*
[11] *Manzoor, F., Wei, L., Hussain, A., Asif, M., & Shah, S. I. A. (2019). Patient satisfaction with health care services; an application of physician's behavior as a moderator. International journal of environmental research and public health, 16(18), 3318.*
[12] *Gulbarga Electrictiy Supply Company Ltd (GESCOM). (2023, March). Proposed Outage Schedule. Retrieved from GESCOM: https://gescom.karnataka.gov.in/info-2/Proposed+Outage+Schedule/en*

Another HC reports,

"Earlier we did have hot water but it was not sufficient for all patients. Now we have sufficient and available on patient demand."

ii. Key Findings of Impact Assessment:

a) Increased Water Availability

Since the interventions**,** there has been a **significant increase in the availability (access and supply)** of **water** in both Karnataka and Odisha. Throughout there is a significant increment in the availability (supply and access) of water as can be seen in the table below. The HCs have clearly benefited from increased water supply and access after the intervention.

Table 4: Water availability at various usages at PHCs

Sr No.	Location of usage within premise	Available	For % of visitors in both states
1	Water available for toilet use	Available	95.61%
		Unavailable	4.39%
2	Water available in labor room	Available	85.41%
		Unavailable	15.58%

b) Improved Child Delivery and Maternal Care

Hot water is critical in health centres which are equipped with delivery service primarily for sterilizing all equipment, materials, and for cloths used in child delivery. All HCs are dependent on water, both hot and at normal temperature, **for cleaning, sterilizing and sanitizing the facilities and all equipment**. Chemicals for sanitizing and sterilizing are rarely used as these can be expensive and for other reasons. Considering the importance of delivery services to HCs, the availability - access and supply - of hot water makes a substantial difference. This development has been the most impactful. It is for this that in each interview, respondents have mentioned that intervention's best benefit comes to **child delivery and maternal care service** for several reasons. Every HC reports in **an increase in delivery cases** since installation, a few have also reported as much as **20-35 and 45-50 more cases per month**. One PHC (Yadgir, Karnataka) reports of handling 80 delivery cases in a month. The patient requires **staying at the HC for a few days after delivery**, and water helps with every aspect of care for both mother and the new born. This is elaborated in excerpts of the HC staffers listed below.

"Our PHC offers two major services, delivery and basic diagnostics. Earlier, most of them would visit Taluk hospital for delivery. After installation of hot water pump, water is available in the labour room, toilet and also for drinking. Now most of delivery cases are coming to our PHC only.". – Head nurse at a HC in Koppal

From Raichur, a head nurse reports,

"It was very helpful for delivery patients. After delivery, hot water has helped to take care of both mother and child. It has helped with cleaning the baby and mothers can also bathe. Before installation, we used to send the mother and child home after delivery and now we can accommodate them for 3-4 days and avail better care here. Water (and hot water) is now available at patient's requirement and convenience".

"At our PHC we are using a lot of hot water as now there are 20-25 delivery patients a month roughly 10-15 patients more per month now. Water systems have definitely helped the delivery patients to maintain immunization." – A medical officer attests in Raichur, Karnataka.

Staffers across the study areas have attested to the benefit for delivery patients even if they perceive that the installations haven't made a difference to their own routine work. An HC reported that since the installation, **gynecology-related services have also increased**. With gynecology related services, it was meant that minor surgeries such as those required for family planning. These can now be conducted at the HCs.

In the words of one of the nursing officers in Haveri (although similar was reported across all districts in Karnataka),

"Hot water is available 24 hours and so that mother and child both are relieved. There is also no problem of cleanliness and hygiene."

Testimonials of HCs' staff

"After installation, the number of delivery cases have increased by 25-35% per month".

"It has helped patients with delivery and sanitization of the HC."

"Delivering children/patients, drinking water, and washing clothes/sanitation, are some of the benefits of hot water supply through solar water heater installation."

"It has definitely helped delivery patients to maintain immunization." "Hot water has helped to sanitize the PHC and clean our instruments, and clean instruments regularly."

"Solar water heaters have made our work easier… Hot water has helped in delivery and when conducting laparoscopy."

Along the similar lines, majority of respondents (HC staffers) have reported that water (and hot water) availability – access and supply – has benefited OPD patients but to a lesser extent as compared to delivery patients.

Figure 7: Kabbur PHC in Haveri, Karnataka

c) Changes Observed by Patients in Health Centres

Patients and visitors were asked about their views on the changes at health centres. Across the study area, mean age of patients/visitors was 37.5 years. There were more male respondents (242) than female respondents (156). More number of female respondents, were non-literate. Patients were probed as to what they think are the reasons for this change. These perceptions/feedback are captured below:

1. **Perceived general improvement in healthcare services offered by HC**
   Visitors/patients see overall improvement in services. They have noticed improvements in services, amenities, and facilities right away.
2. **Improved cleanliness and hygiene**
   Most of the patients/visitors have out rightly noticed the improvement in cleanliness and hygienic conditions of HCs. Since the installations, both access to water and hot water has vastly improved. Patients (across the study states) said that, *"PHC is maintained very well, is it now very clean and hygienic."*
   This is of critical importance as it is observed that 1 in 10 patients, receiving health care, suffer from hospital associated infections (Government of Karnataka, n.d.), either on account of unsafe surgery/giving patient unsafe injection/ birthing under unsafe conditions/imperfect medical devices.
3. **A general sense of contentment with services provided**
   Patients/visitors have expressed a general sense of contentment or happiness after visiting HCs. This is useful for: recommending health services to fellow community members, and in adhering to medical treatment.
4. **Health services accessible to a broader range of population**
   Since the intervention, more patients have been approaching an HC as first time visitors and this has not gone unnoticed by repeat visitors or health centre staffers alike.
5. **Better reputation as a health care and service provider**

Due to improvements in maintenance of the premises and improvement in services (quickness, etc.), patients and visitors now see HCs as highly reputed and the best service providers in their area.

"This area has gotten a good name. The centre is well maintained, clean and hygienic, and has facilities of that of a panchayat. The service is quite good, and it is recognized as one of the best health centres in our area."

85% of visitors/patients interviewed perceive an improvement in services offered by HCs in Karnataka. Visitors have reported that the health centres are now considering the *"best-in-town, is now well-reputed and well-known and is regarded similar to hospitals, neat and clean and comfortable"*

In addition, staffers who directly face patients perceive that their working conditions have significantly improved. Hot water is also used in **suture and episiotomy as a pain relief**, and it helps with ***"controlling infection between patients"*** – as termed by a staff nurse in Karnataka. HCs are dependent on hot water for sterilizing, sanitizing and cleaning the facilities, with water (and hot-water) access and supply. Hot water is also used for cleaning bed sheets, towels, equipment (if applicable), instruments, and floor. Water is even used as sanitizer in some HCs where patients wash their hands and legs on entering the facility.

Patient's account of positive feedback was corroborated by the feedback of medical professionals or staff of the HCs. Some of their excerpts are shared below:

"Through solar installations, the number of patients have increased, we can treat patients more comfortably." – *PHC staff member, Karnataka.*

"Solar water pump has helped. Basic diagnostic services have improved after these installations, and it has been good for PHC staff also." – *Medical Officer, Karnataka.*

"Earlier there were two doctors and now there are four. There is also a new waiting room, a new toilet, and good amount of hot water available for everyone. We didn't have to wait too long to obtain a referral and it was a comfortable and pleasant experience, and it's improving increasingly." –*End-user at one of the HCs.*

d) Patient Footfall

There is **increase in patient footfall by median of 55**. Positive changes in patient footfall is highest in Haveri, median is 200, followed by Raichur District. Haveri's lead could be attributed for its compactness and its central location (within North Karnataka) that makes it accessible to residents of the nearby districts also.

The reason for increase in patient footfall can be attributed to an increase in the number of child delivery patients.

"Seeing the government's intention of making each PHC a delivery point, SWH heater and pumps were installed in the PHCs where there was a labor room. The installation was to enhance the healthcare standards and meet the growing need of the communities." – SELCO representative

Increased Visitation Frequency

57% of total visitors had visited HCs even prior to interventions. 43% of visitors were new patients that is indicative of an increased breadth in the reach of health centres as they are now able to cater to a larger population.

> *"Due to scarcity of water, people used to travel to district hospitals but now they come to our PHC." –* Koppalla PHC staffer.

e) Solar Energy System Maintenance at Intervention Sites

Majority of staffers at HCs, have reported that solar panels, that were installed on the rooftops have been placed carefully in such a way that they receive good exposure to sunlight. The same was confirmed by our field teams. In addition, so far, there has not been issues with bird droppings or dust or any damaged caused by environment incidences. The staffers also reported that they were **trained by implementation partner on how to maintain the panels.** This was a critical step as only after that were the staff able to clean the rooftop panels.

> *"Yes, panels are easy to access, no issues. They are in good condition. There are no taller buildings around our PHC. Hot water is accessible and available 24X7."* – A staff member, Koppal

However, specifically in Odisha, one respondent acknowledged: *"I had no idea I needed to be trained to clean and maintain the installation. No cleaning has been done yet".* Staffers also reported to be hesitant in cleaning the panels, *"in case if we cause any damage to the panels if we don't clean correctly as we are not trained all that well".* 3 out of 4 sites visited in Odisha did not have access to a ladder to climb to the roof and clean the panels on a regular basis. On being enquired about the maintenance process they follow, staff members responded that they borrowed a ladder from nearby villages once a month to do the needful.

While the socio-economic benefits of the solar systems are clearly visible, it is essential that the systems are adequately maintained. One of the ways to maintain the solar systems is proper maintenance which will come from training staff of all HCs within the state. The implementation partner is aware of the existing gaps in the training conducted for the concerned personnel during the implementation of this particular project.

Currently, SELCO has entered into AMCs for these centres with a vendor who has local presence in the districts and can be available immediately. SELCO also tracks the maintenance via regular photo sharing and sharing nudges on the HCs' whatsapp groups

> *"We sensed that training received by each HC isn't uniform. Some staff gets trained and they get posted to some other HC where there is no intervention and vice-versa. Then it*

becomes a challenge to properly maintain the systems. However, in our next phase of installation, we aim to train the staff of all HCs within the state, together."

Case Study

Turvihal PHC, the best practice health centre

Located in Raichur district of Karnataka, Turvihal primary health centre, caters to a population of 65038. This PHC has received several awards from the state government since the intervention. The appreciation award is known as KayaKal which is awarded to the health facility that enhances patient's experience. Since the installations, hot water is available 24X7 at the health centre even when electricity is not available. Hot water availability at the health centre has enhanced the delivery of the following services:

I. *Daily cleaning, sanitizing, and sterilization of the centre premises,*
II. *Patients, who have been treated for snake or dog bites, are able to stay at the health centre for three to four days.*
III. *The health centre is equipped to provide general services such as immunization, critical care, child delivery and maternal care, and treats at least 50 cases of dog bites. (this area has recorded the highest number of cases of dog bites in all of Karnataka).*
IV. *Sterilization: patients and visitors are required to wash their hands and legs with hot water, which is available, right outside the centre. In addition, all OPD patients are required to wash their hands with hot water before entering the premises.*

Since the installations, most, especially female, patients have expressed gratitude for prompt and efficient health service. The number of patients visiting the health centre has increased by threefold, from 100 to 300 per day.

iii Recommendations

- **Necessary resources for the maintenance:**
  In the case of health centres in Odisha, a majority of them did not have access to a ladder which would enable them to climb up to the rooftop to check on the panels installed. Hence, necessary intervention in terms of provisioning of such resource needs to be ensured.
- **Increasing awareness on benefits of solar energy**
  The staff of the health centres need to be sensitized towards the benefits (financial, environmental, etc.) of solar-powered equipment to the health centre itself and extended benefits to the patients/visitors. This would help in increasing a sense of accountability amongst the health workers to maintain these installations. Model PHCs like Turvihal can also be cited as role models for adoption of good practices.

Figure 8: Post- installation visit in Karnataka

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